Industry Canada
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PHOTONICS STUDY

MISSION TO JAPAN

Canada

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MISSION TO JAPAN

Prepared for

Industry Canada

as part of the

Photonics Sector Campaign

November 1992

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PHOTONICS STUDY MISSION TO JAPAN

1.0 INTRODUCTION

In February 1992, Industry and Science Canada (ISC) approved the Photonics Sector Campaign to improve Canadian capability in photonics. During Phase II of the Sector Campaign, an Industry Steering Committee comprised of senior industry executives is overseeing the development of a joint industry-government Action Plan. Phase II includes a global assessment of technology, applications and markets; the Mission to Japan was the first to be undertaken under the Campaign.

The objectives of the Mission were, in simple terms, to find out where the Japanese are currently in photonics, where they are going, how they got there and what lessons can be learned from the Japanese experience in promoting the development of the Canadian photonics industry. The Mission was quite successful in identifying a number of factors tht were instrumental in the development of the Japanese photonics industry to a position of world leadership. Some of these factors can be applied directly in Canada; some of them will have to be modified to suit the Canadian business and cultural climate, and some will not be applicable.

This report describes the Mission and what was accomplished by it in terms of the development of the Photonics Sector Campaign. The main body of the report is meant to present an overview of what was accomplished by the Mission. Detailed information, including individual visit reports, are contained in a number of Annexes.

Included in the two-week itinerary were visits to six large equipment manufacturers, two medium-sized manufacturing companies, three smaller specialized niche companies, a photonics user company, an operating company, an industry association, a research consortium, a photonics trade show and a visual information and data service company, along with briefings on government and industry programs at the Canadian Embassy. Annex A contains the full program of visits.

2.0 MISSION MEMBERS

Because of the Mission's main purpose was intelligence gathering, it was decided not to include members from the private sector. Five experts were chosen with a good knowledge of photonics activities in Canada and globally and with close links to Canadian industry:

- Dr. Akira Watanabe, NGL Nordicity Group Ltd., and Consultant to the Sector Campaign Secretariat;
- Dr. Paolo Cielo, Program Leader, Optical Inspection, Industrial Materials Institute, National Research Council;

- Dr. Ian MacDonald, Director, Photonics Research, TRLabs;
- Dr. Richard Normandin, Group Leader, Optoelectronic Devices, Institute for Microstructural Sciences, National Research Council;
- John Deacon, Photonics Sector Campaign Manager, Information Technologies Industry Branch, ISC.

Drs. Cielo, MacDonald and Normandin were chosen for their ongoing knowledge of and involvement with the Canadian private sector in the development of photonics technology and applications. Dr. Watanabe has been involved with photonics since the early 1970s, when he managed Canada's first research program in optical-fiber communications. As the senior member of the Mission, he served as the Mission Leader. Further details about the mission objectives and the qualifications of the mission members is given in the Mission brochure, which is reproduced in Annex B.

3.0 METHODOLOGY

The final program was worked out through a series of exchanges of correspondence by facsimile over a period of some four months. Most of the visits were arranged by the Science and Technology Section of the Canadian Embassy in Tokyo. All logistics were looked after by the Embassy, and an Embassy officer accompanied the Mission on the majority of the visits.

Before the commencement of the program of visits, the Mission members met to decide on number of operational points, such as:

- the overall Mission objectives and the objectives of each of the visits;
- questions to be asked during each visit;
- designation of the rapporteur for each visit;
- the form of the Mission report;
- the numbering system for the documentation received;
- procedure during each meeting.

Before each meeting, the members discussed what was known about the company and what we hoped to achieve during the meeting. After each meeting, often in an informal setting, a post mortem was held in order to discuss what was learned and to modify, as necessary, questions to be asked and procedures to be followed at subsequent meetings. A post mortem was also held on the Mission as a whole on the final afternoon at the Canadian Embassy.

A lap-top computer was taken in order to facilitate report writing on an ongoing basis. Indeed, the majority of the technical visit reports were completed in draft version during the Mission. Upon return to Canada, the individual reports were sent to ISC by e-mail and were collated by the Sector Campaign Secretariat. They are included in Annex D. The individual contributions were put into a standard format, but no attempt was made to edit them centrally.

Photocopies of the business cards of the people that we met are included in Annex E.

4.0 OBSERVATIONS

This section lists some important observations arising from the Mission. These observations are not meant to be about the technical aspects of the visits, but more about the Japanese structures, way of doing things, their priorities, etc. These observations are mainly focused on what one might learn from the Japanese experience that would be relevant to the development of a Canadian photonics industry, and are given in the following subsections.

4.1 Optoelectronic Industry and Technology Development Association

The Optoelectronic Industry and Technology Development Association (OITDA) was formed in 1980 by a group of Japanese manufacturers essentially to monitor progress and developments in a government funded project, the Optical Control and Measurement Systems project. It now has 257 members from a wide range of industrial sectors, including 91 electronic and equipment manufacturers, but also companies from sectors such as chemicals, precision machinery, banking, trading, advertising, etc.

In its earlier days, the OITDA appears to have played a key role in bringing photonics equipment manufacturers together with potential users of their equipment. Currently, it plays a role in compiling industry data and in standards setting. This latter function is no doubt its most important one today.

It also has committees looking at technology and market trends. However, these committees do not appear to be playing effective roles. From the point of view of the large Japanese equipment manufacturers, there may no longer be a need for such committees, since the companies are very well equipped to carry out such studies on their own.

The role of OITDA in the future is somewhat uncertain. It is still supported by some of its founders, such as NEC and Matsushita, and appears to be well regarded by most of its members. There were some indications, however, that the effectiveness of the OITDA is waning.

4.2 Government Leadership and Funding

The Japanese government has played a small but significant role in the development of photonics-related businesses in Japan. This role is manifested not only in the provision of modest amounts of funding, but more importantly, in the leadership that the government provided in identifying promising technologies and in serving as the catalyst to generate a national vision.

The amount of government funding in photonics-related activities is dwarfed by the expenditures of the private sector. We estimate that government expenditures in photonics R&D currently represents no more than 10% of the amount spent by the private sector. What is clear, however, is that the modest government expenditures have served to focus private sector attention on photonics technologies and markets.

The Ministry of International Trade and Industry (MITI) has been funding photonics activities on a continuing basis since 1973, when it started the Hi-OVIS Project, which provided fiber optics links to a number of homes in the community of Higashi Ikoma. This initial experiment to provide a range of services to home was MITI's answer to the CCIS (Coaxial Cable Information System) project of its rival, the Ministry of Posts and Telecommunications, which oversees the operation of the Nippon Telegraph and Telephone Corporation. Funding for the two phases of Hi-OVIS was about $100 million[1] over a ten-year period from 1973-1983.

Subsequent MITI projects include the Optical Measurement and Control System, which was funded to the level of $157 million over 1979-1985, and which provided the impetus for the formation of the OITDA.

4.3 The Japan Key Technology Center

One important MITI-related organization is the Japan Key Technology Center. It is funded in part from the proceeds of the privatization of the Nippon Telegraph and Telephone Corporation (NTT) in 1986. The Key Technology Center provides 70% funding industry R&D consortia (of 2 or more companies). Examples that we encountered in the photonics area included the following:

- the Optoelectronics Technology Research Center ($70 million from 1986-1995), a consortium of 13 companies that is developing basic optoelectronics materials technologies for applications in information processing;

[1] All conversions from Japanese yen to Canadian dollars are done at a rate of ¥100 = $1.00

- the Interactive Basic Information System ($35 million from 1986-1990)), which is in essence the successor to HI-OVIS;

- Optical Measurement Technology Development Co. Ltd. (OMTEC) ($42 million from 1986-1992), a consortium of 5 measuring instrument manufacturing companies, established to perform research on the fabrication of high-quality photonic devices for measurement use; and

- TERATEC ($75 million from 1992-2001), the successor to OMTEC, a joint venture of five measuring instrument companies to develop ultra-high frequency (up to the terahertz range) optoelectronic measuring technology for testing high-speed IC and optoelectronic integrated circuits.

4.4 Nippon Telegraph and Telephone Corporation

The Nippon Telegraph and Telephone Corporation is Japan's largest telecommunications carrier. Although it was privatized in 1986, it is still 50% owned by the Japanese government, with the remaining 50% owned by small shareholders, none of whom owns more than 1% of the corporation's shares. NTT has two stated objectives: to promote business for its networks and to promote R&D in Japan. In this latter capacity it plays the role of a government entity.

NTT has approximately 250,000 employees and annual revenues of $50 billion. Resources allocated annually for R&D are at the level of $2.7 billion and 8,200 employees. These figures are on the large side for a company with no manufacturing capability; however, this level of effort makes sense in view of NTT's second objective. In the past, NTT has played a leading role in the development of the Japanese telecommunications equipment industry, with whom it has strong traditional ties based on its particular system of joint R&D.
Notwithstanding pressures from foreign suppliers to liberalize its procurement practices, NTT will no doubt continue to have a large influence on Japanese equipment manufacturers.

NTT is a world leader in the development of photonics technology for telecommunications applications. Its current level of effort in photonics is difficult to establish because photonics activity is carried out in a number of organizations as NTT proceeds on the path to have fiber-to-the-home in place by 2015. We estimated that about 3,000 people are involved in photonics. The NTT Opto-electronics Laboratories have a staff of 240 and an annual budget of $40 million.

4.5 Large Companies

The Japanese photonics industry is very healthy and growing, with 1991 production estimated to be $40 billion. Many of the Japanese companies are looking to the consumer goods market as the main outlet for their photonics products, since it is one of the few markets that is large enough to accommodate the outputs of these mega-companies. In addition, they are also looking at industrial applications. Indeed, the companies appear to be covering all possible bases, poising their considerable resources in a position to capitalize on any emerging market opportunities.

The companies that we visited used a market-driven approach in their technology planning process. It is evident that technology is regarded as a very valuable corporate resource, but the manner in which this resource is utilized is determined by the management's perception of where the business opportunities lie. The importance of technology in determining corporate strategy is evidenced by very high percentage of engineers at the very senior levels of these companies. In most of these companies, the chairman and president have always been engineers; in fact, we were told by one company that it is not permitted for a non-engineer to become president.

Most of the large companies that we visited participate in a number of MITI-sponsored projects, mainly in basic technology R&D. We were left with the impression in some cases that they participate in these projects only to make sure that they do not get left behind by their competitors, who in the main are other large Japanese companies. We were told in one case that they are starting to tire of government programs.

One exception to the above is Sony. This very successful company does not participate in Japanese government programs. It should be noted that Sony is by far the youngest of these companies (except for Sanyo, which is a Matsushita derivative), having had its start after World War II.

4.6 Technology Monitoring and Technology Diffusion

Japanese companies have traditionally concentrated their efforts on the commercialization of technology, rather than on inventing new technologies. In spite of efforts by the government to put more emphasis on basis technologies, most Japanese companies are concentrating their efforts on producing products that meet market need.

Most Japanese companies maintain modest-sized (in relation to their overall size) basic research groups whose primary role to monitor external technology developments. In the culture of lifetime employment, these basic research groups also provide a cadre of trained people that can be assigned on very short notice to emerging priority areas.

Within Japan there seems to a great deal of interaction among researchers, so that nothing that happens anywhere in the world seems to escape their notice. These ties usually originate from connections made at university, since a relatively small number of universities produce the majority of the top people employed in these high ranked corporations. There are also many occasions, both formal and informal, for Japanese company employees to meet with their peers both in their own company, in other companies and in other sectors.

4.7 University-Industry Relationships

In the Japanese government, there are essentially three completely separate research budgets, with the Ministry of Education, Science and Culture being responsible for university research funding. Although the total budget for university research in Japan is quite large, it is divided over a large number of professors, so that most university research groups have a relatively low research budget. Also, there are no well-established mechanisms for corporations to fund university research activities. Even the most well-off research professors are able to get only about $50,000 annually from the private sector.

A recent initiative of the Science and Technology Agency, the ERATO (Exploratory Research for Advanced Technology) Program, is attempting to promote closer coupling between university and industrial research. STA is responsible for the second research budget, with the Agency of Industrial Science and Technology Agency of MITI controlling the third.

4.8 Small Companies

The three small companies that we visited were similar in several aspects to similar-sized Canadian companies. There were, however, a couple of major differences. The most striking was their total lack of interest in government funding. Small companies in Japan do not want, and indeed, do not get, government subsidies. The small companies that we met, notably Sumita and Santec, felt that government subsidies were detrimental to their independence and market responsiveness. It is not only small companies, but also some very successful large companies, for example, Sony, reject government subsidies.

Another main difference was the existence of a significant local market for their products. In the case of one test equipment manufacturer, Santec, the main customer was NTT. The company of 85 people has at least 200 contacts within NTT, and was able to develop products in anticipation of NTT's needs. In another case a small plastics injection moulding company, Seikoh Giken, evolved into a metal ferrule manufacturer and also has developed world-class technology for fiber coupling. Its main customer is one of the three leading cable manufacturers in Japan, Furukawa Electric.

Although Seikoh Giken now exports about 60% of its products, it was able to build up its strength primarily serving the domestic market. Santec, which is in a somewhat earlier stage (it was founded in 1985), exports only about 15% of its output. Highly innovative Canadian companies of similar size typically have to export a much larger percentage of their production in order to survive.

Perhaps another significant difference that we detected was the willingness of these companies to enter into alliances with other companies, including foreign companies. The two companies mentioned above both had relationships with a Canadian photonics company.

4.9 Availability of Capital

None of the small companies that we visited has any difficulties raising start-up capital or in getting access to working capital. In the case of Sumita, it was simply a case of a highly profitable company with a modest rate of growth. Santec's business was also sufficiently profitable that it had no difficulty in funding its R&D from its own revenues. Although we did not get a complete picture of the situation in Japan, it our impression that not only are the costs of borrowing lower in Japan, but that some banks are much more oriented to meeting the needs of high technology entrepreneurial ventures than is the case in Canada.

4.10 Vertical Relationships

For the small and medium-sized companies in Japan, their lifeline appears to be the vertical relationships that they have developed with larger companies, usually equipment manufacturers. Not only do they have a ready and relatively stable market for their products, but also they can benefit from the know how of its big brother, in areas such as need identification, manufacturing technology, product evaluation, etc.

The large companies on the other hand are dependent on these smaller companies to provide them with innovative solutions to their needs, particularly in niches that are not large enough to warrant the full attention of the large company. Even smaller companies in Japan are able to benefit from the fact that there exists a good supply of the devices and components that they need for manufacturing their products.

In some respects, the large companies play the role of the government in other countries. Consequently, in Japan the government does not need to be as concerned about small companies. So long as it looks after the large companies, they will in turn look after the small companies that they need.

4.11 Market Opportunities for Canadian Companies

The Japanese see that for them the important markets in photonics are the consumer markets which involve very high volumes. Notwithstanding the large effort expended by Japanese companies in developing markets for photonics in a wide range of applications, there will be opportunities for Canadian companies even in Japan. An important observation to keep in mind is that many of the Japanese companies that are well-known in North America are so large (sales in the $50 billion range) that they are not in a position to exploit medium-sized market niches.

In general, there is good potential for a strong Canadian presence in photonics, and Canada is already on the road that will develop it. The key to success is to realize that the opportunities lie in "niche" products for the most part. Most Canadian companies are too small to take on the major development projects that would lead to profits in large scale concepts related to photonics, for example, automobile navigation systems, or optical computers.

Smaller countries will have a better chance of being successful in the specialty equipment market: sensing, instrumentation, trunk telecommunications, switching, etc. The obvious opportunity for Canada is to develop items that are wanted primarily on a smaller scale where economies of scale are less important. Canada has internal markets that could support developments of this type, and Canadian companies are already filling these niches.

5.0 IS THE JAPANESE OPTOELECTRONICS INDUSTRY A VALID MODEL FOR CANADA?

The Japanese optoelectronics industry is currently very strong and is a world leader. Obviously the Japanese have done many things right; it is also evident that they have made a number of mistakes along the way. In the following subsections we discuss some items distilled from the Japanese experience are worth consideration by Canada in promoting the development of its photonics industry.

5.1 A National Technology Vision

Perhaps the single most striking conclusion of the Mission is that the Japanese government through the efforts of MITI and others has been successful in arriving at a national technology vision that includes the clear identification of national technological goals. The key to guiding industrial technology toward a national vision seems to have been to get companies to collaborate in consortia that have had a considerable effect in advancing basic technology development in Japanese industry.

Even though photonics is gaining widespread recognition as one of the key strategic technologies that will drive the development of industrial capabilities than are not possible with existing technologies, a vision does not yet exist in Canada about photonics, and it not clear whether such a vision will ever exist. Industry/government consensus in setting long-term objectives for the Canadian photonics industry should act as a catalyst to the development of photonics technology and its application over a range of Canadian industrial sectors.

5.2 The Role of Government in Industrial Development

The concept of Japan Inc. is well known, and whether or not it exists in a formal government-led manner has been the subject of study and debate. What is clear in Japan is that industry and government work on the basis of cooperation rather than on confrontation. Industry and government together establish the agenda, with industry taking the lead in implementation.

The Japanese government's industrial policies do not focus on individual companies, but on sectors, so that government program mainly benefit larger companies, who in turn assist the development of smaller companies who are their suppliers. Current Canadian government policies are focused on developing small and medium-sized companies. Policies that would encourage collaboration between small and large companies would no doubt serve a useful role in Canada.

Many of the successful companies that we visited, such as Sony, Santec, Seikoh Giken and Sumita Optical Glass, have avoided government subsidies. Perhaps there is a lesson here for Canadian companies.

5.3 Technology Diffusion - the Human Dimension

It readily apparent, however, that it exists quite strongly at the informal level. The strong human linkages that overcome corporate and institutional boundaries are very strong in Japan, and is one of the chief reasons for the quick and effective diffusion of technology both into and Japan and within Japan.

While Japanese mechanisms may not be directly transferable to the Canadian geographical and culture setting, it is apparent that some means must be found to promote the ready exchange of information and ideas within the Canadian technological and business communities so that good technological solutions to real business needs and opportunities are put together in a timely and effective manner.

5.4 Coupling Technology Generation and Use

The Japanese consortia that we were exposed to, such as the Optoelectronics Technology Research Corporation and other such groups funded by the Japan Key Technology Center, appeared to be doing very high quality research. However, it was not clear what technology was developed, and there were no instances of technology transfer that were identified to us. A demonstration experiment, the Interactive Basic Information System, which the Mission visited, was trying to establish a need for an existing capability.

