A Postcard from Taiwan

Charles W. Tu

While attending the International Conference on Electronic Materials (ICEM '94) held on the campus of the National Chiao Tung University, Hsinchu, Taiwan, December 19-22, 1994 (which was reported in the last issue), I took the opportunity to visit a number of laboratories. I shall describe first those in the Hsinchu area, home of the Science-based Industrial Park, then the Chung-Li area, which is half way between Hsinchu and Taipei, and finally the Taipei area. Contact information is included.

Hsinchu, Home of the Science-Based Industrial Park

Hsinchu is located in the northwestern part of Taiwan, about 40 minutes from the international airport and one hour from Taipei, the capital of Taiwan. The Science-based Industrial Park was established by the Taiwan government in 1980 to foster the development of high-tech industry – a "Silicon Valley" of Taiwan. The December 10, 1994 issue of the Sino-American Sci-Tech Newsbrief (published in Taiwan) reported that the gross income from the Science-based Industrial Park in Hsinchu reached over 4 billion US dollars in 1993 and is projected to be over 8 billion US dollars in 1995. It took 13 years to reach 4 billion US dollars, but will take only two years to achieve the second 4 billion. This growth rate is phenomenal indeed.

The Taiwanese government's goal is to have the Science based Industrial Park transformed from being Taiwan's Silicon Valley into a high tech centre for Pacific Asia.

Phase I and Phase II, within an area of about 940 acres and a total employment of about 22 000 people, were completed in 1980. Phase III (with an additional area of about 500 acres) has been started and is scheduled to be completed by the end of 1996.

About half this area will be for factories, and the rest for support services, including housing. A very interesting aspect of the Industrial Park is the large number of employees who have studied abroad.

They number over 1000, half of whom returned in the last three years. Many of them have had several years experience in America. Out of the 155 companies in the Industrial Park, 73 were started up by these people!

Industrial Technology Research Institute (ITRI)

A key ingredient in the success of these companies is technology support and transfer by various laboratories in ITRI. It was established in 1974 to accelerate the development of industrial technology in Taiwan by focusing on applied research in a wide range of fields.

ITRI has two main strategies for assisting the industrial sector in strengthening its technological capabilities. The first is to employ existing industrial technology to improve manufacturing processes and revitalize traditional products. The second is to assist the industrial sector in breaking into high-technology fields and manufacturing profitable new products. In 1993, for example, ITRI provided 19 000 cases of technical services to the local industrial sector. However, increasingly the focus of ITRI is on exploratory or pioneering technology.

ITRI has been funded by both government and private industries. In 1993 industrial research contract services accounted for one-third of funding, which amounted to 160 million US dollars, and government research projects sponsored by the Ministry of Economic Affairs accounted for two-thirds, or 330 million US dollars. The goal is for revenue from private industry be more than half of ITRI's total funding by the year 1997.

In terms of human resources, slightly over 6000 employees work in 11 laboratories, including

- Electronics Research & Service Organization (ERSO),
- Opto-Electronics & Systems Laboratories (OES),
- Computer & Communication Research Laboratories,
- Materials Research Laboratories (MRL),
- Union Chemical Laboratories,
- Energy & Resources Laboratories,

About 18% of the employees are graduates of junior colleges; 26% have bachelor degrees; 36% master degrees; and 9% Ph.D.'s. Over 60% have over 5 years of experience. The turn-over rate is relatively high because so many start-up companies in the Industrial Park need experienced scientists and engineers. This is really another form of technology transfer.

A technology achievement that was referred to by Dr. Morris Chang in his key-note address at ICEM '94 is the establishment at ERSO of a class 0.1 (based on 0.3 μm particles) clean room for 8-inch Si wafer processing (making Taiwan the fourth country in the world to possess 8-inch wafers), development of 0.7 μm and 0.5 μm process technologies, installation of 0.5 μm and 0.35 μm 8-inch wafer process equipment with independently designed piping and layout, and successful development of 16 DRAM with 5 V external power supply and 3.3 V internal voltage.