Consortia formation has been encouraged in Canada through the Network of Centres of Excellence and other initiatives, but there is not clear recognition in Canada on the crucial issue of how these research efforts tie into Canadian industrial development. Recent Canadian initiatives, such as the Strategic Microelectronics Consortium, are more focused on industry development.

On the other hand, we found that all of the companies that we visited had very strong connections to their markets. This was true particularly of the three small companies that we visited. In Canada, because of geography, much lower population density and a different kind of societal interactions, it may be desirable to establish mechanisms to promote closer coupling between the innovative technology generation companies and the potential users of the technology in Canadian industry.

5.5 Capital Availability

The small Japanese companies avoid and abhor government subsidies. Nevertheless, they appear to be successful in meeting their requirements for capital. One reason for this is that the Japanese appear to place a greater value on technology as the key to developing future business than do most other Western societies. Other important reasons are the longer term outlook that most business have, the specific inclusion of technology in their long-term planning and the way in which the stock market evaluates their shares.

While it is not the place of this report to make an analysis of the Canadian situation in this regard, it is apparent that an environment in which risk capital is more readily accessible be an important factor in the development of a developing sector, such as the photonics sector.

5.6 A Photonics Industry Association

The OITDA was an important factor in the development of the optoelectronics industry in Japan in three respects: in bringing equipment manufacturers together with the potential users of their equipment, in setting industry standards and in collecting data about the industry. Industry associations in Japan are similar to some extent to the British Technical Research Associations, while in the past Canadian industry associations tended to be more like the American industry lobby groups.

The establishment of a Canadian photonics industry association would be a useful first step in promoting the effective development and application of photonics technology in Canadian industry. If such an organization is formed in Canada, it should not be limited to the "core photonics industry", but should strive to include significant potential users, as is the case for the OITDA.

OITDA functions, which could be adopted by a Canadian association, could include the forging of informal links between technology generators and users, standards setting, compiling industry data, and possibly, reporting on technology and market trends.

6.0 CONCLUSIONS

The Photonics Study Mission to Japan identified a number of factors that were instrumental in the development of the Japanese photonics industry to a position of world leadership. The information gathered by the Mission will be used as one of the inputs, along with the two study contracts that are now under way and the planned missions to the U.S. and to Europe, in the development of the Photonics Sector Campaign.

Some of what we learned in Japan may be directly applicable in Canada; most of it will have to be modified to suit the Canadian business and cultural climate. It is clear, however, that a plan, no matter how good it is, can lead to positive benefits only if it is executed well and is adhered to for a reasonable length of time.

The methodology employed by the Mission was no doubt an important factor in the success of the Mission. The Mission proceeded with very clearly defined targets and procedures, emphasizing "listen and learn" behaviour as opposed to "show and tell". Equally important was the small size of the Mission and the success of the members in establishing very positive group dynamics in very short order, so that a team approach was effectively utilized. A by-product of the Mission is that three of the Mission members, for whom this was the first visit to Japan, were able to learn not only about how things are done in Japan, but more importantly, how they can do business in Japan.

To date, briefings on the Mission have been given to the Solid State Optoelectronics Consortium Technical Committee meeting on January 29, 1993 and to the Photonics Sector Campaign Industry Steering Committee meeting on February 17, 1993. It was intended to present the Mission findings at meetings in a number of cities across Canada with the private sector regarding the Sector Campaign have now been put on hold due to ISC budget cutbacks announced in January 1993.

7.0 ACKNOWLEDGEMENTS

The assistance of the Science and Technology Section of the Canadian Embassy in Tokyo, particularly, Ms. Noriko Abe and Mr. Gregory Rust, was invaluable in suggesting possible visits, in making the necessary appointments, in arranging for interpreters and in making the travel arrangements was invaluable to the success of the Mission. The provision of an Embassy mini-bus for some of the visits facilitated group discussions prior to and following the visits.

Travel expenses for four of the Mission members were provided by the Japan Science and Technology Fund. The assistance of Ms. Peggy Tsang of the Japan Relations Division of External Affairs and International Trade Canada in arranging the funding and in looking after liaison with the Canadian Embassy is greatly appreciated.

The cooperation of TRLabs and of the National Research Council's Industrial Materials Institute and the Institute for Microstructural Sciences in making their key staff available for the Mission is gratefully acknowledged. The contributions of Drs. Cielo, MacDonald and Normandin were invaluable to the success of the Mission. They contributed their insight and experience during the Mission, made valuable contributions to the this report and prepared most of the technical visit reports.

ANNEX A

MISSION ITINERARY

Photonics Study Mission to Japan
November 9 - 20, 1992
Itinerary

Monday, November 9

0830 - 1330	Embassy briefing
1400 - 1630	Optoelectronic Industry and Technology Development Association (OITDA) (Tokyo)

Tuesday, November 10

0930 - 1200	Optoelectronics Technology Research Laboratory (Tsukuba)
1400 - 1600	NEC Tsukuba Research Laboratories (Tsukuba)

Wednesday, November 11

0930 - 1300	Sumitomo Electric, Optoelectronics R&D Laboratories (Yokohama)
1430 - 1630	Sumita Optical Glass (Tokyo)

Thursday, November 12

0930 - 1130	NTT Atsugi R&D Center (Atsugi)
1430 - 1630	Sony Corporation (Tokyo)

Friday, November 13

1000 - 1330	Opt'92 Hyogo, Japan (Kobe)
1430 - 1700	Sumitomo Metal Industries (Amagasaki)

Monday, November 16

0900 - 1400	Matsushita Electric Industrial, Central Research Laboratory (Osaka)

1500 - 1700	New IBIS (Interactive Basic Information System Development Corporation) (Osaka)

Tuesday, November 17

0930 - 1315	Mitsubishi Electric, Central Research Laboratory (Amagasaki)
1530 - 1730	Sanyo Electric Semiconductor R&D Laboratory (Osaka)

Wednesday, November 18

0915 - 1130	Hamamatsu Photonics (Hamamatsu)
1530 - 1730	Santec Corporation (Komaki)

Thursday, November 19

0930 - 1230	Nippon Sheet Glass, Tsukuba Laboratories (Tsukuba)
1500 - 1700	Seikoh Giken (Matsudo)

Friday, November 20

1000 - 1300	NEC Otsuki Plant (Otsuki)
1530 - 1700	Embassy Debriefing

ANNEX B

MISSION OBJECTIVES

AND

MISSION MEMBERS

CANADIAN PHOTONICS MISSION TO JAPAN
November 9 - 20, 1992

MISSION OBJECTIVES

In February 1992, Industry, Science and Technology Canada, the Ministry responsible for the development of industry in Canada, approved the Photonics Sector Campaign to improve Canadian capability in photonics, with the major objective of producing a joint industry-government Action Plan. An Industry Steering Committee comprised of senior industry executives is overseeing the development of the Sector Campaign.

The current mission is the first part of a global assessment of technology, application and markets to be undertaken under the campaign. The mission, comprised of experts with close links to Canadian industry, is visiting leading companies and organizations in the use of photonics in telecommunications, industrial, avionics and other promising applications.

MISSION MEMBERS

Dr. Akira Watanabe, Consultant, Photonics Sector Campaign, Industry, Science and Technology Canada. Mission Leader. He has a background in photonics and telecommunications dating from 1970, when he managed the Optical Communications Research Program at the Communications Research Centre. He has also carried out business studies of the telecommunications industry and related sectors.

Mr. John Deacon, Manager, Photonics Sector Campaign, Industry Science and Technology Canada. He has overall responsibility for developing the Photonics Sector Campaign, and has experience in working with industry in a number of related areas, such as information technology, intelligent buildings, remote sensing and environmental technology.

Dr. Paolo Cielo, Program Leader, Optical Inspection, Industrial Materials Institute the National Research Council of Canada. He is an expert in optical sensors for industrial control in the materials processing industry and in optical technology, e.g. laser systems, fiber optics and spectroscopy. IMI performs R&D on materials processing.

Dr. Ian MacDonald, Director, Photonics, TRLabs. His technical interests centre on photonic interconnect, switching and broadband signal processing, and on optical sensing. TRLabs, a non-profit consortium of industry, university and government, conducts applied research in telecommunications, focusing on photonics, wireless and telecommunications networks and systems technologies.

Dr. Richard Normandin, Group Leader, Optoelectronics Devices Group, Institute for Microstructural Sciences of the National Research Council of Canada. IMS undertakes research in semiconductor device and optoelectronic integrated circuits. He is also the Manager of the research program of the Solid State Optoelectronics Consortium.

ANNEX C

QUESTIONS POSED DURING VISITS

QUESTIONS POSED DURING VISITS

Listed below are typical questions that were posed to our hosts during the mission visits. These questions were used for starters, and were modified as we proceeded, depending on they way in which the discussions developed.

Optoelectronics Industry and Technology Development Association

1. When was OITDA formed, what was the reason for setting it up, who provided the impetus, and what role did the government/MITI play?

2. What is your current membership? What is the difference between a full member and a supporting member? How do governments and university people participate?

3. What are the priority areas that you are looking at currently? How are these areas chosen, how are the studies conducted and how does the private sector use the results of these studies? How are feasibility studies managed?

4. In your opinion, have photonics developments in Japan been spurred by the producers or the users of photonics technology and equipment?

5. What have been your biggest successes and failures? What have you learned from your failures?

Optoelectronics Technology Research Laboratory

1. Relationship with members: How do members participate, how do they benefit, how do you treat intellectual property?

2. The technical program: what are you doing, why, who decides on priority?

3. Operation: how well does the current system work, what is the relationship with users, what would you do differently? How many staff do you have, what are your research and personnel costs?

4. Future directions: what are the future priorities (technology, applications and markets for OTRL? What will happen after the end of the stated life of OTRL - to the facility, to the intellectual property, etc.?

5. Successes and failures: what have been your most notable successes and failures? What have you learned from them and what would you do differently?

Nippon Telegraph and Telephone Corporation

1. In view of the fact that you are not a manufacturer, why do you continue to do R&D at such a high level? Why don't you get equipment manufacturers to do more of the development work? Who are your major shareholders and what do your shareholders say about this situation?

2. How do you select major research directions? Where are you going in photonics? What are the opportunities/obstacles? With privatization, has there been a shift in the balance between R and D?

3. What is the relationship between NTT and MITI and its various agencies and mechanisms, such as OTRL, the Japan Key Technology Center, national projects, OITDA, etc.?

4. How is your R&D structure organized? What are the roles of the various laboratories? How many people are involved in photonics R&D?

5. How are your plans for FTTH proceeding? What caused the delay from your stated plans? What about complementary technologies, such as wireless?

6. What about the introduction of new services e.g. entertainment, software?

Large Manufacturing Companies

1. How are the major technical decisions made in your company? How does this particular unit fit within the corporate structure, and how do your planning decisions meld with corporate decisions? How do you coordinate with your sister companies?

2. Who are your major customers? How do they influence technical decisions? How are market needs taken into account in the planning process?

3. What influence does MITI have on your long-term vision? What do you think of MITI initiatives, such as OTRL, OMTEC, TERATEC, etc. and how do you interact with them? What benefit do you derive from participation in such projects?

4. What are your priorities for the 21st Century? Where do you see major growth areas for photonics markets? What are the major obstacles/what needs to be invented for these applications to proceed?

5. Which is the greatest priority - devices and components, equipment and subsystems, total systems?

6. What do you think of the ....(e.g. optical switch)......?

Small Manufacturing Companies

1. How did your company get started? When did you get into your present product line? What future areas are you looking at?

2. What support did you get from the government? What support do you get now? What do you think of the OITDA?

3. What connections do you have with larger companies, with other small and medium-sized companies? Do you belong to any consortia? How do you benefit?

4. Do you have any foreign connections?

5. How do you overcome your working capital requirements?

6. Who/where are your main markets/customers/applications? How do you get market information?

7. What is the level of your R&D in relation to your total revenues?

8. How much work do you subcontract out?

ANNEX D

INDIVIDUAL VISIT REPORTS

BRIEFING AT CANADIAN EMBASSY TOKYO

Monday, November 9, 1992
Report prepared by A. Watanabe

Briefing by Gregory Rust, Science and Technology Office, Canadian Embassy

Presentations by

Shoji Watanabe, Assistant Chief, Technological Section, National Research and Development Program Office, Agency of Industrial Science and Technology, Ministry of International Trade and Industry

Dr. Hajime Okumura, National Research and Development Program Office, AIST, MITI

Dr. Kunio Tada, Professor, Dept. of Electronic Engineering, University of Tokyo

Introduction

The Embassy staff briefed the Mission on the program of visits, and provided an overview of roles of the government, industry and universities in Japan and how they inter-relate. More detailed presentations followed by the two MITI staff on MITI programs and by Prof. Tada on his own research activities, as well as on a particular program were there is strong interaction between the private sector and universities on a government/industry jointly funded project.

MITI Programs

Dr. Okumura and Mr. Watanabe gave an overview of MITI programs. In the past, MITI supported large national projects. Now there are pressures to put more emphasis on basic research rather than on application. The role of MITI is changing because the capability of Japanese industry has changed dramatically over the past several decades. In the past, Japanese industry was trying to catch up with the rest of the world, so that the government's role in introducing new technology into Japan was very important. Now, however, Japanese industry is among the world's leaders, particularly in high technology areas. They are also finding it increasingly difficult to purchase technology from abroad. There is criticism that research in the past focused too heavily on things that can be seen, i.e. hardware, rather than on ideas. Hence the increased emphasis on basic research to create rather than to adopt, improve and commercialize.

Government laboratories, such as MITI's Electrotechnical Laboratories, are gradually reducing in size. There is also a trend to more joint research with the private sector.

MITI's photonics-related projects have been carried out under a variety of programs, for example:

- Optical Measurement and Control System (1979-1985, ¥15.7 billion), carried out under the National Research and Development Program (Large-Scale Projects);

- Non-linear photonics materials (1989-1998, ¥523 million), under the Research and Development Program on basic Technologies for Future Industries (JISEDAI Program).

The Japan Key Technology Center

In addition to programs under MITI's supervision directly there are a number of photonics related initiatives carried out under the Japan Key Technology Center. Created in 1985 using dividends from government-owned shares of NTT and the Japan Tobacco Inc., contributions from government financial institutions and funds from the Japan Development Bank (a MITI organism) and from the private sector, the Center (Japan Key-TEC) is under the joint supervision of MITI and the Ministry of Posts and Telecommunications. A total of ¥18 billion was received from these sources in 1985, and an additional ¥21.7 billion in 1986.

Japan Key-TEC provides low interest loans for a maximum period of five years or subsidies for a maximum duration of seven years on a repayable basis for collaborative projects that are somewhat closer to commercialization than is the case for MITI directly funded projects. The Center funds up to 70% of costs for eligible projects in which two or more companies are collaborating. In practice, Japan Key-TEC has invested in a number of R&D corporations that have been established on a joint venture basis by several companies.

The Optoelectronics Technology Research Corporation, whose laboratory in Tsukuba was visited by the Mission (see visit report below), is one of the projects funded by the Center. Another project is the ATR Optical and Radio Communications Research Laboratories and the Interactive basic Information System (IBIS), which received ¥4.8 billion between 1986 and 1990 (see visit report below).

Dr. Tada described two other projects supported by the Center. The first, the Optical Measurement Technology Development Co. Ltd. (OMTEC), is a cooperative research joint venture of five measuring instrument manufacturing companies, Yokogawa Electric, Advantest, Ando Electric, Anritsu and Iwatsu Electric. The project duration was from 1986 to 1992 and the total funding was ¥4.3 billion, of which 70% was provided by the Key Technology Center. It was succeeded by TERATEC, which is developing high-speed electro-optic sampling devices. The duration of this project is from 1992 to 2001 and total project funding is ¥7.5 billion. Along with the Key Technology Center's 70% contribution, other participants are Yokogawa with 14% and Advantest, Ando, Anritsu and Hewlett-Packard Japan with 4% each.

OMTEC's research was carried partly in its Central Laboratory in Tokyo and partly out on a distributed basis, subcontracting much of the work to universities and to government laboratories. According to Dr. Tada, this did not work out very satisfactorily. Yokogawa paid back all of the funding for OMTEC upon its resolution, and owns the Central Laboratory and presumably the intellectual property generated by OMTEC during its lifetime.

University Research

In Japan, university research appears to be under funded, with some exceptions, such as the Research Center for Advanced Science and Technology of the University of Tokyo. Officially, universities are forbidden by the Ministry of Education from receiving private sector funding. Unofficially, universities receive small contracts from a number of companies to provide equipment for graduate students, for travel, etc. Some companies, such as Hitachi, have set up their own foundations to support young university researchers to get around the Ministry of Education's rules.

Dr. Tada described a university photonics research project, the Ultrafast and Ultra-Parallel Optoelectronics Project (1991-1994, ¥200 million per year) funded by the Ministry of Education, Science and Culture under its program to fund Scientific Research on Priority Areas.

Documents Received

9-1 Research and Development Program on Basic Technologies for Future Industries (JISEDAI Program)

9-2 National Research and Development Program (Large-Scale Project) 1992

9-3 The Japan Key Technology Center

9-4 Investment & Loan Service Projects Promoted by the Japan Key Technology Center

9-5 Ultrafast and Ultra-Parallel Optoelectronics April 1991-March 1994. Interim Report, October 1992

9-6 Research Review No. 11, 1989-1991 and Research Review Supplement to No. 11, 1991-1992. Department of Electronic Engineering, Faculty of Engineering, the University of Tokyo

9-7 Optical Measurement Technology Development Co.

9-8 TERATEC

9-9 Science in Japan, Nature, Vol. 359, 15 October 1992

OPTOELECTRONIC INDUSTRY AND TECHNOLOGY DEVELOPMENT ASSOCIATION TOKYO

Monday, November 9, 1992
Report prepared by R. I. MacDonald

Discussions with:

Takuzo Sato, General Manager, Development Dept.

General

OITDA is a secretariat for the assembly of intelligence on the optoelectronics industry in Japan and the identification of opportunities for it. It is largely supported by its members. These include companies from a wide variety of industrial sectors including:

- Construction
- Pulp & Textile
- Chemical
- Glass & Ceramics
- Steel & Nonferrous metals
- Wire & Cable
- Heavy Equipment
- Engineering
- Electronics & Appliances
- Precision Instruments
- Commerce and Advertising
- General Manufacturing
- Banking

The major sponsor areas are electronics, precision machinery, chemistry. There are at present 240 member companies. This number is down from a high of 257 due to the economic slow down in Japan. Much of the withdrawal has been small and medium size steel companies.

Funding

The headquarters is operated by about 30 staff members, largely seconded from sponsor companies. The total annual budget of OITDA is 700-800M Yen (7-8 Million dollars). The financing of OITDA is difficult to figure out. The fees constitute the major source of funding: one unit of membership is 360,000 yen/year. The 11 founder companies pay 15 units each. Other major companies may pay 2 or 3 units. The major benefit of membership, both to manufacturers and consumers of optoelectronics, is information. The costs of membership are tax deductible, but there is no direct support from government for membership. Sponsorship seems to be considered a social duty by many of these companies. MITI supports the standards activity. The Association also receives contributions from bicycle racing associations. This support seems to be analogous to support from a Lottery in Canada.

Activity

There are 35 committees to conduct the overall activity. These fall into the general categories:

- Trends Research: Industry Technology
- Feasibility Studies
- System Development (50% bicycle races, 50% companies)
- Standards
- Specific technology surveys

Committee meetings are held three times per year. Committee members are from research staff of sponsors and universities. Committees are reconstituted yearly. There may be up to several meetings per month. Reports issued by committees are not available outside sponsor group. It is noteworthy that a large proportion of these committees are chaired by Professors from the Universities, or the staff of government labs like ETL. The "production scale survey" has been produced yearly for the past ten years. These data on the optoelectronic industry are collected only by OITDA. MITI does not collect this information. Feasibility studies are carried out on about four themes every year to explore the possibilities for optoelectronic technologies. Subjects are selected from proposals and requests from members. The secretariat makes a preliminary selection, then a committee makes a final choice. This year surveys were carried out on "Overseas Optoelectronic Systems", "Optical LANs for Marine Environment Measurement", "High Sensitivity, High Resolution Optical Measurement Technology".

The Systems Development activity is unusual in that it consists partly of international projects which lead to the donation of results to other countries. The aim is to promote optoelectronic technology both in and outside Japan. There is operational support for this activity from MITI but not from the foreign ministry. Systems supplied are not competitive with commercial offerings from Japanese companies.

Examples of this activity include:

- a rural optical transmission system for India
- a fibre trunk for Hungary

The first year of an activity is feasibility study. Then two years work is carried out by consignment to a member company. An assessment is the carried out by committee. The development department of OITDA is staffed with seconded personnel from private companies. The work on these projects is consigned to sponsor companies.

Communications systems were developed successfully for several EXPOs (i.e. regional fairs) with budgets of several billion Yen ($10 M). These were commissioned from OITDA by the EXPOs.

About 70 draft JIS Standards based on proposals from OITDA have been done. OITDA also participates in the Japanese National Committees of IEC and ISO. In addition to these activities, OITDA operates a Laser School to promote laser equipment safety standards and ensure the safety of operators. It is working toward formal recognition of its laser equipment operator's licence, and has requested MITI approval for this similar to pollution-prevention managers' licences.

OITDA publishes books, and holds seminars. It also sponsors symposia, notably the large exhibition InterOpto. This exhibition is the flagship activity, receiving 100,000 people in 4 days.

History

OITDA grew out of the MITI "Large scale project" entitled "Optical Measurement and Control System (OMCS)". This was started in 1979 to run for 8 years, and funded with 15B Yen ($150M). OITDA was formed in 1980 to monitor this project. (Such a procedure is apparently common - see the Hamamatsu report.) OITDA shared accommodation with the OMCS project and its successor until this year. The OMCS project was a demonstration of a total sensor system for instrumenting a petroleum complex. MITI had gathered money from large petroleum refining companies to put into R&D. Demonstrations budgets were difficult to get so MITI provided budget. OITDA provided carry-on and promotion activities.

Future activities

- Activities under Overseas Development Agency budgets may decrease in future because it is anticipated that bicycle racing revenues may drop. Some of these projects have led to systems donated to Southeast Asian nations which are not being fully utilised, but overall there have been more successes than failures.

- Optical communications/ optical info processing technology remains the major activity of OITDA. More detailed research will be carried out on applications of optical interconnection this year.

- Next year's work will centre on information technology-related areas.

- Optical interconnect, optical neural computing and similar. This relates to the Real World Computing MITI project, which contains an optoelectronic component. Joint research labs are now set up in Tsukuba.

- Entertainment video seems beginning of a new industry in the sense that the ratio of investment in hardware/software (i.e. programmes) should be about 1 to 5. If programming standards (such as HDTV) are accepted worldwide Japan may be able to generate a video content industry as it has begun to dominate the computer game industry.

Comment

The OITDA obviously carries out a useful function, given that the Japanese optoelectronics industry is very large and requires some agency to keep track of it for the general good. The costs of membership are moderate - about $3K to $10K for a small company, but it is impressive that such a wide variety of firms wish to keep informed in this area. Based on population, a Canadian equivalent to OITDA would have a membership of 45 companies!

Technology study

Committees run by researchers are obviously useful in establishing a national vision of the general direction in which industry should go. We lack such a national vision in Canada. It is unlikely that individual companies can generate such a vision, since their primary activities are very short term. OITDA brings the views of industrial, government and other researchers into high prominence, and provides the possibility of letting research influence industry, rather than the other way around. MITI also operates in this realm, through the key technology centres. The down side is the danger, which one could sense in OITDA, of degenerating into a mere bureaucracy.

Documents Received

9-2-1	The Optoelectronics Industry and Technology Development Association
9-2-2	OITDA Activity Report Vol. 4 For Fiscal Year Ended March 31, 1991
9-2-3	OITDA Activity Report Vol. 5 For Fiscal Year Ended March 31, 1992

OPTOELECTRONICS TECHNOLOGY RESEARCH LABORATORY TSUKUBA

Tuesday, November 10, 1992
Prepared by R. Normandin

Present from OTL

Dr. Yoshifumi Katayama, Research Director
Dr. Izuo Hayashi, Advisor to Director

Introduction

Unlike many of the very applied outlook of semiconductor research in Japan the mission of OTL is to focus on the materials technologies needed for the future demands of information processing optoelectronics at a basic research level. The main research activities are dealing with atomic scale controlled epitaxy, beam assisted pattern formation, characterisation of surface and interfaces down to atomic scale properties and quantum solid state physics.

Rationale

From funding by the Japan Key Technology Center (Key-TEC) set up by MITI and 13 industrial participants a budget of 10B Yen has been secured for the 1986-95 period. Approximately 30% is from the industrial participants. The concept is not quite new as can be seen in document 10-2 about a precursor to OTL the "Collaborative Semiconductor Research Joint Laboratory" from MITI that was in effect a much larger effort.

General comments from the meeting

Staff is presently composed of 20 scientists coming from the member companies and 4 employed directly by the OTL. These are basically students from U.S. (MIT), Mexico, from the University of Tokyo and the Institute for Molecular Sciences. There are also a few secretarial and administrative positions. These are few as can be seen by the OTL glossy. In general there are no technical assistants. The buildings are rented and most of the equipment will either be bought by the member companies or donated to universities at the end of the programme. The hope of a continuation of the activities was expressed, however.

Research is of a very basic nature and there are presently efforts in finding suitable subjects to continue, much like the procedure followed by the OMTEC to TERATEC metamorphosis. Plans to form another organisation with a similar mandate are being presently formulated but it is obvious that a certain degree of insecurity exist presently at the management level due to the uncertain economic times. A simple promise of continued support past the 1995 deadline would be welcome at this time. This is viewed to be particularly relevant for an organisation dealing with long term research goals. This is also why OTL will tend to hire young scientists for a period of 3+1 years instead of the more usual, in Japan, 2+1 year in order to get time to fully exploit the research base and provide continuity to the programme.

Interactions with members

Not surprisingly there are some problems when dealing with member companies with a very applied and shorter term outlook. OTL finds it is difficult to get researchers from the member companies as they are unwilling to let go some of the best researchers to OTL for long periods of time. Training of particular individual at OTL is viewed well, however. Companies realise that it will be difficult to get good and timely information about new OTL developed technologies without a member scientist on site. This tends to help in striking a balance.

Also since the research at OTL is of a very basic nature companies find it difficult to perform and justify doing in-house. This can thus be used as a motivating factor to have some of their staff at OTL. As an example the demonstration at ETL of a new GaAs growth mechanism can lead to a quick transfer to a member company if they have staff working at ETL but it is understood that it may still take a long time before an application of the research in an actual device can be possible.

In general there is a good representation from the member companies compared to other consortia type organisations in Canada, the US and Europe.

Programme direction decision making and evaluations

Within the broad direction mandate from the initial set up directions of "material properties for optoelectronics" there is a good latitude for research directions within OTL. This was initiated after a three to four month negotiation with scientists from the member companies.

The aim is looking at future technologies for information processing. Therefore the emphasis is on GaAs instead of InP which is mainly for telecommunications purposes.

Progress reports are submitted twice a year to several committees composed from the members. There are three levels of such committees; management, scientific and technology. The committees therefore represent the views and interests of the members. It was noted that a few years back, at the "mid term evaluation" very frank criticism was mixed with good comments. From a mandate of providing a future vision, the application of OTL research results in a closer desire to ultimately apply the OTL research to device engineering was expressed by the members. The reality is that due to budget restrictions only basic research can be performed at OTL although it would indeed be nice to be able to pursue device application to member companies. There is a 30% of OTL programme that is performed at the member companies in theory but this tends to be difficult to control from OTL's point of view and this part of the research tends to be closely related to their individual in-house interests. There is little control of this "part time" internal member research by the OTL. From a unified programme point of view it would be better if all OTL related research was done in a central location. This looks more like a zero-cost option for OTL membership fees from the member's perspective. This centralised and non-centralised research organisation approach to research activities is thus "historical" in nature.

Intellectual Property Disposition

Patents are owned by OTL who pays for all the procedure. Companies have to pay OTL for access and exploitation but at a reduced rate compared to outsiders. All results are eventually published freely after patent procedures.

Benefits of membership to industrial partners

Most of the advantages to the members will be in the training of personnel, access to sophisticated characterisation and basic research resources and materials property knowledge. For example in document 10-3 the UHV processing of nanostructures and epitaxial growth techniques understanding developed at OTL can be of critical nature to several members involved in related subjects for device purpose. This is also true of the III-V growth on silicon.

Since OTL is much smaller than most of its members in optoelectronics research terms, what OTL can achieve for its members have to be weighted carefully. OTL has to look at future directions, concepts and proof-of-concept demonstrations at the basic material level. There is a typical ratio in optoelectronic effort of 200 times between OTL and a typical member optoelectronics labs (ie 1500 time for all members taken together). Considering that OTL is extremely well equipped from my perspective as there are more CBE, MBE and E-beams in one room as the whole of Canada put together, this ratio is impressive in terms of member company effort.

Plans for the near future

Despite the winding down in 95, plans for the next four years include the feasibility of some of the developed projects as presented in document 10-3, the understanding and possible applications of controlled epitaxy applied to nanostructures and the further development of the III-V on silicon work.

Collaborations with universities and outside organizations

No real collaboration with universities. They would like to accept more student, however. Similarly they would invite collaborations with foreign companies if possible. Since OTL is in control of intellectual right they can easily sign-on agreements with visitors. Some practical facts limit more outside interactions, such as the visitor's financial support, field suitability and ability to speak Japanese fluently. There are several meetings internally to discuss research (in Japanese) and visitors would be expected to participate fully.

What changes would help OTL

Since OTL is looking at long range and long term basic research the view that the MITI Key Tech funding is considered an investment makes it difficult to justify this approach. A "profit," even long term, is expected. Indeed under that type of funding the "loans" are repayable if profit is derived from the exercise. This is, of course, near impossible with the OTL mandate that cannot be fully linked to be sensitive to short term "real world" issues.

Laboratories tour

As previously mentioned the OTL is extremely well equipped by Canadian standards if not by a Japanese one. Results were discussed freely in group or individually with much candour. They are up to date and of high quality. A full range is presented in document 10-1. Of note is the development of a sequential growth technique within situ glancing incidence REED and simultaneous imaging by secondary electron emission in a CBE environment. Second harmonic surface generation growth monitoring. Nanostructure epitaxy with integrated patterning, cleaning and monitoring, STEM visualisation of MQW and surfaces and the GaAs on silicon with Si-Ge monolayer control of dislocations were also highlighted.

Equipment costs are kept under control by a close interaction with companies. There are several small UHV companies able to provide the various components of the huge systems assembled by the OTL. They get price breaks and flexible terms. Data is fed back to the companies as to the performance of the system.

Conclusion

Emphasis is on epitaxy at a basic material and interface understanding level. Hope is for a continuation of the programme. Well equipped facility turning out excellent quality research. The outlook is not what is found in typical Canadian universities however as there is a programme sensitivity to members as opposed to individual activities with industry and a well defined focus of research. Programme direction is by several committees at the managerial, scientific and technical level by the members.

Documents Received

10-1 Basic Technologies for Future Optoelectronic Integrated Circuits, OTL-RL-V4, p. 508

10-2 Collaborative Semiconductor Research in Japan, Proc. IEEE, 77, 9, 1430 (1989)

10-3 Technology for Crystal Control on the Atomic Scale, Report and summary sheet

10-4 Characterisation of Oxidised GaAs(001) Surfaces Using Temperature Programmes Desorption and X-Ray Photoelectron Spectroscopy, Jpn. J. Appl. Phys. 31, 721 (1992)

10-5 Effects of atomic Hydrogen on GaAs(001) Surface Oxide Studied by Temperature Programmed Desorption, Jpn. J. Phys. 31, 1157 (1992)

NEC OPTO-ELECTRONICS RESEARCH LABORATORIES
TSUKUBA

Tuesday, November 10, 1992
Report prepared by R. I. MacDonald

Discussions with:

I. Mito - Senior Manager, Optoelectronic Device Research Laboratory
K. Asakawa - Senior Manager, Optoelectronics Basic Research Laboratory

General

NEC has 38,000 employees overall. The company's goal is "C and C" which means "integration of communications and computers". There are 1800 researchers in the R&D division, which has a budget of 1% of total sales. (This is a remarkably small percentage for Japan!) The optical devices lab has 150 researchers overall (10% of research staff). There are four divisions - 2 in Tsukuba (materials and devices for optical equipment, and basic research), and 2 in Kawasaki (systems research, and equipment development).

Overview

Optoelectronics Basic Research activities:

- MBE microfabrication
- VSTEP devices
- nonlinear phenomena in fibre
- micro-cavity lasers
- synchrotron sources for lithography

Optoelectronic Device Research activities:

- InGaAs LD
- MQW lasers
- detectors
- tunable lasers
- 0.98 micron pumping diode for Er amplifiers
- various detectors, InGaAsP/IP photodiodes, apd's etc.
- Photonic Integrated Circuit
- Tunable LD array for WDM
- Optical switching: AlGaAs Electro Optic Directional Coupler switch matrix Visible and short wavelength ld for optical disc writing
- Optoelectronic Equipment Research Activities (K. Kubota)
- Optical disc head
- excimer lasers
- Lithography for LSI using excimer
- Projectors using Liquid crystal display
- Optoelectronics Systems Activities (Namiki)
- High Speed direct detection (including equalisation)
- Optical Amplifiers
- coherent transmission
- Subscriber loop
- LiNbO3 Matrix switch
- Optical FDM

Optoelectronic Device Laboratory

Dr. Mito spoke on activities of the Optoelectronic Device Laboratory:

Coherent Optical Transmission

- Phase shifted DFB-Directional Coupler-Planar Buried Heterostructure-LD using MQW is under development as a narrow-line laser array (250 kHz linewidth) for coherent WDM. Output power of 30 mW and 27mA threshold have been achieved in a device for operation at a wavelength of 1500 nm. Fibre coupling efficiency is 50%.

- A frequency stabilised transmitter has been built with these devices. It has <1 GHz frequency shift from 10C to 50C, 7 GHz modulation bandwidth for 20 mW output.

- An integrated dual-pin diode balanced receiver has been produced for coherent systems, and a 2.488 Gb/s coherent transmission system using fibre amplifiers has been developed. The problem is to find a requirement for such a system and to establish the reliability of the coherent characteristics.

- The reliability of the overall system has been investigated, and 100,000 hours lifetime has been demonstrated. The laser spectral linewidth increases with driving current (The criterion of failure was 100% linewidth increase, corresponding to a 20% drive current increase). Wavelength drift was due to temperature increase with current increase and was small. Tunability is around 300 MHz/mA.

Optical Fibre Amplifiers

- High power long wavelength laser diodes have been produced, emitting over 300 mW CW at 1.48 micron, and over 400 mW at 1.3 micron. Lifetime of $2x10^6$ hours at 100 mW has been demonstrated. Bidirectionally pumped Er fibre amp with four diodes (two each direction with and Polarisation Beam Splitter combiner)has demonstrated +22.3 dBm output with 200-400 mW launched, corresponding to gain about 18 dB.

- Amplifiers pumped at 0.98 micron by a diode with a DQW-SCH strained quantum well structure have been build and 550 mW output power obtained. The amplifier has demonstrated reliability of 7000 house at 100 mW. Pumped at over 500 mA.

- An Er doped fibre preamp using 0.98 micron pump has led to receiver with -37 dBm sensitivity at 10 GB/s, and -45 dBm at 2.5 GB/s.

Optical Disc Lasers

- A 30mW 690 nm LD for optical disk systems developed. It has a 50 to 100 mA threshold. It uses GaInP/AlGaInP strained QW active layer structure.

- A short wavelength visible LD at 632.7 nm, with 2 mW output has been developed. Wavelength Division Multiplex.

- Arrays of tunable MQW laser diodes have been made. Each laser has a phase control region, DBR region, modulator, and couplers for WDM applications. NEC have demonstrated 5, 10 and 20 A spacing for WDM multiplexers.

Semiconductor Photonic Integrated Circuit (SPIC)

This device combines detection and light emission in the same epitaxial structure. It uses 5-step selective epitaxy with SiO2 mask. This idea comes from the Optical Technology Lab, and is a possible example of technology transferred from this lab. Control of bandgap is obtained by controlling width of ridge during diffusion of In the epitaxial process. Epitaxial growth of laser and modulator material on the same substrate has been demonstrated. Selective MOVPE using this technique to control thickness of QW in order to integrate sources and modulators. Modulators grown this way are demonstrated capable of 5 mW throughput, extinction ratio 7 dB at 2 V, modulation bandwidth 4 GHz.