According to Dr. Li-chung Lee, Director of MRL (who spent about 20 years at IBM) there were about 200 projects on electronics-related materials in 1993, including welding and fusion, light alloys, shape memory alloys, biomaterials, and optoelectronic materials, and in 1994 there is the initiation of a 5-year plan on ICs, amorphous Si devices, compound semiconductors, communication devices, optical storage, display, micro machining, packaging materials, and synchrotron applications, which I shall describe later.

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Drs. Minghuang Hong, Li-Chung Lee, and Charles Tu, in the MOCVD room at OES.

Opto-Electronics & System Laboratories (OES), ITRI

I have visited the III-V department in OES three times in three years. OES is doing R&D on optical and magnetic information storage technologies (*e.g.*, 128-Megabyte magneto-optic disk drive, CD-ROM, 3.5-inch, 240-Megabyte magnetic hard disk drive, etc.), color printing, optical devices (lenses), fibre optic passive components (coupler, attenuation), E-O image capture, and optoelectronic materials and devices.

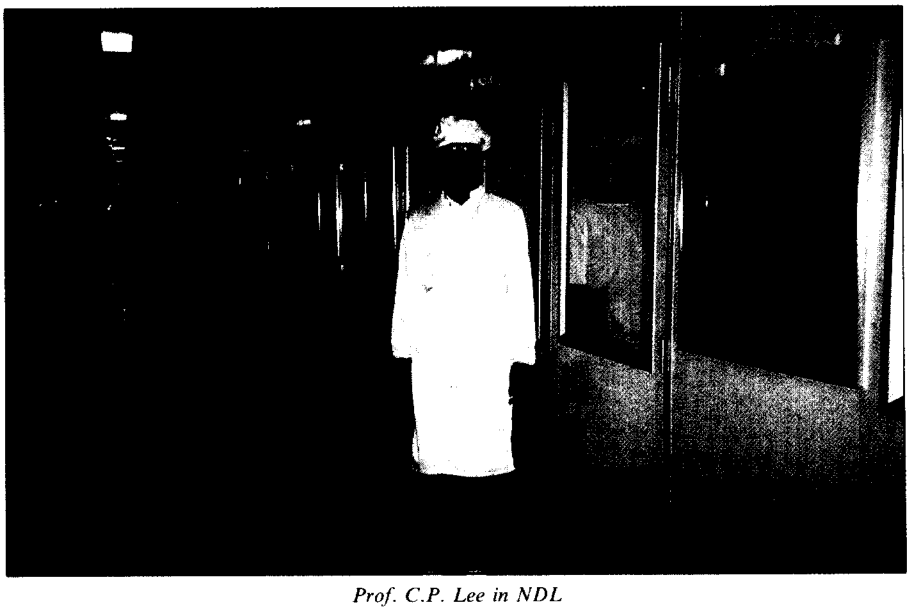
The last area, which used to belong to the Materials Research Laboratories until last year (and is more interesting to myself and the readers of this magazine) has transferred GaAs substrate fabrication technology to local industry for the application of LPE growth of high brightness AlGaAs LED and OMVPE growth of high brightness AlGaInP LEDs and laser diodes; and developed large-scale GaP substrate fabrication technology for the application of VPE growth of GaAsP LED's. Packaging is also under development.

My hosts were Drs. Minghuang Hong and Li-Chung Lee. Dr. Hong obtained his Ph.D. from Berkeley and worked in Dr. Leroy Chang's group at IBM for 8 years before joining MRL last year. He is in charge of a new group on exploratory technology in compound semiconductors. Dr. Lee obtained his Ph.D. under Professor Jerry Stringfellow at Utah and is in charge of three MOCVD reactors (Thomas Swan, EMCORE, and Aixtron). Their projects centre around GaAs and InP-based compounds for light-emitters. Not surprisingly blue LEDs are on their list of future projects.

National Nano Device Laboratory (NDL)

NDL, located on the campus of the National Chiao Tung University and adjacent to the Hsinchu Science-based Industrial park, is one of seven national laboratories operating under the aegis of the National Science Council.