Optical Basic Research Laboratory

Dr. Asakawa spoke on activities of the Optical Basic Research Lab. This lab has About 30 researchers in 6 groups as follows:

- Quantum Physics
- Optical Functional Devices
- Ultrafine Epi Growth
- Micro/Nano fab
- Photo-assisted Processing (using synchrotron radiation, apparently)
- Quantum Physics group: Ultrafast (100 Gb/s- 1 THz), low power devices Chi3 (Kerr) nonlinear devices, microcavity lasers
- High Speed All-Optical Time Division Multiplexing

All optical mux-demux under study using passive multiplexing and an optical switch network for demux. Aim is 12 Gb/s. Optical drive of optical switches is under study: Mach-Zehnder switches are fed with optical pulses whose phase in one branch is shifted by a nonlinear optical device placed before the MZ device. 80 ps has been obtained with 250 mW switching pulses (20 ps achieved recently).

Microcavity Lasers

Thresholdless microcavity lasers are being studied, with cavity length similar to wavelength. For some reason the devices being studied are made with dye solution sandwiched between dielectric mirrors, optically pumped at 2400 A. These are used as models for the ultimate semiconductor devices.

11.4% power efficiency achieved with low threshold vertical microcavity lasers (output power/ electrical input power). 99.8% reflectance was required in the mirrors. High precision MBE is required for surface emitting devices to do the periodic doping for vertical structures. Dry etching for OEIC, EB-excited etching. They have a RIBE machine integrated with an EB etch machine. Vertical smooth etching being developed for InP materials using Cl2 as etching gas. STM evaluation of surface roughness better than 10 nm. Dry etching applied to form microcavity laser columns.

Intelligent Optical Signal Processing

The VSTEP device is being used for optical self routing. A flip-chip bonded laser array on Si waveguide substrate is used (no details given). Optical switch and memory functions are sought as well as source and detector by means of the bistability of the VSTEP emitter (This is a sort of thyristor whose threshold voltage is controlled by optical input). The device is configured with substrate emission, fabricated in GaAlAs.

General Questions

1. There was discussion of the details of numbers of staff in the various laboratories of the Optical research group.

   There are 40 people in the Kawasaki systems laboratory. Display devices are no longer part of the optoelectronics lab activity. Equipment and systems work is at Kawasaki, and there is a new lab in Kansai on very high speed electrical devices and optoelectronic devices, based on compound semiconductors. The Ibaraki lab was established to look at very basic technologies. It was felt that Kawasaki has developed a very narrow focus.

2. We asked about interaction with Optoelectronic Technology Lab, of which NEC is a member.

   Formally OTL would develop new technologies and the company would apply these. Actually this does not happen. Collaboration occurs on dry etching techniques. Work is rather independently carried out, and discussed every few months - collaboration is not the basis of the connection. OTL has been asked to perform characterisations, analysis, etc. OTL connection considered successful, but not perfect.

3. We asked about university connections.

   There is no ongoing collaboration. Formally donations are given to professors in exchange for new results from universities. This connection did not seem to have very high priority.

4. What is the future of photonics?

   The field of application is narrow, unlike previous expectations. This is because of the intrinsic properties of optical systems and also the immature state of fabrication technologies. Some years ago OEIC's were promising, but this is no longer true. Until now the LD, detector and modulator switch were the only devices, but in future, optical functional devices for massively parallel computational systems will be important. MITI is instituting an optical computing project which is promising. In 5 or 10 years there will be developed microfabrication technologies for small devices (Quantum wire or dot) these may bring new applications.

5. Are there applications in other fields such as transportation, fabrication, or are they only in the information technologies?

   Two applications were raised-optical subscriber loop and optical disk. Very sophisticated technology is required for these. Integrated circuits will be important for optical subscriber loop. Fibre to home will come for the high bandwidth, and integrated optical devices such as optical fdm systems will be necessary. Packaging is really the most difficult problem - it is avoided by integration: the highly sophisticated integrated devices are actually the simplest in use.

   The driver for wideband service to the home is entertainment: They mentioned the use of broadband FTTH for squirt-mode television. An optical/microwave delivery system for personal communications has recently been proposed internally at NEC as a new project.

6. What new device concepts are needed?

   Surface emitting devices are needed. Optical computing systems are very big, and will take long development to surpass Si components, but interconnections are possibly an important area. It is not interesting just to replace wires, but adding the optical routing function, and with self routing systems, such as ATM, may be interesting. To get 1000 channels and more requires 2-D interconnections in free space. Power consumption needs to be reduced and therefore we need low power devices. Hybrid packaging may be useful, but chip size needs to be less than 1 cm square, and so hybrid is an intermediate goal only. Trunk line markets have saturated, so device business is not growing.

7. Is Photonics a priority activity in NEC?

   C&C activities require it - very high priority, but actual production scale is small. Most transmission systems now use optical devices.

Documents Received

10-2-1 NEC Research and Development
10-2-2 NEC Tsukuba Research Laboratories

**SUMITOMO ELECTRIC INDUSTRIES, LTD.
YOKOHAMA WORKS**

Wednesday, November 11, 1993
Report prepared by P. Cielo

Discussions with:

Y. Ishibashi, Assistant Manager, Overseas Operations, International Business Division
Y. Saito, Manager, Planning and Adm., Fiber Optic Division
S. Suzuki, Manager, Communications R&D Department
Y. Asano, Manager, Optomechatronics R&D Department

Also present: K. Nishie, A. Fukuda, G. Sasaki and T. Okamoto

General company information

Sumitomo Electric has a total staff of 15,000 (average age 36), established since 1911. Comprises 70 organisations in 6 locations.

Total sales nearly 800B Yen. Nearly 50% of their products are in the production of wire and cable, which is their original business. Gradually they have expanded to other fields which are related to the original one more in terms of technological basic similarity than in terms of similar user market: sintered alloy products, special steel strands, antilock brake systems, optical sensors etc.

Their official R&D department has a budget of 3.2% of the sales, but it is estimated that the total R&D effort including the work performed in each separate division is of the order of 10%.

The total effort spent in photonics-related activities (mainly in the Yokohama Works location) was estimated to be 10% of the total activities, and this field has experienced steady growth in this company. This appears to be related to the search for new, more profitable systems products as the wire and cable business tends to saturate.

Description of Sumitomo optoelectronics products

Optical links and LAN. Mr. Fukuda described a number of recent commercial developments:

- An Interactive Basic Information System (IBIS) has been developed by a joint venture (a separate IBIS corporation) with Fujitsu, Matsushita and the Osaka City, with some government help which was estimated as 20% of the total investment. This is based on a star architecture operating at 143.2 Mbps, with fiber links (one multimode fiber per subscriber), WDM, 20 video inputs and 80 data inputs, over a 2.5 km span.

- Optical Network for CATV: the main motivations are to provide superior CATV transmission, cost reductions and increased performance. They are working on 10 Km range, 8 dB loss, 60 TV channels.

- CATV-LAN: development of SUMINET 5600 (400 Mbps), 5710 (1.2 Gbps, 12 video and 24 audio channels) and 5720 (2.4 Gbps), using single-mode fibers, 1310 or 1550 nm emitters.

Fiber optic sensors

Mr. Okamoto described a distributed fiber optic temperature sensing system which was developed (with an input to date of nearly 10 person-years) for a variety of possible applications such as monitoring hot spots along high-power cables, transformers, fire detection in tunnels etc. The basic concept is to compare by OTDR (optical time-domain reflectometry) the back scattered Stokes and Anti-Stokes components whose relative intensity is related to the local temperature. This has been obtained over cable lengths of up to 3 Km, with a temperature resolution of nearly 1K over short ranges and 2K over longer ranges. A standard gradient-index 50-125 microns core-cladding fiber was used for these tests. The spatial resolution is about 5 m.

Optoelectronic Epitaxial devices

G. Sasaki described a few devices:

- 1.3-micron MQW Fabry-Perot laser diode, up to 8 mW, with thresholds as low as 7 mA, verified operation over 4000 hours without degradation;

- 1.48-micron strained-layer MQW laser, up to 312 mW with a 1.5 mm cavity length;

- 980 nm GaInP/GaInAs Sch-QW lasers useful for amplifiers;

- OEICs with 6 Ghz bandwidth, 62% yield.

Fully-automatic fusion splicing systems and related equipment

Y. Asano described several such systems: an automated splicer capable of splicing single-mode single or multiple fibers over periods of 3.5 minutes, with splice losses of the order of 0.05-0.1 dB, a carbon re-coating system increasing substantially the fracture strength of carbon-coated fibers after splicing, surveillance systems for automatic in-service testing.

Other systems were described such as transmitter/receiver modules, high-speed buses, overall quite state-of-the-art technology with a close relation with market needs.

Conclusion

This is an example of a large company having started mainly with manufacturing of components for telecommunications, which maintains its strength on this field but which is in the meantime diversifying its pool of products based on its technological expertise while assuming more and more a systems-oriented approach.

Documents Received:

11-1 Sumitomo Electric Annual Report
11-2 Sumitomo Electric Corporate Brochure
11-3 Yokohama Works brochure
11-4 Technical description of Optical Link and LAN
11-5 Technical descriptions of SumiThermo-100
11-6 Technical description of optoelectronic devices
11-7 Technical description of fusion splicing system
11-8 Technical description of Transmitter-Receiver
11-9 Technical description of single-mode fibers

SUMITA OPTICAL GLASS, INC. TOKYO

Wednesday, November 11, 1992
Report prepared by R. I. MacDonald

Discussions with

M. Sumita, President
S. Nagahama, Chief Engineer
T. Kinami, General Manager, Export Dept.
F. Maruyama, Research and Development Division

Presentation

The Sumita company was formed 40 years ago to make optical glass. Lenses and other optical business is now 60% of the activity, while, 30% is fibre optics, and 10% special glasses. The original company was actually founded 70 years ago to grind optical glass for military purposes. The new company dates from 1953, and was formed really to acquire a supplier of glass.

The company has a U.S. office with one person. There are 30 people in R&D, which has a budget 10% of sales. Sumita has connections to Tsukuba ETL as well as MITI Osaka lab, and some universities, but these are informal, personal connections only. R&D department has a visiting researcher from China.

A demonstration of their "Photo-Turkey" IR up-conversion card was given. The card operates by multi-photon absorption, to convert 900 and 1500 micron radiation to visible and requires no visible light excitation. It looks like a good product because of the convenience and the very good resolution, which shows focused spots clearly. (The demonstration card we saw was made by Mitsubishi under contract to Sumita).

It is noteworthy that the product was developed in house. After it was shown at Inter- Opto two years ago NTT showed interest. It was agreed that NTT would buy if a target power sensitivity of 0.1 watt could be achieved. This has not yet been achieved but NTT continues to encourage the company. Questioning did not reveal any sources of revenue other than Sumita itself for the development of this product. There is no government presence and apparently only cordial relations with NTT.

We were also shown high intensity UV light units with fibre bundle delivery optics, intended for curing epoxy and similar applications, and an inexpensive fibrescope intended for throw-away medical usage. Other optoelectronics-related activity is the development of preforms for moulded glass lenses, with Matsushita.

Questions

1. How does government help with relationships with big companies?

   Some Sumita staff have spent time researching at the MITI Osaka industrial research institute. The purpose seems to have been primarily training.

2. Do you get assistance to set up plants?

   No.

3. What are the new directions for the company?

   Recent work has concerned visible light. Future projects concern UV and IR fibres. Recently hollow glass fibre for IR (10 micron) has been developed for surgical applications. The fibre uses no metal reflector. (Hollow fibre using metal has been developed by Hitachi).

   Low-cost (disposable) fibrescopes are also a new area of business. The idea is disposable fibrescopes for surgery. Sumita has joined with a U.S. company to fabricate these, Sumita supplying only the fibre bundle. The U.S. company deals with certification.

There is no work in rare earth doped glass and in semiconductor doped glass. One gathers that they have a proprietary idea for double photon pumping.

4. Do you have problems getting working capital?

   No. This is a low growth company, and growth is based on capital raised by the company alone.

5. How do you generate new product ideas?

   Two ways: customer requirements for product development, and ideas for future products coming out of the Osaka industrial lab or other scientists.

Summary

This was an interesting visit in that it demonstrated the strong sense of independence both of the government and of big industry that a successful small company can feel in Japan. Sumita seem to see no need for grants, or for guaranteed business. They depend strongly on personal relations in business with colleagues in other companies.

Documents Received

11-2-1	New Glass and Fiber Optics Guide
11-2-2	MY-Scope Type II-S
11-2-3	New Efficient Infrared to Visible Upconverter: Photo Turkey - 1

NIPPON TELEGRAPH AND TELEPHONE CORPORATION NTT OPTO-ELECTRONICS LABORATORIES ATSUGI R&D CENTER

Thursday, November 12, 1992
Report prepared by R. Normandin

Contacts:

Dr. Mitsuru Naganuma, R&D Group Leader, Optoelectronics Labs.
Dr. Takashi Kurokawa, Senior Research Engineer and Supervisor Research Group Leader, Optoelectronics Lab.
Dr. Takayuki Sugeta, General Manager, Optoelectronics Technology Dept., Atsugi Division

Introduction

Nippon Telegraph and Telephone (NTT) is Japan's largest telecommunication company and second after ATT in the U.S. It has been converted to a private concern in 1986 after a monopoly position. It now has to compete with newcomers albeit from a dominance position on the Japanese market. Current profit outlook is not that great due in part from the separation of mobile telephone services. In any case this is a BIG company with 250k employees. They have 11 labs and 2 development centres.

The NTT Optoelectronics laboratory (12-3) is one of 13 division issued from the R&D development headquarters and is further divided as:

- research planning: research programmes, budget and coordination
- integrated optoelectronics: laser diodes, photodetectors, OEIC and OOIC.
- photonics functional devices: 2D devices, nonlinear devices and laser diode on silicon.
- photonic component: planar lightwave circuits, fiber amplifiers and connectors.
- photonic materials: fluoride glass fibers, and organic nonlinear materials.
- Fujimoto Research: advanced MBE growth.

These have about 240 researchers, most are engineers, physicist and chemist. Foreign workers are also welcome as summer students, visiting researchers and post doctoral fellows. Note that for a company that does not sell hardware or products this is an impressive R&D effort on devices. The 240 researchers involved in optoelectronics (4B Yen/year) are part of 3000 researchers broadly characterised to be in photonics.

Technical Presentation

Of note during the technical presentation of some of the highlight are:

- semiconductor devices: DFB and DBR lasers resulting in 10 Gbit/s and 100 nm tuning range DBR lasers (still in the R&D stage). Also DFB arrays of 8 to 10 channels, FD laser arrays for 5 channels at 2.8 Gbit/s and 0.98 μm lasers for fiber amplifier pumping.

- photodetectors: PIN diodes with >50 GHz response at 68% quantum efficiency and Si APL with 110 GHz bandwidth.

- optical amplifiers: MQW TWA which are polarisation independent and suitable for monolithic integration

- optical switching: based on LiNbO3 technology a 4X4 switch was demonstrated with 20 GHz response for a 5V drive.

- modulators: MQW semiconductors with 2V drive and 20 GHz response.

- monolithic integration of optics with electronics
  PIN diode with HEMT and FET with 10 Gbit/s on 1 channel or 2.8 Gbit/s on 5 channels.
  MQW gates with bistable lasers for memory and switching uses.
  CW lasers 1.5 μm and silicon substrates.

There is also work on lossless 4x4 switches. The 0 dB insertion loss is obtained by using laser diode amplifiers to compensate. A new type of Y branch was developed for this work. This work was from a request by the Systems Application division.

The PIN-HEMT OEIC demonstrated respectable performance at 1.3 μm on a InP substrate with BER of 10^{-9} at -19.8 dB. This is comparable to Bell's performance with a HBT OEIC. NTT does not think hybrid technology will be suitable for greater than 10 Gbit/s, thus they are pushing the OEIC approach despite increased manufacturing difficulties.

The interaction between the opto-electronics lab and other sections and labs at NTT is through request for specific device work. This is in addition to internal work.

Future implications for photonics

In the near future they expect an increased demand for visual (high bandwidth) information and image transmission, higher capacity and data rate networks and more network intelligence. However photonics will probably be relegated to simple transmit and receive functions and will not be part of the network intelligence. As for the impact of fiber to the home or fiber to the desk it would seem that right now NTT considers fiber optic systems as simple building blocks for that goal. B-ISDN is separated from that aspect. It would be installed only if cost effective and only in those areas such as central Tokyo. Only when B-ISDN is "grown up" would it make sense to introduce it to all regions. This is going beyond present services provided by NTT but NTT could consider this business area should the numbers warrant it.

Considering NTT is a private company how can this level of advanced device research be sustained? The present network was built 20 years ago and NTT has to take time to change it to a new systems and technology. It makes sense to consider building the network of the future immediately. This may imply taking photonic switching all the way down to trunk or even subscriber lines. (This seems an artificial and predictable answer for NTT).

Again, coming back to the initial question, how are the share holders reacting in view of these research costs at NTT for that type of research level? "We can probably survive!" was the answer. NTT has two stated objectives, to promote business for the network and promote R&D in Japan. Both these objectives are still valid even if NTT is a public company. It is important to note however that half the share holder is the government! The rest is sold on the open market with the employees holding the largest block of 1%. Therefore the government still has the control even after going "public".

Since they are required by law to provide services "freely" and they would like to be involved in CATV and other services they tend to develop the needed systems and components even if they cannot provide services. Indirectly NTT will get profits by creating or helping the creation of these services and systems anyway despite the regulations. The basic idea is to have as many people use the NTT network as possible even if this implies getting involved in the development of services they cannot provide directly.

Note also the large number (over 200 including 20 manufacturing concerns with a total of 4 to 5k employees) of NTT subsidiaries getting involved in manufacturing of all types. Since NTT cannot manufacture, sell devices or products the subsidiaries will do so based on NTT technologies. These products will then appear on the markets as part of systems which will use the NTT network. Many are fully owned by the NTT Advanced Technology Corp. (12-2). This is an interesting "back door" scenario. Again the net long term results strengthen Japanese R&D, manufacturing, research directions and NTT network traffic.

In terms of future services NTT is actively exploring options such as the visual network, satellite communications, school and video teaching with 10 to 15 km separation linked with fiber. Unless the customers provide the programming NTT has little interest per ci in bidirectional video.

Interactions

We were told that NTT is not involved in consortium efforts, OITDA or MITI directly (although they definitively have input on the Japanese R&D scene). They are privately in contact, however. In reality MITI and OITDA must take in consideration NTT's directions somehow, privately or otherwise. OITDA is viewed as an information storehouse.

Similarly there are no interactions with OTL as NTT does their own basic research involving MBE growth mechanisms. There is thus little point for NTT to get involved with OTL.

Lab visit

This consisted in an overview of some clean room and the usual support equipment and MBE growth. Research budget per scientist is comparable to twice what is typical in Canada. The video switching demonstration included a very small fiber amplifier package but the rest was standard fare. It was obviously set up for visitor and were did not see the many more setups shielded from view by curtains in the rest of the room.

Conclusion

NTT is extremely well equipped for OEIC research including their own X-ray lithography set up. Most research is state of the art although we were not shown truly outstanding novel or revolutionary subject. It is obvious that the mode of operation and importance of NTT in setting directions in communication policies and technologies for the NTT network in Japan is considerable but also intricate. This is true for the Advanced Technology Corporation, NTT subsidiaries as well as for involvement with smaller independent companies, universities and government agencies.

Documents Received

12-1 Overview NTT Electrical Communications Laboratories
12-2 Worldwide Technology Transfer, NTT Advanced Technology Corporation
12-3 NTT Optoelectronics Laboratories 1991 annual report
12-4 NTT Atsugi R&D Centre, Overview
12-5 Optical High Capacity Transmission systems

SONY CORPORATION TOKYO

Thursday, November 12, 1992
Report prepared by P. Cielo

Persons met:

T. Yamada, Corporate Director and Senior General Manager, R&D
R. Moriya, General Manager, R&D External Affairs
O. Matsuda, Deputy General Manager, Semiconductor lasers
O. Kawakubo, Ass't Mgr, Director's Project Office, Corporate Res. Labs
N. Kishii, Research Scientist, Molecular Materials Research Dept.

General Introduction

Mr. Yamada gave us an introduction to the company's orientation and research activities. Sony has nearly 120,000 employees, annual sales 3,000 B Yen. Sales have been increasing by nearly a factor of 2 over the last 4 years.

The company products include consumer products, non-consumer (mainly office systems) and, more seldom, components. They have recently expanded into movie-music software.

Their research activities correspond to nearly 7% of the sales, a relatively modest proportion for such an innovative company. The company has focused its R&D on rather short-term fields, so that basic R&D expenditures are limited. Optoelectronics-related R&D activities correspond to nearly 10% of the total.

The company has 3 layers of R&D institutes

1) the Applied Research Institutes, including the Corporate Research Center. The Corporate Research Labs and the Telecommunications and Information Labs, with a total of 700 employees;

2) the Development Groups, spanning the various Sony technologies such as Audio, Computer and Multi-media, ultra-large-scale integration and production technology; and

3) the Affiliated Institutes, limited entities including small independent labs (e.g. one headed by a retired Sony director) and overseas labs.

Discussion

R&D focus and relations with government granting organizations. Sony is highly product-oriented, so that it tends to stand alone and focus its R&D on market-driven technologies. It does not participate, e.g., to the Optoelectronics Technology Research Center which we have visited, and which is supported e.g. by Hitachi and Fujitsu. They seem to feel that too wide a range of research activities would be harmful to the company's requirements to focus on their specific products.

Influence of technology on corporate decisions

The company must have a deep knowledge of present and future technology in order to make big decisions. For example, when they decided in 1980 to go ahead with compact disks, they specified a 780 nm diode-laser even though this device was not yet fully developed, they had to gamble.

In-house development vs. buying technology, in particular concerning laser-diode devices: Laser diodes were developed at high costs and are now produced at only $2 a piece. Should they thus have purchased their laser diodes once developed, and incorporated them on the much more profitable total products? Mr. Yamada (himself a laser scientist when he was a development engineer) feels that such components are strategic for the company's products so that it is important for the company to develop and manufacture such devices in order to foresee future opportunities and to insure their availability. Obviously, such a decision depends on the company size.

Technological orientations

They have expanded into software. Should they also go into distribution? No, that would be too far. Do they consider more important compression or wide-band delivery? Both are important, but band compression is priority. They are doing more R&D on photonics related to information than to display. Why? They have advanced a lot on display technologies in the past, now they must catch up with information.

Technical Presentations

Dr. Matsuda (who has moved from R&D to production and back to R&D in the last 10 years) has given an overview of the laser-diode R&D activities and their strict relation with the company products, mainly the compact-disk players. They are now producing 3 million low-power AlGaAs lasers per month, mainly for their CD's. They also produce higher power lasers, up to 10W, which they sell directly in the components market waiting for internal applications such as microsoldering. They are also developing multi-beam lasers, 1- and 4-beam, also 100-laser arrays, for possible future applications such as printers. Dr. Kishii described their research program on photochemical hole burning, a field pioneered by the NRC scientist A. Szabo. This means recording photochemically 1000 times more bits on the same memory element by wavelength multiplexing thanks to the distinctness of the molecular absorption peaks at very low temperatures. They demonstrated 114 holes over a 272 cm^{-1} spectral band in TPP, TFP and TMP materials. The requirement for liquid-He temperatures limits, however, the applicability of this technique. This research program is funded by MITI.

We also had two lab tours, one given by junior workers on photolithography, the other on a conventional frequency-doubling experiment. The low level of such demonstrations may be due to confidentiality reasons. More probably, these people are simply too busy and do not expect much help from external organization to invest a lot on visitors.

Conclusion

This is a good example of a successful market-driven company. Their technological orientations, including photonics, are very much determined by product requirements.

Documents Received:

12-2-1	Sony Annual Report
12-2-2	Sony Corporate Research Laboratories
12-2-3	Sony Research Center

OPT '92 HYOGO JAPAN KOBE

Friday, November 13, 1992
Report prepared by A. Watanabe

Introduction

The Third International Conference and Exhibition on Optoelectronics (Opt'92 Hyogo Japan) is an annual conference and exhibition held at Kobe, organized by the Optoelectronics Industry and Technology Development Association (OITDA). The exhibition was included in the itinerary in the hope that Mission members could get a feel for what was happening in photonics among smaller Japanese companies. It would be a major understatement to say that the exhibition was disappointing. The conference, which we did not attend, was the focal point, and exhibition appeared to be almost an afterthought. There were some 50 exhibitors, ranging from the mega-companies, such as Matsushita, Fujitsu, Hitachi, NEC, Toshiba, Mitsubishi Electric, Sumitomo Electric, NTT, Sony, along with a number of start-up companies, service companies, etc.

Not only were the exhibits disappointing, but also the attendance was extremely small, no more than 100 people when we went through the hall. In some respects, the exhibition was revealing, for example, about the influence of the OITDA in the western (Kansai) region of Japan.

Among the more interesting smaller companies was one called Y&Y Corporation, whose Femtowave Division was exhibiting a rapid scanning interferometric auto-correlator for monitoring femtosecond pulses. This tiny company, which was started up recently by Dr. Akira Watanabe, a physics professor at the Okayama University of Science, was similar in some respects some Canadian companies.

Coincidentally, in the bottom floor of the two-story exhibition hall was a show which was far more interesting and revealing. It appeared to be a regionally focused equipment and components show. There were a large number of companies exhibiting a wide variety of goods, and this exhibit was so crowded that it made it difficult to move around. We were able to get a glimpse into some of the reasons why smaller Japanese companies are able to move quickly to produce and sell equipment so successfully in their local markets.

SUMITOMO METAL INDUSTRIES, LTD. AMAGASAKI

Friday, November 13, 1992
Report prepared by P. Cielo

Persons met:

Dr. T. Sakai, Ass't Gen. Mgr., Planning and Adm. Dept., Systems Engineering Division (SED)
Dr. Y. Tamura, Gen. Mgr., Instrumentation, SED
K. Hiramoto, Ass't Staff Mgr., Instrumentation Technology Section, Control Technology Dept., SED
T. Sakamoto, Section Mgr., Instrumentation Technology Section, Control Technology Dept., SED

Also present:

T. Honda, who described his work on laser plasma spectroscopy with the Okayama University.

General Introduction

Dr. Sakai gave us a general introduction to the company. Sumitomo Metals has a workforce of 20,000 persons with annual sales of 1,100 B Yen, somewhat stagnating in recent years. Most of the company business is in steel products, although new ventures have been taken up recently, including electronic devices, software, medicine and biology, which now account for nearly 5% of the company sales. This reflects the problems faced by the steel industry worldwide.

All of the employees present at this meeting were from the Systems Engineering Division (SED), which includes 365 persons in the Head Office and 2500 more located at the SteelWorks and Subsidiaries. Most of the persons we met were from the Head Office's Control Technology Dept., Instrumentation Tech. Div., which is developing instrumentation for on-line steel process control. Dr. Sakai also introduced, however, the activities of the SED which are not related to steel, such as software and systems for transportation, banks, etc., which now occupy nearly one third of the SED workforce.

General discussion on Optical Sensors

Dr. Tamura reviewed recent developments in optical sensors at Sumitomo. Computer integration and sensors are increasingly needed in the steel industry in order to increase quality and productivity in view of the strong competition. Nearly 15% of the sensors used by this company are of the optoelectronic type, and this proportion tends to increase. The choice between optical or other technologies is based on the judgment and background of the development scientist, but the decision of whether to install or not such sensors on-line is made by the plant manager strictly on the basis of its proven performance and, above all, reliability and low maintenance. This is because the process costs for a sensor failure are orders of magnitude higher than the cost of the sensor itself. The main advantages of optical sensors are their remote operability, resolution and increasing reliability. However, certain problems cannot be solved with optical sensors, such as detecting deep inclusion defects in the metal. Problems which are not yet satisfactorily solved are temperature measurement in the liquid melt (thermocouple lances wear off quickly and are impractical) and surface defect detection (optical methods are expensive and unreliable; eddy-current ones lack resolution; thermography (Elkem) is too slow).

Nearly 30% of the sensors used by Sumitomo are internally developed, many others are developed jointly with instrumentation companies such as Mitsubishi, NEC and smaller instrumentation companies often spurred by Sumitomo itself. In certain cases Sumitomo joins instrumentation-aimed associations with competitors such as Nippon Steel. It is difficult to have an instrumentation company developing the sensors for all the users, as these sensors are process-specific devices with a limited market volume; moreover, there are exclusivity questions in order for the steel producers to obtain a competitive advantage. They have limited interactions with other members of their group such as Sumitomo Electric.

Technical Presentations

A number of technical reviews were presented by Y. Tamura, K. Hiramoto, T.Sakamoto and T. Honda on fiber optic and 6-wavelength pyrometry, shape and size metrology, laser range finding, velocimetry, slag vs. liquid metal discrimination while pouring (by measuring the emissivity change), surface flaw detection with a magneto-optical film held at 0.3 mm from the steel sheet surface (needing positioning feedback), and laser-plasma spectroscopy. Many of these techniques have been successfully implemented on-line, others are experimental. We received reprints or papers for most of these developments.

I shall report in detail on the laser spectroscopy project, as this is a new development for which no paper has yet been written. This activity has been going on for 3 years in collaboration with the Okayama University (Prof. Koga). The purpose is to determine the composition (mainly C and Mn) of liquid steel in the converter (applications to the liquid zinc composition in the galvanizing pool are also contemplated). They excite a plasma with a pulsed laser beam and perform optical emission spectroscopy on the plasma (main emission lines are at 378 and 382 nm for Fe, 193 and 247 nm for C, 293 nm for Mn). This is a relatively near technique for which only Krupp in Germany, to their knowledge, has shown feasibility on-line. In Japan, Nippon Steel is using an on-line spectrometric device, but they use a passive technique monitoring the emission spectrum of the injected oxygen flame. Their novelty is to use a double YAG pulse to improve the emission intensity and line sharpness by bombarding the initial plasma with a second pulse (the two pulses are spaced from a few hundreds to a few thousands ns). We have seen their system, operating on a solid, argon-shielded sample in the laboratory. On-line implementation will have to solve problems of surface oxide and spectrum perturbation by air components.

Conclusion

This is a good example of an application field for optical sensors. We have in Canada similar application needs in the resource industry and, possibly, in avionics and remote sensing. Does this mean that we should have a sensor R&D center in Canada? Not necessarily, as sensors must be application driven. If we had a center developing sensors per ci and then looking for applications, we would end up in most cases with applications (e.g., in general manufacturing) which do not correspond to Canadian strong sectors. I think sensor development should be performed, as we have seen here at Sumitomo, in close association with the user.

Instrumentation and sensor R&D should thus be performed in branches of application-oriented R&D institutes, and it should be the responsibility of these institutes to search and promote the appropriate sensor technology (optical or other) corresponding to the user needs.

We were very well received by this company, including a traditional Japanese dinner at the company's club, thanks in part to previous NRC-IMI connections. The technical information we obtained was very detailed, including recent reprints of papers and unpublished data. This visit was also useful, I believe, because it gave to the more telecommunication oriented members of the optoelectronics delegation a clearer impression of the extreme diversity and application-oriented characteristics of the optical sensors needed in the materials industry.

Documents Received:

13-1 Sumitomo Metals Annual Report
13-2 Research and Development Division

Also received were a number of technical papers which are held individually by the delegation members.

MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD. CENTRAL RESEARCH LABORATORIES OSAKA

Monday, November 16, 1992
Report prepared by R. I. MacDonald

Discussions with:

T. Ishikawa, Manager R&D Planning, Overseas Dept., Corporate Technology Management Office
N. Saeki, Manager Photonics and New Media Development, Promotion Department, Corporate Technology Management Office
M. Ogura, Manager Semiconductor Laser Development Group, Semiconductor Research Laboratory
K. Ohkawa, Senior Researcher, Central Research Laboratories Matsushita

Overview (Ishikawa)

Matsushita has at present:

- Annual sales $56B,
- 242,000 employees
- Main business in Audio/video, appliances, information systems, communication systems, housing, building industrial products
- R&D is 6% of sales

The group contains 87 domestic companies, and 214 overseas subsidiaries in 38 countries. The Matsushita Electric Organisation has corporate R&D reporting directly to the President.

Divisions within R&D are:
- Research Centres,
- Technology Management,
- Corporate Product Engineering

The business sectors run various labs in:

- television,
- audio/video,
- info equipment,
- appliances,
- air conditioning

Overall, this is an ENORMOUS company.

The Central Labs

Future technology (basic, 5-10 year horizon) is the responsibility of the central labs. Joint research with universities and other private companies is carried out.

Four business fields are covered:

- A/V and home appliances,
- Information and communication electronics,
- Housing and building products,
- Industrial products.

Central Labs Centres include:

- A/V Research Center,
- Information and Communication Center,
- Living Systems Center,
- Semiconductor Center,
- Device Process Technology Center

There are also 5 systems development centres:

- for example in HDTV.

Total staff in corporate R&D is 3,400. Of these 200-300 are in systems development labs, the rest in the four other labs and corporate technology management office. There are many overseas labs- Panasonic Technology Inc. is the U.S. research subsidiary and runs 9 labs. There is some cooperation with U.S. labs, but mostly these are involved in independent work. Matsushita has one Canadian undergraduate in the Japan/Canada Co-op programme and find this programme very satisfactory.

Matsushita have had missions from U.S., U.K. and Taiwan similar to ours. Matsushita feels need to study future directions as well.

Presentation on Business environment (Saeki)

(a) Optoelectronic Market trend. Total market in electronics is 2.5×10^{12} yen. Of this 0.37×10^{12} is optoelectronics. The Expansion ratio is 5%/year in electronics, but optoelectronics increases at 18% year. (These figures are quoted from OITDA.) The 1997 prediction is 10.7×10^{12} yen (Matsushita data). Matsushita's share is 7%.

(b) Optical Disc Market trend. Digital Video Disc recorders are being emphasized. The market share for CD is decreasing. DVD will replace some VTRs. They want to get 2-3 hours video per disc (currently about 70 min).

Data storage discs,

Optical Digital Disc and CD-ROM are also growing markets. Computer applications are emphasised. Optical growth in Matsushita is greater than the rate for the whole market.

(c) Optoelectronic sensor devices and applications. The sensor area seems to have generated a lot of speculative interest at Matsushita. Noncontact sensing is seen as the advantage.

Applications cited were:

- Medical sensors,
- human status sensors,
- comfort sensors,
- FOG,

The 1993 sensor market is 295 B yen ($3B). Matsushita sees very rapid growth after 1992 to 700BY ($7B) by 1995. Major growth comes from industrial requirements for sensing of length, distance, thickness, etc., and also security. They are less sure about the potential for optical sensing in avionics.

There is a software effort ongoing in sensor output integration for robotics application. Highly speculative examples of robotics application were shown: floor wax robot, carrier robot, and the like.

Fundamental technologies of sensing:

Sensor applications is a key technology for Matsushita, and sensing formed a considerable portion of what we were shown. Several examples of sensor technologies were identified as under investigation.

- Current and voltage sensors with application to sense breakdown of power distribution lines by checking leakage current. This is operated by the Faraday effect. No technical details were given.

- Fibre Optical Gyro for automotive applications.

- Opto-microphone to avoid EMI in a broadcasting centre. Dynamic range was problem, and project discontinued.

- Optical transmission sensor to detect dirtiness of water for use in washing machines.

- Air conditioner sensor system detects IR radiation to determine the number of people in a room and operates the air conditioning at minimum power consumption level. They claim real demand for such a system.

Matsushita are developing all sensors for internal use, not sale. Government involvement is nil in this research area.

Medical Applications of Photonics

- 10 micron laser scalpel was shown, using thallium bromide optical fibre made by Mitsubishi. A business partner was sought overseas, without success. Equipment now sold only for Japanese hospitals.

- Pain attenuator 60 mW at 830 nm. Apparently dumps heat into tissue to perform acupuncture. Similar system developed for dentistry as anaesthetic.

- Cancer treatment with 200-300 mW lasers in visible red (664) at surface of skin with hematoporphyrene dyes.

Technology Transfer Procedures

Generally once a prototype has been developed, they bring in business people, then begin product development toward a second prototype (product model). If the research has been done in one of the R&D labs in a business sector, then project engineers will take it to finished product. About 70% of project ideas come form the corporate research group, rest from the business sector labs.

Development cycle:

- can take up to 20 years, typical length is shorter in consumer, longer in industrial area. For example - laser acupuncture took five years concept-to-market. Strategy is to introduce first to industrial markets, then home.

Optoelectronic devices:

Ougura Epi growth of Semiconductors is the root technology. They are aiming to obtain lower power dissipation at high speed, and to obtain higher power and shorter wavelength lasers and WDM devices.