Planning was initiated in 1988, and the basic form of the present laboratory was completed in May 1992. It is opened to qualified users with the aim of conducting research on sub-0.35 μm technology, training re-



Prof. C.P. Lee in NDL

search personnel, and advancing the technological level of the local semiconductor industry. My host was Professor C.P. Lee of Chiao Tung University, who was at Rockwell Science Centre for many years before becoming the first director of NDL. The current director is Professor C.Y. Chang, the first Taiwan-produced engineering Ph.D., and a powerful figure in Taiwanese R&D.

NDL is one of the most well equipped and advanced semiconductor research facilities in the world. The clean room area consists of a class 10 laminar flow area with 3000+ square feet, which houses e-beam, stepper, dry etcher, ion implanter, etc.; a class 1000 area with 4700 square feet, which is used as an air return path for the class 10 area and houses special gas and chemical supply; and a class 10 000 area with 18 700 square feet, which is a general fabrication area for silicon and compound semiconductor devices. As in ITRI, most of NDL deals with silicon, but there are some activities in SiGe too.

For compound semiconductors Professor C.P. Lee is in charge of a Varian GEN-II MBE system for different device projects, including quantum wires, and Professor C.Y. Chang's lab has MOCVD reactors for SiGe and III-Vs. Projects in development at NDL include deep submicron CMOS device technology, Si- and SiGe-based monolithic integrated circuits (MMICs), and 0.1 μm electron beam lithography.

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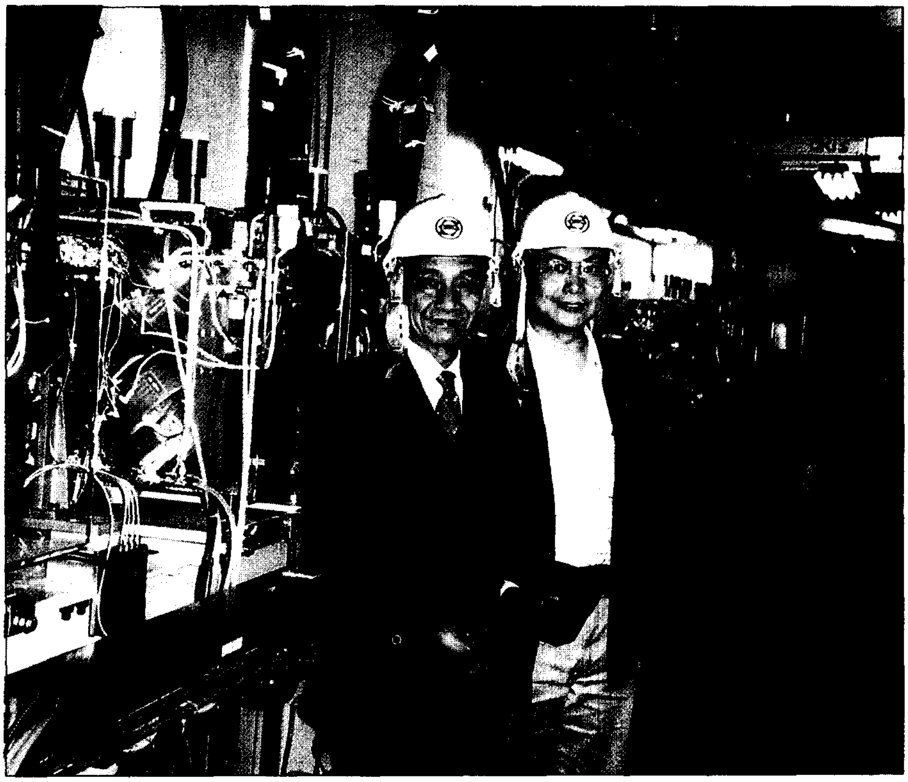
Synchrotron Radiation Research Centre (SRRC)

My host at SRRC was Professor Poh-Kun Tseng of the Physics Department of the National Taiwan University in Taipei. He is a founding member of SRRC, which is also located in the Science-based Industrial Park.