They have finished projects to develop

- 1.55 and 1.3 μm communications transmitter modules,
- fibre amplifier,
- visible red diode (680 nm).

Technologies under investigation are elemental, and III-V and II-VI semiconductors, Rare earth and fluoride fibres, and ferroelectrics for nonlinear optics.

Review of the technology trend of CATV (Ogawa)

Linearised 1.3-1.55 μm sources under development for FTTH, CATV analogue modulation applications (FTTH systems are new areas for Matsushita). Product will be supplied to NTT family of companies (For optoelectronics the NTT family is Oki, NEC and Matsushita). The package contains isolator, monitor PD, cooler and thermistor.

Applications are fibre backbone, then FTTH based on optical amplifiers (1.48 micron pump), and upgrades from this to include exchanges and digital transmission. The specifications of the linearised MOVPE MQW 1.3 micron laser are C/N-50 dB and CSO and CTB-70dBc at 4 mW output power. It chirps at 200 MHz/mA. They claim they get 80 NTSC channels over 20 km using modulation index about 3%, with no amplifier. The FDM complex spans 100-500 MHz.

Short wavelength devices

- 780-830 nm diode for CD now developed and in production.

- A 680 nm laser has been developed for bar code scanners, laser printers, displays and optical disc. Ith is 40 mA, 20 mW. It has stable single transverse mode operation. It was fabricated in strained MQW grown by MOVPE. The device is now available as sub production models

- current cost is 70,000 Yen.

- Blue LED and Green Blue LD have been developed in II-VI materials (ZnSe- has 2.7 eV bandgap). Blue LED's are essential for full colour displays. Undoped ZnSe had poor carrier properties up to 1985. Now Matsushita have 10^{19} cm^{-3} by Cl(n) and N radical doping (p). Contact to p- type is difficult. They use Pt which has a smaller Schottky voltage than gold. They also etch the surface by sputtering to increase surface states. The devices are made by MBE (Zn,Ci, $ZnCl_2$, Nitrogen plasma cell for p- doping). LED emits at 461 nm in single line (other emission is weak).

The alternative material SiC is an indirect semiconductor, but ZnSe has a direct transition, so can be very bright.

Blue-green LD has been demonstrated in ZnCdSe/ZnSSe/ZnSe single QW. Ith was 160 A/cm^2 at liquid nitrogen temperature. The beam spread was 18 degree by 2 degree.

At 77K they have produced 6 wavelengths spanning the green and blue, controlled by Cd content. Up to 200 mW per facet in pulsed operation, Quantum efficiency about 60% Facet reflectivity is only 20-30%, which is why the threshold is high. With coated facets they got near to room temp operation. Expect RT operation within months. 14% power conversion efficiency was observed.

Rare earth doped fibres

Used as laser, amplifier, and two-photon upconverter. Tm(1000 ppm)Eu(5000 ppm) codoped fibre used as upconverter pumped at 650 nm, emits at 450 nm. (Eu provides a decay route for the Tm line at 950 nm.

Other work:

An OEIC was developed for telecom and parallel processing systems in 1987, both for memory and interconnect.

Production of integrated xmtrs was not transferred because no advantage over hybrid.

Other matters:

- The "smart house" concept is called Home Automation (Living) System in Japan, (HALS). Matsushita is working in this area on its own.

- Human interface research is one of the central labs responsibilities. This is an important area for home appliances which have already used this technology.

Documents Received

None

NEW IBIS

Monday, November 16, 1992
Report prepared by A. Watanabe

Discussions with:

Mr. Shibukawa, Manager, Planning and Administration

General

The Interactive Basic Information System Development Corporation (IBIS) was established in 1986 to develop and apply a highly advanced information system. Total budget for IBIS during its four-year lifetime was $48 million, 70% of which was provided by the Japan Key Technology Center. The industrial participants in IBIS were Matsushita Electric, Sumitomo Electric and Fujitsu, who were the main participants in the technological predecessor to IBIS, Hi-OVIS (Higashi Ikoma, or Highly Interactive, Optical Visual Information System) the MITI-sponsored fiber-to-the-home demonstration in the town of Higashi Ikoma, just east of Osaka. IBIS designed and installed the system and operated it on an experimental basis until 1990. It was then passed on to its successor corporation, New IBIS.

The real purpose of New IBIS appears to be to try to learn how to develop a business using the equipment that was developed i.e., to study which of the services being offered can be provided on a profitable basis. It has a staff of 16 people, 11 on loan from the member companies (Mr. Shibukawa is from Sumitomo Electric) and 5 permanent staff (mainly female). It occupies spacious quarters in a building owned by its largest shareholder, the city of Osaka, who owns 40% of the corporation. The other shareholders are the regional government of Osaka, Sumitomo Electric, Matsushita Electric and Fujitsu, each with a 10% share, and 46 others, who own the remaining 10%, including the Mitsubishi Research Institute and the National Institute for Research Advancement, 7 banks, 32 apparel manufacturers, C. Itoh Co., NTT Data Communications Co., etc.

We heard about new IBIS during our visit to Sumitomo Electric the previous week, and tried to have a visit arranged for us by the Canadian Embassy, only to be told that it would be very difficult to arrange the visit on such short notice. The visit was arranged by the Mission during our meeting with Matsushita Electric in the morning of the same day. Accompanying us was Mr. Kobayashi of Matsushita Electric's Photonics and New Media Development Section.

Visual and Data Information Services

New IBIS provides visual information services and data information services to businesses located in the Semba area of Osaka. At present there are 143 subscribers, most of whom subscribe to the visual services and about 70 of whom also subscribe to the data services. The Semba area was formerly the centre for textile manufacturing in Osaka, and is now a business area with a high concentration of fashion stores. Many of the stores subscribe to the visual services to provide background images for the sales areas. These images show world-wide fashion trends from both Japan and overseas.

The data services consists of four basic services:

- business software;
- ordering and distributions support system;
- transactions among the users of the system, including banking services;
- gateway services to data systems outside IBIS.

The subscription fees for the service appear to be quite high, for example for the combined image and data service there is a joining fee of $5,000 and a monthly fee of $1,200.

Documents Received

16-2-1 IBIS: Looking Forward to New "Semba", the Information Center of World Fashion Business

16-2-2 Request Program 1992 (in Japanese)

16-2-3 New IBIS (in Japanese)

MITSUBISHI ELECTRIC CORPORATION CENTRAL RESEARCH LABORATORY AMAGASAKI

Tuesday, November 17, 1992
Report prepared by R. Normandin

Discussions with:

Dr. Masatami Iwamoto, General Manager, Central Laboratory
Dr. Enju Nishiyama, Deputy General Manager, Central Research Lab.
Dr. Tetsu Takeyama, Manager, Quantum Electronics Department
Dr. Noriaki Tsukada, 3rd Group Manager, Solid State Quantum Electronics Department
Koichi Hamanaka, Manager, Strategic Planning Department
Kazuko Katsuragawa, Public Relation and Overseas Liaison Group, Strategic Planning Department

Introduction

As a company Mitsubishi is involved in space, satellites, communication and information processing, networks, ICs of all types, turbines, nuclear stations, sub-station equipment, transportation, building equipment, industrial equipment, audio-visual (both consumer and industrial), air-conditioning and appliances. Net sales are in the $25,000 million US for slightly over 100,000 employees. It now ranks 3rd in electric machinery makers and is also involve in defence contracting.

Mitsubishi Electric has approximately 50,000 employees of which 4,000 are in research.

Like many Japanese industries sales and profits lack lustre these days. Mitsubishi is attempting to boost its lead in electronic memory and ICs. The visit was at the central research laboratories, Amagasaki, Hyogo plant.

The four main laboratory divisions in the Advanced Research Centres are involved in interdisciplinary research and will work with the manufacturing division.

Central Research Laboratories involved in long term exploratory research, new technology and enhanced business fields. This lab also takes care of administration and strategic planning. There are four main research departments in the central labs:

- advanced electro-technology
- information & system sciences
- advanced mechanical systems
- energy and environmental technology

These will in turn look at technologies in these departments:

- solid state quantum electronics
- molecular electronics
- advanced process research
- laser physics

The next division is the Manufacturing Development Laboratory:

- with a planning group
- electronic packaging and assembly
- advanced manufacturing apparatus technology
- material processing
- insulation engineering
- technical services
- manufacturing systems technology centre

There is then a Material and Electronic Devices Laboratory:

- planning group
- display and electronic devices
- storage and memory devices
- metal and ceramics
- polymers and plastics
- materials analysis and evaluation
- TFT-LCD business planning

The final lab is the Industrial Electronics and Systems Laboratory consisting of:

- planning group
- FA systems
- advanced systems
- control systems
- image electronics
- automotive electronics
- optical storage development (further divided as systems applications, storage devices and optical disks)

In more detail some of the technologies explored in these labs deal with:

- optical neural computers
- simulation experiments on the learning mechanism of sea mollusc
- ergonomic research

New technologies such as:

- synchrotron X-ray lithography for ULSI
- excimer lasers (MITI project on advance material processing)
- thin film monitoring
- atomic layer epitaxy

Basic technologies in support to production:

- fuel cells
- recycling of heat energy, Stirling engines
- sound absorption in plastics
- ozone treatment of water

Manufacturing development:

- building prototypes
- new manufacturing techniques
- surface mount technologies
- general improvement of manufacturing
- ionized cluster thin film deposition (MBE technique for ceramics of sorts).

Look at multiple source for high Tc superconducting thin films.

- manufacturing high precision prototypes
- high precision three-coordinate position measure to sub-micrometer accuracies

In material and electronic devices:

- molecular design (modelling)
- conducting polymers (modelling)
- material synthesis
- simulation analysis for refrigeration
- carbon fiber reinforced plastics and metals

In advanced electronics there are also efforts in high resolution LC displays and improved VCR heads. Finally the analysis and evaluation in support of R&D is centrally handled with services such as TEM, TEM, X-ray and NMR to name a few.

It is seen that apart from the central lab itself research is geared to the many products sold by Mitsubishi. In that aspect the central labs is somewhat detached from the day-to-day product concerns by a large margin but only in certain department. This is seen from the organisation chart (17-10) in the breakdown of the Headquarters-Research & Development of Mitsubishi Electric Co. as:

- R&D planning and admin
- central research lab
- manufacturing development
- materials & electronic devices
- industrial electronics and systems
- consumer electronics
- consumer products lab
- industrial design lab
- computer & information systems lab
- communication systems lab
- electro-optic and microwave system lab
- LSI lab
- optoelectronic and microwave devices lab
- ASIC design engineering centre
- Mitsubishi Electric Research (U.S.A.).

Thus overall the Mitsubishi R&D headquarters consists of 13 research laboratories in Japan and one in the U.S.

Of particular relevance to this mission are the eastern area labs conduct research in:

- information and communications systems
- consumer products and systems
- industrial design

The western labs are involved in:

- micro-electronics
- consumer products
- fundamental technologies in computer sciences (USA)

In terms of hard product oriented research there are efforts in automotive systems, elevators, lighting units, high resolution displays, car navigation systems (the big thing all over Japan these days), engine monitoring, optical electronics for CD-ROMs and switching power supply.

There are some optical sensor work such as voltage and current sensors as well as Doppler velocimeters and fiber gyros. This is done at the central research lab.

Collaboration with governments projects

In terms of MITI supported effort Mitsubishi is involved with the Read World Computing theme. They are looking at strategies for RWC such as optical processing and intuitive processing. The optical computing project is viewed as important (at least by the people involved, 17-3, 17-4, 17-8). Officially the project developed from interactions with MITI. MITI requires companies to bring ideas and these are selected for funding by the various committees. We were not told or it is not known who initiated the particular project as this is typically done "back of the stage." The present goal is to come up with a prototype as yet undetermined in detail. It is just an outline and will be negotiated between Mitsubishi and MITI. It looks quite flexible at this time and is likely to be suitably modified and adapted to suit whatever progress is available at the time! The final targets will be set by the several professors and senior members of the committee.

Technical presentations

These are outlined in the agenda 17-1 as well as in the overhead copies and papers 17-3,4,5,6,7,8. All presented material was in the open literature except a few general conceptual "road maps" for RWC. This is one of the few companies that seemed to take RWC seriously. This feeling may be in the particular lab only and may not truly reflect the position of the other, more product oriented labs. The overall approach is on human like I/O using artificial retina, neural processing, optical interconnections and processing. Central to the effort are optical neurochips and bistable devices. These are based on ideas previously published by MacDonald at TRLabs and the general work of Bell Labs in SEED and DOES devices. The improvements were in the monolithic integration of memory in the neurochip with a common structure for the LED and the PD. A conventional computer was still in the loop for processing links between nodes. The SEED devices demonstrated also had an interesting improvement in that the use of asymmetric QW in the feedback element provided the needed built-in field to shift the operating bistable point to a monopolar region and eliminate external applied bias. This results in low optical switch thresholds and ease of integration in array configuration. Speed is still an issue with slow ms response times. The aim is to use it as the optical memory.

Level of effort

Note that out of 300 researchers this optical computing effort has approximately 10 part time researchers. The quantum devices efforts involve more than 40 researchers divided in four groups:

- optical neurochip: 5PY for the artificial retinal and neural net theory
- nP lasers, blue-green lasers, II-IV lasers and STM manipulation
- Quantum characterisation, functional devices and electronic wave device
- High Tc research and tree terminal superconducting devices

Technology transfers and lead time

In theory the relevant basic research performed here is transferred to the other labs for suitability evaluation and technology transfer. The person affected in this technology transfer may or may not come back the Central Research Lab. For example the neural net research looks at a 20 year horizon.

Telecommunication research

This is performed in the telecommunication systems lab. Not much more information could be gathered (see 17-12, 17-9 for opto and microwave) except the research on Er doped fiber amplifiers and high speed telco applications. OEICs not a current priority right now (sic).

Lab tour

We were shown demonstrations of the artificial retina and the neurochip. The lab was well equipped and contained an unusual amount of international equipment from Newport, Antel, Coherent, Burleigh etc. This is not typical of the other laboratories we visited in Japan. A quick look around the other setups in the room did not reveal information on future directions or new technologies. The demonstrations worked as stated in character recognition and neural net learning patterns. They have been presented to visitors several times before.

Exploratory research funding

In effect the research performed at Mitsubishi under MITI programmes is well funded by MITI. The personnel wages are fully taken care of by MITI. Mitsubishi only has to cover the 30% social benefits. Similarly 100% of research equipment cost are covered by MITI. There was no answer on overhead costs, depreciation, in-kind efforts and material use from the company. The net result for Mitsubishi is that it is better to have some partial coverage of research cost on these 20 year lead time projects than none at all (assuming they would get involved in then at all although they said they would still be involved in RWC without the MITI programme but a much lower scale). The idea is to share the risk. The government owns the equipment during the course of the project and will announce they are available for a nominal cost at the end.

Conclusion

Although the research performed in most other divisions and laboratory can be related directly to the very wide and diverse product lines at Mitsubishi the research performed here is extremely exploratory. There is a notable lack of focus and direction to it. The common theme of RWC for the research could be more MITI than Mitsubishi. The use of government money to perform the research is efficient but it is an open question they would do the research at all without the external support. Even within this lab only 5pys out of 40 are involved in this. There is little evidence of MITI money in all the other labs from the supplied literature.

Other product related research and organisation relationships was typical of other large companies in Japan, as far as can be gathered from the material supplied 17-9,11,12.

It would also appear that the mandate of this mission was not made evident to Mitsubishi prior to our visit since the emphasis was only on this exploratory programme.

Documents Received:

17-1 Schedule and welcome from Dr. Iwamoto
17-2 Mitsubishi lab and research centre descriptions: Socio-Tech
17-3 E. Lange, E. Funatsu, K. Kyuma, A new artificial retinal device, Proc. of 53rd meeting of J. Appl. Phys. Soc., 810 (1992)
17-4 E. Lange, E. Funatsu, K. Hara, K. Kyuma, Optical neurochip for direct image processing, Proc. of IEICE, (Tokyo, 1992)
17-5 Press release #0358 about neurochip
17-6 Y. Nitta, J. Ohta, S. Tai and K. Kyuma, Proposal of an optical neurochip with internal analog memory and characteristics, Jpn. J. Appl. Phys. 31, 1182 (1992)
17-7 Overhead copies: All-optical bistable p-i-p-i-n device, Dr. Tsukada
17-8 Overhead copies (selected): Real-World Computing and optical retina, Dr. Tsukada
17-9 LSI R&D lab, Optoelectronic and microwave devices, ASIC design overview.
17-10 Organisation of Mitsubishi Electric
17-11 Description of the four labs
17-12 Corporate profile.

SANYO ELECTRIC COMPANY SEMICONDUCTOR RESEARCH CENTER OPTOELECTRONICS RESEARCH DEPARTMENT OSAKA

Tuesday, November 17, 1992
Report prepared by P. Cielo

Persons met:

Dr. T. Yamaguchi, Manager, Optoelectronics Research Department
Dr. K. Yodoshi, Manager, Optoelectronic Device Laboratory
K. Yagi, Manager, Semiconductor Materials Laboratory
A. Ibaraki, Principal researcher

Introduction:

Sanyo was established in 1950. It has now 30,000 employees, of which 5,000 R&D personnel, 1500 in the R&D Headquarters and the rest spread over the company. Their R&D budget represents 8% of the sales, which amounted to 1,200 billion yens in 1991. This company produces a variety of consumer products and electronic appliances, such as audio-video products, copiers and FAX machines, biomedical systems, computer processing systems, semiconductor and optoelectronic devices, batteries and solar cells. It makes a relatively wide use, for a large company of this kind, of government grants by participating to a variety of nationally sponsored consortia, such as the Clean Energy and the Softronics consortia.

The Sanyo R&D Laboratories

The research laboratories were very centralized, to a point that the R&D Administration Headquarters (under pressure from their Corporate Technology Strategy Division) felt they were more and more removed from the company's products. They were thus reorganized 5 years ago, so that they are now divided in 8 sections corresponding to the (rather diversified) fields of the company's products. This appears to have improved the communication between the Central R&D Labs and the plants, although still nearly half of the research projects are mainly related to the personal interests of the researchers. Dr. Yodoshi said that the general technological level of the people in production has much improved in the last decade; consequently, the Central Labs researchers usually transfer technology development to the production plants when these developments require a lower level of technology.