It was conceived in 1981; construction began in 1988 and completed in 1993, costing about 100 million US dollars (which is a modest amount for synchrotrons). Except for the injection linear accelerator, which was contracted out to Scanditronix AB of Sweden, the booster, transport line, and the 120-metre-diameter 1.3 GeV electron storage ring were designed and constructed in Taiwan, a veritable achievement.



Profs. Poh-Kung Tseng and Charles Tu inside the storage ring of SRRC.

The storage ring is supposedly the third operating "third generation" synchrotron in the world, which means that it is designed to be optimized for the use of bending arc sources and insertion devices (wiggler and undulator) to boost the flux and brilliance. (According to Professor Slade Cargill of Columbia, however, although its undulators and wigglers were installed after the completion of the synchrotron, the "second generation" Brookhaven National Light Source has a higher brilliance.) The critical photon wavelength is 8.89 =C5 (10 keV). There are three beam lines with experimental stations, mainly performing VUV and X-ray photoelectron spectroscopy, and another long straight section for undulators and wigglers. There are about 100 staff members and 100 additional users, including a group from Sweden.

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Telecommunication Laboratories (TL)

I visited Telecommunication Laboratories, Ministry of Transportation and Commerce through Professor Guo-Chung Chi, a professor in the Physics Department, National Central University, which is near TL in Chung-Li, half way between Hsinchu and Taipei. (Professor Chi was the Director of the Optoelectronic Materials and Devices Division, ITRI until last August and had about 15 years of experience in the US).

Our host was Dr. Yuan-Kuang Tu in the Photonic Technology Research Section. In his charge is a Thomas Swan MOCVD reactor. Projects include InGaAsP 1.3 μm and 1.55 μm DFB lasers, high-speed InGaAs/InP PIN photo detectors, etc.

The materials/device effort involves about 60 people. The Telecommunication Laboratories function like Bellcore, in that they work on the technologies that are necessary for qualifying telecommunication components and systems so that they can provide timely advice on technology issues to systems people.

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Institute of Atomic and Molecular Sciences (IAMS)

Finally, I would like to introduce IAMS, situated inside the Taiwan University, even though it does not deal with III-Vs, because it illustrates the current trend in the development of research in Taiwan.

In 1982 a group in Academia Sinica led by Dr. Yuan-Tseh. Lee, (he was a professor at UC Berkeley at the time (Dr. Lee later became a Nobel Laureate in chemistry and returned to Taiwan in 1993 to become the President of Academia Sinica), recommended that IAMS be founded as an advanced institution for fundamental research related to atomic and molecular sciences. The institute's new building was completed last year.

IAMS is designed to provide young scientists with an excellent auxiliary education opportunity. Such a highly interdisciplinary institute is expected to promote collaboration amongst scientists from various institutes of Academia Sinica and universities in Taiwan, and to emphasize international exchange and co-operation.

There are about 25-30 permanent researchers, some of whom are also university professors. About one-third have many years of research experience abroad. A case in point is my host, Dr. Tung Jung Chuang, who just returned to Taiwan from a 25-year career in the IBM Almaden Research Centre in San Jose, California. IAMS currently has research groups engaged in the investigations of photochemistry and molecular spectroscopy; extensive laser facilities; molecular reaction dynamics; condensed matter, surface science and theoretical atomic/molecular sciences. In particular, Dr. Chuang's group is studying CVD of diamond films, dynamics of surface photochemistry and chemical interactions on diamond. The rest of the research staff are quite young, usually having spent two or three years of postdoctoral fellowships after obtaining their Ph.D.'s in the U.S. By chance, I also met a friend from my Yale days more than 20 years ago, Prof. Keh-Ning Huang, a theoretical atomic physicist.

Profs. G.C. Chi and Charles Tu at the National Central University.

A note-worthy observation is that I saw a number of foreign researchers at IAMS, who comprise about one quarter of the 30 postdocs, attesting to the internationalization of scientific research in Taiwan.

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