We were hosted by the Optoelectronics Research Department, one of the 8 divisions of the R&D Headquarters. This department focuses on leading edge technologies for the company's consumer products, including future possible products in high-definition video-disks, 3-D television, optical computing and car navigation. Much of the department activities are in the development of laser diodes (LD), with good results in 4 directions:

- short-wavelength LD's, for high density video-disks and 3-D TV;

- high-power LD's, for printers and optical communications;

- high coherence and low-noise LD's, for CD players, video-dish players and CD-ROM's; and

- integration, for optical computing and communications.

Their LD products now span the range from 630 nm, typically with 3 mW output,to 870 nm with powers to 200 nW. They also developed recently a 615 nm room temperature LD, and they are pushing for still shorter wavelengths, in the blue region, and higher powers.

Technical Presentations

Dr. Yodoshi presented recent developments in optoelectronic devices at Sanyo. He described their high-power LD, used in particular for second-harmonics generation. They reach 200 mW at 852 to 865 nm with a cavity length of 0.9 mm. The angular emission pattern is 18 x 6.5 degrees, and their reliability was tested for 2000 hours at 50°C, at the output level of 150 mW. He also described typical results obtained with the lower power, short wavelength lasers at 615 nm. They also produce 4-beam lasers, at 100 mm spacings, which are monitored through a grooved-Si light guide coupling them to a 4-photodiode array. Their maximum power was 30 mW at 830 nm, and the typical cross-talk for adjacent photodiodes was less than 1%. Possible applications are high-speed laser printers and optical disks.

Dr. Ibaraki described recent results on surface-emitting lasers. In order to reduce the threshold current and improve the thermal dispersion, they opted for a very small active region, with an active layer width of the order of 15 mm, and a high-reflection heat sink. He gave details on the fabrication steps, on the reflectivity of the top and bottom layers, and on the obtained performances: typically, outputs of 0.5 mW with a threshold current of 5 mA at 20°C, over a wavelength range of 894 to 897 nm, depending on the current and heat-sink temperatures. He also described a 780 nm surface-emitting laser under development, as well as 2 x 2 and 5 x 6 laser arrays.

Dr. Yagi discussed recent results in blue and green sources, including SiC and ZnSe LED's, second-harmonics generation devices, and 16 x 16 and 24 x 24 arrays. He also talked about quantum structure confinement to control atomic arrangements.

We had an extensive laboratory tour. We saw their Hi-vision LCD displays, with typically 4.5×10^6 pixels, high-density broadcasting with 1125 lines, and a voice-activated car audio system. They are also producing a variety of solar cells. In the optoelectronics laboratories we were introduced to their holographic lithography processes, reaching resolutions down to 0.19 mm, as well as to their 4-beam arrays for multiple-track recording, a 2 mW frequency-doubled 435 nm laser, and GaAs monolithic microwave integrated circuits.

Conclusion

From what we saw in their optoelectronics research laboratories, Sanyo appears to be a technology-driven company, but sensitive to the market. There is an effort to improve the coordination of their R&D activities with their marketing strategies, through their R&D Administration Headquarters.

Documents Received:

17-2-1	An invitation to Sanyo Electric Co.
17-2-2	An introduction to R&D Headquarters
17-2-3	Optoelectronic device brochure
17-2-4	Copies of presentations and papers

HAMAMATSU PHOTONICS K.K. CENTRAL RESEARCH LABORATORY HAMAMATSU, SHIZUOKA PREFECTURE

Wednesday, November, 18, 1992
Report prepared by R. I. MacDonald

Discussions with:

Y. Suzuki, Director, Central Research Lab.
Y. Osumi, Manager, Technology Transfer Div.

Hamamatsu Organisation and Business

Hamamatsu was founded in 1953 and has grown to a present size of 2000 employees. The initial business was phototubes, and was based on the interests of the founders who were connected to pioneering efforts in television in Japan between the wars. More recently Hamamatsu has become a well-known company in a variety of photonics areas, primarily related to instrumentation. High quality electron amplifier tubes are still an important part of the business.

The technical divisions, excluding research, are:

- Electron Tube Centre, consisting of two divisions. These divisions manufacture photomultiplier tubes, specialty lamps, imaging tubes for IR, UV, X-ray, image intensifiers, microchannel plates for mass specs, electron specs light sources for photolithography and other specialty applications, and high power lasers

- Solid State Division manufactures photodiodes and PD arrays for the UV to near IR; middle IR detectors for measurement and imaging; LED's, LD's, optocouplers, photointerrupters, and photoreflectors.
- System Division manufactures complete systems for a variety of applications.
- high precision analytic tv cameras and measurement equipment, including software.
- computer compatible video camera for image processing.
- IR-X- Ray image measurement units for image analysis in production.
- Digital Image Processing System.
- Streak Camera system -1 ps resolution.
- Image analysis system for biological analysis.
- Photon counting imaging system.
- Sampling optical oscilloscope with direct optical input.
- Infrared IC internal imaging system (Fibre bundle).

The System Division in particular had a bad year this year, and the whole company is affected by the U.S. turndown.

Research Organisation

There are three factories and three laboratories in Japan, and ten overseas affiliated companies, of which five are in the US (and none in Canada!). One of the Japanese labs (P.E.T. Center) is a special centre for positron emission tomography, in which Hamamatsu has a strong presence. Another is located in Tsukuba, taking advantage of the interdisciplinary culture in the "Science City".

There are 100 researchers in the Central Research Laboratory founded in 1990 outside Hamamatsu. This centre is unusual in that it occupies quite a generous campus, shared with the P.E.T. Center. Hamamatsu has plans for a research park around the central lab. The overall R&D budget is Y4B/year ($40M), which is 13% of income. Half of this budget is spent in the central laboratory, the other half in R&D in the production divisions. The company is an R&D-oriented enterprise, so that production employees and R&D employees are difficult to distinguish. Research activity in the production divisions is accounted for on a man hours basis.

More than half the overall staff are engineers. Hamamatsu hires 50-60 new graduate engineers per year,of which about 10 are at Masters, and perhaps 1 or 2 at Doctorate level. Approximately 20 other staff are taken on per year.

Hamamatsu research projects are selected by management. Ultimate responsibility for project selection resides with the president, who takes a strong technical guidance role. The research division responds to inputs from Universities in Japan and overseas. Every six months each researcher makes a plan and budget.

As in most companies technology transfer is by people transfer. Engineers move to production along with the technology, but may have difficulty returning to the lab. It their philosophy that patents are the output of the laboratory. The lab justifies itself by licensing developments internally or externally.

The central lab works by extensively by contracts and collaborations with outside organisations. There are fifty collaborative projects. Hamamatsu has also used Government funding extensively. This has been very valuable to the company.

Consortium

Ten researchers attached to the Central Lab have been located in a laboratory set up by a consortium, also in Tsukuba. This consortium consists of the following sponsors

- Hamamatsu
- Teisan
- Stanley Electric
- Yasukawa Electric
- Harima Chemical
- Nihon Heavy Chemical

The purpose of the consortium is to track what is going on in the Tsukuba government labs. In conversations we were unable to identify an overall technical theme- the activities seem to be determined on an ad- hoc basis. There is no MITI funding for this consortium. The directorship of the consortium rotates among the presidents of the members companies. Intellectual property rights are shared by Hamamatsu, JRDC, and the inventor. Themes come from the heads of the participant companies and are reviewed every six months. Apparently the biotechnology aspect of the Hamamatsu research programme originated from the consortium in Tsukuba.

Foundation

Hamamatsu has established a foundation: "Hamamatsu Optoelectronics Research Foundation" to activate collaborations with international firms and to generate collaborations with research professors at Japanese universities. The Japanese Ministry of Education and MITI are felt by Hamamatsu to be too conservative about receiving researchers from abroad. Hamamatsu has set aside a 500M yen ($5M) fund for this activity, and a 100MY ($1M) annual budget. A dormitory for foreign researchers has just been built on the campus. One researcher from Sweden is presently visiting.

Lab Tour

Most of what we were shown in the lab tour was work related to systems division activities. Some assorted highlights are listed below:

- Two point-to-point optical free-space links were operating. One carried 100 Mb/s over 8.2 km using a 60 mW 1.55 micron laser; the other operated over a few hundred yards using a visible light diode laser. It was stated that spectral constraints in the microwave would make such links profitable in future. There was no work on in-building wireless being carried out.

- There was a lot of work on image analysis for medical use, and also photonic surgery at various scales, from orthopaedic, to laser dissection of individual chromosomes. In the latter connection, Hamamatsu was receiving a delegation from the Human Genome project the following week to discuss photonic applications in that project.

- A microchannel plate was adapted for use in a $LiNbO_3$ spatial light modulator. Applications were for optical interconnect, imaging, and in an optical neurocomputer project being done in collaboration with other organizations.

- There was work on nonlinear optics going on, including parametric amplification, oscillation, and wavelength doubling.

- A major activity is the improvement of P.E.T. imaging systems, including a veterinary version for lab experimentation.

In addition to these research activities Hamamatsu has been involved in other projects because it is a unique equipment supplier:

- Photomultipliers for Proton decay experiment at Kamioka.
- UV imagers for satellites
- Fusion experiments- photomultipliers for plasma measurements

After the lab tour, the delegation was presented a special video taped message from president Hiruma. The president seems to be a highly charismatic character, well known in Japan for being outspoken. The address was a very high level philosophic and idiosyncratic view of the importance of photonics, mixed with considerable boosterism.

Documents Received

18-1 Hamamatsu Photonics K.K. Annual Report 1991
18-2 Overview of the Central Research Laboratory January
18-3 Photon is our Business
18-4 Hamamatsu PET Center
18-5 Photonics

SANTEC CORPORATION
KOMAKI, AICHI PREFECTURE

Wednesday, November 18, 1992
Report prepared by R. Normandin

Contacts:

Dr. Masao Sadamura, President
Dr. Seiji An, Head of Photonics Labs., Managing Director
Dr. Tomohiro Murakami, Director, Manager Photonics Labs.
Dr. Te-Ho Chong, Senior Research Engineer, Integrated Optics Labs.

Introduction

Santec is a company with approximately 85 employees addressing specific niche markets in fiber optics technology measuring devices and Photonics in general. It was established in 1979 and demonstrated an interesting sales profile. Sales in the 2,000,000,000 Yens range for 1992 after a similar figure for 1991. Santec has 16 distributors and OPEL Corp. and Santec U.S.A. as subsidiaries.

Background information

Visitors are greeted in the lobby by the "Attack Optopia" slogan. This is a play on utopia and optoelectronics but it does describe some of the company philosophy! Initial dialogue was with Dr. Masao Sadamura, the president. Noting we were from Canada he describe several contacts, relationships and business with JDS, University of Toronto, BNR, Hydro Quebec etc. He stated that JDS would like to have the right to market Santec products in the U.S.

Santec also has operation in the U.S. (New Jersey, near Bell) with 3 PY at this time and is looking at the European market too.

Sales of Santec products have been successful worldwide. However export are only 15% of business they would like to increase this to 30% if possible. Sales were 1.8B Yens last year for 80 PY divided as 50 for R&D and production (2 PhD, 3 MSc, most are college graduates) and 30 for sales, accounting, purchasing etc.

All monies, except for expenses necessary for materials goes to research. There are five laboratories in R&D:

- optical image processing
- optical fiber measurements
- applied laser systems
- diode laser controlling
- integrated optics.

The company (most likely Dr. Sadamura) has a clear strategic policy when it comes to R&D and market identification:

- target new products and R&D that no one is active or likely to become active at this time. This is true worldwide and insures no competition at least in the beginning.

- look for a unique niche market not in competition with a large company. There are many targets and even large companies cannot pursue them all.

- only go for mid size volume in the 5M US$ range. Large enough for Santec to make a profit but not large enough for a large organisation to consider getting into. Santec tries to get 100% of the identified market if possible.

- go only for very high value added high profits products. Santec requires large amounts of R&D support.

- timing is important in product introduction with short 3 years life time cycles. Santec has to be able to supply some test products just in time or just before people realise they need it. Santec claims many of their employees work close to 12 hours a day in order to meet market demands. Indeed Dr. Sadamura realises that without such dedicated 4 or 5 key employees the operation would not have been so successful.

- large corporations and research labs are the target for Santec products as they can afford the price and will be reluctant to develop a low volume test product for their own internal needs unless absolutely necessary.

- the final point is that Santec tries to provide service before and after a sale. Engineers are in contact with clients in order to learn better of future needs and get leads.

Presentation

A summary of Santec products and Santec (i.e. Sadamura's) philosophy were outlined.

Optical fiber test systems, laser spectral linewidth analyzers, chromatic dispersion measurement systems, tunable laser sources, image processing systems for fiber measurements, multi-electrode laser controllers, high repetition short pulse lasers are all typical of Santec products. Actually they claim that since 1973 they have developed over 70 kinds of new products!?? The fastest rate in Japan according to Sadamura.

We were presented the ICC (Interdependency, Creativity and Consciousness) philosophy of Santec with much fervour and imagery from people management environment. This was followed with a copious amount of OITDA statistics on photonics and extrapolations and projections by Dr. Sadamura applied to Santec.

Note: some of these OITDA projections are well condensed and presented in last month issue of Optics News from the OSA.

Possible future directions

There is an interest for Santec in the Japanese multimedia PC market which is estimated at 30B Yen. They also want to compete in the hand-held OTDR and fiber network analysis instrumentation. Dr. Sadamura estimates the top hand-held OTDR instrument maker is Anritsu at 100MY followed by Antel with 4MY and Advantest at 2MY.

How are projects selected?

Basically two different mechanisms. The so called "seeds," when the needed technologies are available and "needs" that can be identified. Up to now the company has had more products that relate to the needs of particular areas or customers. The identification of future or present needs is through the myriads of contacts at NTT and NEC for example. When they (NTT or NEC) start a new project they very often do not have the measuring equipment for it. Typical example being submarine cables leading Santec to develop a fiber dispersion measurement instrument that did not exist at the time. Close relationships with researchers in those large companies are cultivated as a source of information for Santec. Some are formal but many good information comes from complaints about problems or after hours after a long dinner. Furthermore sales are done by engineers who have a chance to discuss with and extract information from the customers. Networking is more important for Santec size companies than it first appears.

Collaboration in government projects

Santec is very independent. There are no government projects or subsidies. The initial capitalization of Santec was with private funds and bank loans. Santec was then careful not to lose any chance at making a profit and never looked back.

Other issues

Presently Santec is developing a compact laser gyro for direction finders and positioning in cars and military navigation. Any interest in sensor applications? The response: "Yes, do you have something of interest?"

Conclusion

This small company has done well by aggressively identifying needs and marketing its product. The main drive within Santec is from a small number of dedicated hard working people with a quasi religious motivation. Although they have done well opinions are divided at large on Santec products and business. In many ways Santec is similar to several small Canadian companies that are fiercely independent and market driven. Santec appears to have an excellent "inside track" record, however.

Documents Received:

18-2-1	Profile of Santec
18-2-2	OPELS new product
18-2-3	History of Santec
18-2-4	Introduction to Santec Corporation
18-2-5	Assorted product descriptions

NIPPON SHEET GLASS CO, LTD. TSUKUBA RESEARCH LABORATORY TSUKUBA

Thursday, November 19, 1992
Report prepared by P. Cielo

Persons met:

Dr. Y. Mitsuhashi, Deputy General Manager, Tsukuba Res. Lab
Dr. K. Nishizawa, Deputy Chief Researcher, Tsukuba Labs and Fiber Optics Div., Kanagawa
Other members of the Tsukuba Lab, who described their research work.

General Introduction

Dr. Mitsuhashi gave us a general description of the company. NSG has been established in 1918 as a sheet glass manufacturer. It has nearly 3800 employees (avg. age 41) of which nearly 300 are doing R&D, including 60 in the Tsukuba Laboratories, 70 in the Central Research Laboratories at Itami and the rest in the plants. Total sales in 91 were 280 billion yens. It is a member of the Sumitomo group, but has little interactions with the other members.

As the demand for sheet glass is not growing, the company has made considerable efforts over the last decades to diversify into high-technology products, mostly related to optoelectronics. This has led to the creation of the Tsukuba Labs 10 years ago, which are devoted to photonics and thin films, while the Central Labs are only oriented to glass manufacturing and glass properties. The Tsukuba Laboratories have been more oriented towards future products, they make large use of government subsidies and are very open to the international research community. Recently, however, pressure is mounting from the Headquarters (an office including 10 persons, located in Tokyo) to focus more on marketable applications.

The Tsukuba Research Laboratories

There are 60 permanent researchers at the Tsukuba Labs, plus a number of foreign visitors and workers from NSG plants who come here for projects having a duration of a few months,for a total of typically 90 people in the labs. They work in 4 areas:

- Micro-optics, including optical waveguides, optical devices and planar waveguides;
- Optoelectronics, mainly Silicon and compound semiconductor devices;
- Thin-film devices, mainly memory disks and flat-panel displays; and
- Glass coating techniques, including glasses for optics and for industrial uses.

Many of these projects are in collaboration with other organisms and make use of government grants. They have very good relations with MITI; 3 senior researchers at the Tsukuba Labs, including Dr. Mitsuhashi, were previously working at the ETL Labs. They participate, between else, to support the Optoelectronic Technology Research Laboratory, which we visited last week. Dr. Mitsuhashi said that their relations with this organism have, however, become less strong recently, as they realized that this laboratory has a mission which is too far from the practical concerns of NSG. He feels, however, that such interactions are useful for a number of reasons: they help maintaining contacts with funding institutions, contribute through exchanges of personnel to the high-level training of young employees, and help attracting good researchers, although he mentioned that several workers having experienced such a fundamental research environment had adaptation problems when transferred to more industrial projects and ended up leaving NSG.

Dr. Nishizawa discussed the evolution of photonic products at NSG. In 1970 they developed their graded-index waveguides and their Selfoc lenses, which made them well-known worldwide. They later transferred their waveguide technology to a joint-venture company, Opnotec, in 1980. These products stimulated other developments, some of which, e.g. in the fields of glass fibers and of fiber lasers, were practically abandoned. They are now focusing on planar waveguides and on microlens arrays for copying and FAX machines, which are commercially successful. In general, they have evolved from bulk optics to graded optics, and increasingly, to planar waveguides, in response to the technology evolution. They participate to many consortia which are typically 50% funded by the government, such as the Real-World Computing project, even though this project is somewhat removed from their main business. They have also made a proposal for the development of fiber optic sensors (e.g. fiber gyroscopes for car navigation), but they could not demonstrate the existence of viable applications or found that the proposed technology was unrealistically expensive.

Technical Presentations

Several members of the Tsukuba Labs presented their recent work, mostly published in the open literature.

Mr. Shimoto(?) presented work on the production of planar microlens arrays by the ion-exchange technology: deposition of Ti films on glass, patterning and ion exchange in molten salt to produce a matrix of micro-lenses on the substrate. The final plates are used in conjunction with liquid-crystal displays in colour television. He demonstrated an optical power increase of 2 to 3 times by using the focusing power of the microlens plate as compared to a simple LCD. License agreements are under way with the company Sharp for this technology.

K. Hamanaka described his work on Optical Bus Interconnection Systems (OBIS)using Selfoc micro-lenses to periodically refocus a LED display image containing typically 200 x 200 pixels. He discussed the precise alignment and index matching requirements, as well as the effect of surface quality.

A laboratory demonstration has been carried out on an optical bench, but no real device has yet been built. This project has received public funding; commercialization is uncertain.

T. Koyama has presented his work on the production of nonlinear optical materials by embedding nm-size CdTe micro-crystallites in silica by laser evaporation and silica deposition in a vacuum coater. They set up a Degenerate 4-wave Mixing system to evaluate the properties of this material, which gave excellent response times. This project has received funding from the MITI High-performance Polymer Center.

H. Wada presented recent work on planar waveguides, with particular reference to fiber-to-the-home applications. The approach consists in a two-step ion exchange: first, immersion in molten salt through a mask, second, electric-field assisted ion exchange to produce a nearly circular cross-section. A number of passive optical networks have been demonstrated, including a 1 x 8 splitter which has recently been introduced in the market.

We also visited their display room, where we saw between else some more glass-related products developed at their central Research Labs, such as heated automotive windshields, transmittance-controlled and directional liquid-crystal films.

Conclusion

This is an example of an originally relatively low-tech glass company which has been struggling for the last decades to penetrate the optoelectronic field with government help. The approach is more technology driven than market-driven. The results are mixed; the best success appear to be related to the basic expertise of this company in the production of thin-film coatings and on glass processing such as ion exchange techniques.

Documents Received:

19-1 Nippon Sheet Glass-Company Profile
19-2 Nippon Sheet Glass Annual Report, 1992
19-3 Tsukuba Research Laboratory
19-4 Reprints of recent research papers

SEIKOH GIKEN CO, LTD. MATSUDO, CHIBA PREFECTURE

Thursday, November 19, 1992
Report prepared by R. I. MacDonald

Discussions with:

M. Takahashi- President
M. Ueno- Managing Director
K. Koyanagawa- Director: International Sales
T. Ohizumi- Manager: International Sales Div.

Company profile

The company was founded in 1972 and currently has 125 staff. There are now two locations: the original headquarters plant and a new plant (where the meeting was held) completed July 1992 to manufacture optical components. The company is not related to Seiko the watch makers.

Seikoh Giken makes precision moulding die, optical connectors and connector parts and is the Japanese agent for JDS- Fitel optical measurement equipment made in Canada. The company started in the precision die business for powder metallurgy of automobile gears. Later precision injection moulding of plastic discs for CD-ROM, VD, etc. was added. Optical parts and equipment was identified as a potential business in 1982, based on the match between their machining capabilities and the very high precision required for ferrules in optical couplers. The company now manufactures and sells fibre connector parts, assemblies, and fixed and variable attenuators. They are now developing a wavelength independent coupler. Optics comprises 50% of the sales, but only 35% of the staff because of longer history in precision machining. 30% of staff are engineers. There are 10 engineers in optics, some may not be doing exclusively R&D, but all are engaged in it.

The balance of product in future will change. The company intends focusing more on optical circuit parts in the future because it is a better export business than precision die. Optical products are 60% exported overseas. The Japanese Economy is not good, and sales are slow at present. Moulding die customers are mostly auto manufacturers, and saturation point has been reached in this industry. Optical disc injection die is a very promising area. There will be a steady increase (20%/year up to now). The reason for the steady increase is the storage volume of the CD and the growth of environment problems lead to the paperless office requirement. Demands will grow, but it will be a slow process. With developments in optical communications there will be growth in optical memories.

They expect the moulding business will stay stable, or there may be a small growth in discs. ISDN will likely drive optics to 85-90% of the sales.

When the company started manufacturing fibre coupler ferrules and housings they found that fibre termination and polishing was required in-house. This led to the development of their own fibre polishing machines, which are now also a product. Back reflection performance of couplers became an issue, and with their newly developed capability in polishing they were able to develop the angle polishing technique. As a result they have established (collaboratively with JDS) a unique technology for extremely low back reflection (APC) fibre connectors. Recognising the growing importance of low back reflection as a product differentiator in their fibre devices they have also developed fibre attenuators as a product. Seikoh has acquired special machines to make the optical parts. Interestingly the Japanese precision machine industry inadequate to then and their machine tools come 50% from Switzerland 20% from USA, and Japanese machine tools only constitute 30%. Tools have been developed in-house for fibre couplers, but these have not been put on sale.

Relationship with the Canadian firm JDS Fitel

The company has an intimate relationship with the Canadian firm JDS Fitel (now 50% owned by Furukawa). This relationship started in 1984. JDS became interested in Seikoh because JDS were selling wavelength division multiplexers and optical switches which suffered problems from connector back reflection. Low back reflection was already identified as a Seikoh target, and Seikoh had the best technology (-40 dB) at that time. JDS bought jumpers specified at -50 dB to connect to their WDM equipment. From then JDS took on the role as distributor in U.S. and Canada. The current connector (<-60 dB) was jointly developed with JDS. The two companies have named this product angle- polished connector (APC). European connector manufacturers have used the name, and now it is commonly accepted. Development was done at Seikoh, JDS tested and assessed jointly. JDS did marketing worldwide. The collaboration centred on the common objective to have low back reflection techniques. The patents seem to be jointly held. There is some potential for competition between Seikoh and JDS (plug type attenuator for example), but the relationship is a friendly one. JDS are pushing the Seikoh plug-type attenuators in their equipment. On the other hand the switches that JDS makes are being bought and sold by Seikoh. The companies are complementary in many ways - Seikoh is developing a wavelength independent coupler (WIC), while JDS has a WDM coupler. Seikoh recognises JDS as having "very excellent" technology. They state that JDS has first rate measurement unit reputation, and NTT is taking a great interest in their product.

Philosophy

In Japan the sales of the auto industry amount to 40 trillion yen. By 2030 the information/telecommunication industry is expected to replace this industry, with sales of 38 trillion Yen. How this growth will occur is still unclear, but Seikoh look to this development as the long term environment for their company.

Some other details of how Seikoh operates:

- Seikoh believes that patents are very important. Fourteen US patents have been obtained and the same number are pending. They have more US than Japanese patents because of the speed of US Pat. Off.

- Licenses have not been given on patents up to the present. The company may take cross licenses or give licenses in future. The patents they have applied for are only applicable to own product at present. Seikoh thinks patents are valuable in promoting the company as well as protecting the product.

- No university contacts, or outside institutes have been used in developing new product. In future it is expected that the necessity will arise. They feel that they would not limit contacts to Japanese universities, but would seek also joint collaborations with foreign universities.

- They were asked about optical sensing. They have not seen a match between their technology and opportunity.

- Seikoh has had an impact on standards. OITDA handles Japanese standards processes into IEC, and Seikoh provide data to the Japanese standards bodies. Their APC coupler is the basis for an IEC draft standard. It is noteworthy that the Research Manager for JDS is an experienced Canadian representative in the relevant working group of IEC.

- There do not appear to have been any government subsidies or participation in government programmes in Seikoh.

Comment

This is a company that sticks to its knitting and gets good results. We asked whether they focused on producing product rather than R&D. Interestingly, this did not appear to be a flattering perception, and they were at pains to point out that they really did have many people doing R&D.

However, research and development has been narrowed down to certain themes, and they are confident in their area of expertise.

A very interesting aspect of the company is that it was in business already when it discovered a specific photonics niche that it could fill on the basis of an existing capability. A question put by Takahashi to the mission reveals one weakness in this approach. From the perspective of the optical component manufacturer 1995 was target for ISDN, but the outlook for optical ISDN by that date is not good in Japan. They wanted to know whether things were running smoother for ISDN elsewhere. It seems they count on a large market opportunity with optical ISDN installations. It seems likely that a more intimate connection with the telecommunications companies would have made them a little more cynical about ISDN and optics in the loop.

Documents Received

19-2-1	Company profile
19-2-2	Optical fiber products

NEC OTSUKI PLANT OTSUKI, YAMANASHI PREFECTURE

Friday, November 20, 1992
Report prepared by R. Normandin

Contacts:

Hiroshi Okazaki, Assistant General Manager, Engineering Coordination Div.
Akihiko Tsukui, Senior Manager, Production Engineering
Kouichi Minemura, Senior Manager, Second Transmission Division
Yuichi Odagiri, Technical Manager, Production Engineering
Mr. Saita, Manager, Otsuki Plant

Introduction

NEC was founded in 1899 in partnership with Western Electric as the first Japanese joint venture. It now has sales in the 3.6B Yens (for 1991) and approximately 40,000 employees. Approximately 330,000 MY are spent in all forms of R&D. NEC is an international supplier of communication systems (30% sales) and equipment, computers (50% sales) and industrial electronics systems as well as semiconductors and ICs. The theme is called C&C for the integration of communication and computing elements under a common system. As most with Japanese companies' sales are stagnating.

NEC is divided in 10 functional groups, 4 marketing, one administrative and one operation group. The focus is towards market and customer oriented C&C needs.

The R&D group conducts basic and applied research in electronic materials, devices and systems. The C&C software group is responsible for software development and engineering for the whole organisation. The Production Engineering Group is then in charge for the development and upgrading of NEC's manufacturing technologies and the C&C Product Technologies Group integrates product development functions to factory automation and control systems.

Another major effort for NEC is the C&C Systems Group which is divided according to the different markets or industries. They perform the actual integration of computer and communication systems. There is also a Personal C&C Group looking at mass volume products such as FAX, PCs and mobile telephones. NEC has three domestic and one international groups for marketing. One of the domestic group is in charge of business with NTT and government agencies in addition to the public sector.

NEC manufacture communication systems in 16 Japanese plants and also has 16 plants in 11 countries outside Japan. They concentrate on digital central office switching systems, digital PBXs, FOTS, earth stations and satellite communications, terminal products and ISDN.

Also important are the computer products (approx 50% of sales). NEC has OEM agreements with Bull (France and U.S.). They have 21 software subsidiaries in Japan and overseas. Factory automation equipment, robots and numerical control are also important in sales volume. The consumer market only accounts for a few percents of total sales after the semiconductor (20%) memory and microprocessor business (the famed V series micropros).

Compared to other large Japanese manufacturers NEC is remarkably focused in market philosophy. The U.S. is its single largest overseas market but overseas manufacturing is mostly in the Pacific rim.

Unlike the NEC Tsukuba Research Laboratories visited last week the Ohtsuki plant is closer to manufacturing and product base as a test bed for new production techniques and its implementation to manufacturing of photonic components.

Presentation

A review of activities relevant to the Ohtsuki plan was presented with an effort to situate NEC with the local traditions and scenery. Indeed the plan is in a beautiful part of Japan with mountainous terrain. Certainly not a typical place for a manufacturing plan.

C&C is viewed as a natural result of the fiber optics age. Components manufactured at the plan are wide ranging. They include:

- optical modules from electrical-to-optical and optical-to-electrical modules. They cover the 0.8, 1.3 and 1.5 μm range.

- fiber connectors

- "NEO" links. These are full modules used mainly for computers with an electrical input and processing. These allow to send signals several km optically.

- SAW filters and signal processors

- Optical interface modules for digital switches and transport devices with 10 km ranges.

- magnetic resistance (sic) sensors. Movement and rotation sensors and boiler flame strength sensors.

- optical waveguide switch. High speed switches for OTDR applications.

- function modules. For PBX and corporate network uses.

- various type of electrical connectors for sub assemblies

The plant is basically all new technology and an effort has been made to fully automate it. There is an automated warehouse, production line robots, full automatic detector module fabrication and testing, automated connector sub-micro machining by computer control and laser scribing and micro-welding. SEM and X-ray inspection are also available.

The central computer system (available to all employees) monitors each device throughout their process and fabrication. It is not fully automated, in many situations a worker may have to input the device parameter. There is 100% testing of all assemblies. This system is called ISS for comprehensive manufacturing Information System. The ISS also monitors expected vs actual performance and rates in near real time for quality control and statistics gathering. This information can be used by all employees at any time for speedy decisions.

There is also a TOP programme (Tactics for Ohtsuki Plant) to promote courses for the employees as well as good sports facilities. The TOP programme is aimed as an employee friendly programme for quality control, fusion of manufacturing concepts, cost reduction and planning system.

Most of the components required for the assemblies come from several NEC plants in Japan and overseas. Items such as fiber connectors are made at the plant from scratch and will typically take 2 to 3 hours from beginning to end. Electrical connectors are also made at the plan, which is unusual since these are large volume but low cost items. The response is that the needed technology for fabrication is quite similar to the rest of the activities and thus they can make many and maintain in-house cost down for these items.

The retooling time to switch to a new module assembly is of the order of two to three months. This is longer than a typical operation but is explained by the very high level of automation in the plant. That depends, of course, on the exact machining and module size. No great advantage in quick change over can be perceived for photonic modules, however. The basic structure has not changed much over the last few years but there is an increased demand for smaller and cheaper products in order to satisfy customers. At this time it is perceived that there is not much of a large market volume for optical devices in telco. This trend makes devices more expensive as over 200 types of laser modules with wavelength, power, fiber types, DFB, DBR, electronics, packages and connector combinations on 5 to 6 production lines have to be maintained. This is such that one week time is required for a typical specific type run at present volume level. Typically 15,000 modules per day will be produced.

Because of automation 2/3 of workers at the plant are for manufacturing and 1/3 are office workers. There is space reserved for a full doubling of capacity when needed as the building has been designed for it and land is reserved next to the present building. Of note however is that NEC has 5 manufacturing plants within 100 km radius at this time.

In particular, some systems of consideration manufactured here are the regenerative submarine systems and pig-tailed laser modules as well as amplifier modules including equalisers for optical receivers. Usually these also act as AGCs but sometime band equalisation is needed and available.

Most of the engineering and applied research for this plant are done at the Tamagawa plant. Central R&D is commissioned and paid for by technology transfers of relevance to the manufacturing plants. In the process the designated engineer will move with the product here (and hope to move back to the Tamagawa plant one day). Each division can order specific R&D from the Kawasaki plant in systems research and equipment development and thus control 30% of R&D budgets. Note a slide making the point well (20-5) showing the short 3-4 years lag time between lab demo and production for fiber communication systems. Also of note is that most of the "Hero" demonstrations are from the US but commercial implementations are shared between and with many Japanese companies.

A 1.8 Gbit/s systems with submarine cable is now in implementation and this is expected to be big business in the US too (see 17-5). NEC has many networks in there and 56 other countries. Of relevance for Canada is work on SHD SONET 622 Mbit/s high capacity transporter, digital cross-connects and multiplexer in networks.

In the near future 2.4 Gbit/s with optical amplifiers and heterodyne detection for long distances or 10 Gbit/s IM-DD with pre-amplification will be available from NEC.

One of the modules available is an Er-doped fiber amplifier (approx. 10 m long fiber) with a 40 nm bandwidth, 30 dB gain and 3 to 5 dB noise figure. Connector losses are kept in the 0.1 dB range. Working wavelengths are 1.53 to 1.57 μm.

Visit to factory

We only saw one (top) floor of the plant after visiting the cafeteria on the top floor (the view is superb even with fog in the mountains). It is obvious the plant is not working near maximum capacity (estm. 10% only). It is highly computerised and automated but very much in a demonstration mode. We were constantly interrupted in the clean room by automatic (singing!!) robots, carrying nothing at all, going on their rounds. However, the production capacity was there and workers were putting together many laser modules assemblies with Nd-YAG laser micro-welding in epoxy-less packages technologies. All are 100% tested in environmental chambers. We were shown a fully automatic laser to fiber coupling machine in a demo mode but they did not seem to be actively used as part of the production line. Although this is a pilot plant with a lot of show for visitors the potential output cannot be denied. NEC must be loosing money at this time but is well placed to step up production by several orders of magnitude when and if required. Whatever we think of will not be competitive if it can be made on this production line!

How about Real World computing (RWC)?

No real impact on NEC although they are a major force in mainframe computers. Most of NEC does not take this too seriously. There is a feeling RWC is going too far too fast. Unlike the VLSI project where the targets were well defined, and most importantly doable, this (RWC) is too vague.

OITDA is viewed as a way for NEC to make comments to MITI. OITDA committees for setting standards beneficial to Japanese industry is a desirable target. However, all these committees with university professors and senior company people for new technologies are not so effective. Anyway, why are many OITDA reports written in English, as is InterOpto? NEC is a member because MITI ask them to be. Networking and contacts are not important with MITI since NEC already have good contacts at conferences and international events anyway. Universities in Japan are eager to establish good contacts with industries and government help to do so is secondary. In NEC views MITI influence has decreased during the past decade, in addition MITI employees (others in government too) are prohibited by law from working in private industry. This is viewed as a negative by many Japanese industries.

Conclusion

NEC is a fairly successful large company with an independent attitude. The organisation is well thought through an includes committees overseeing internally the global directions of the company. For example, not shown on 20-4, there is a group of senior managers in computing and communications that meet regularly to advise directly at the chairman of the board level. Although people at the Tsukuba level have more freedom many of the R&D divisions have to be justified from the mainstream business lines of NEC. The investment in pilot plants such as the Ohtsuki plant is a risk but could be an indication on how seriously NEC views its future in communication and computing. Although the same size as Northern Telecom in telco applications the research investment and future manufacturing investment are of a greater scale. This does not take into account the computer and IC side of NEC business which, in the future, are very likely to be of prime importance.

Government contributions at NEC research are very small (as in most successful Japanese companies). NEC is contributing to MITI sponsored efforts, however; such as 3 projects in VLSI and 5th generation computers. The official position is that these projects are successful as they always end in success. For example hardware was the result of the latter although software was the mandate!

Documents Received:

20-1 This is NEC 1991 - NEC statistics summary
20-2 Guide to the Ohtsuki plant
20-3 Agenda for visit
20-4 NEC top management organization chart
20-5 Copies of overhead presentation

ANNEX E

BUSINESS CARDS OF HOSTS

Nov. 9/92

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