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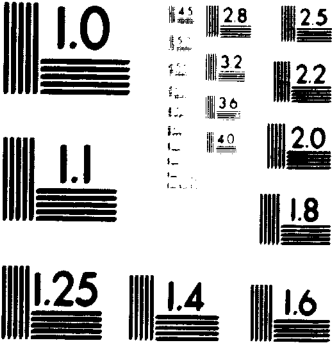
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



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SEMICONDUCTOR MATERIALS TECHNOLOGY

DP/ROK/75/019

REPUBLIC OF KOREA .

Terminal report *

Prepared for the Government of the Republic of Korea
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations
Development Programme

Based on the work of Yoon Soo Park,
Consultant in Gallium-Arsenide Materials Technology

United Nations Industrial Development Organization
Vienna

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Abstract

Post Title: Consultant in Gallium-Arsenide Materials Technology

Duty Station: Korea

Duration: Phase IV (April 9-May 7, 1984)

Objective: To assess the technical progress and accomplishments of the UNDP-UNIDO assisted semiconductor materials technology program. To advise and assist the technical staff of the Semiconductor Materials Laboratory of the Korean Advanced Institute of Science and Technology in the preparation of the final report to UNDP.

Conclusions: Steady progress has been made in achieving the goals set forth in the Semiconductors-Materials-Technology Program of UNDP. The growth technology of Si and GaAs single crystals and GaAs epitaxial layers has been established for the first time in Korea. The quality of Si and GaAs materials grown at KAIST is comparable to that of the crystals available in the world market.

Recommendations: Although the initial aim of the program has been brought to fruition, additional and continuing support from UNDP is needed in establishing adequate and competitive research efforts to cope with technological advances being made in advanced countries. The characterization capabilities at KAIST should be expanded and strengthend.

I. INTRODUCTION

Since the initiation of the project in March 1979, the project has been progressing with the cooperative efforts of UNDP and KAIST personnel. Although some difficulties in the procurement of equipment and in the training of the personnel were encountered, impressive progress has been made in the growth of both Si and GaAs single crystals and the epitaxial layers of GaAs, in the establishment of material characterization facilities, in the transfer of materials growth and processing technologies to domestic industries, and in the collaborative efforts in the materials characterization and device fabrication activities with universities and research institutions.

For the first time in Korea, defect-free, high-quality silicon single crystals of 3-4 in. diameter and high-purity, GaA single crystals of 2 in. diameter and GaAs epitaxial layers by both Vapor Phase Epitaxial (VPE) and Metalorganic Chemical Vapor Deposition (MOCVD) techniques have been grown by KAIST scientists and technicians.

II. ACTIVITY AND OBSERVATIONS

A. Activity

The specific purpose of my phase IV mission was to assess the technical progress and accomplishments of the UNDP-UNIDO assisted Semiconductor Materials technology program and to advise, assist the technical staff of the KASIT-SML in the preparation of the final report to UNDP.

During my stay at KAIST from April 9-May 7, 1984, I examined and reviewed carefully all the crystal growth, processing and characterization facilities and activities. I read the interim progress reports of KAIST-SML to UNDP-UNIDO and the Korean government on the UNPD-KAIST Project and the research publications in scientific and technical journals and meetings. I analyzed the data and findings of the KAIST-SML staff members on the growth, processing and characterization of Si and GaAs materials.

By the time of my departure, the first draft of the final report to UNDP was completed. On May 4, 1984, I briefed Mr. Fabrizio Ossella, Deputy Resident Representative, UNDP, on the content of the first draft and the progress of the project.

In addition to the activities at KAIST-SML, I delivered a seminar on "Materials Analysis by Ion Beam Techniques," at the Jungbuk University on May 5, 1984.

B. Facility

With the support of UNDP, KAIST-SML acquired certain pieces of equipment essential for the growth processing and characterization of Si and GaAs. The following facilities are established during the project period:

- Silicon Crystal Growth Facility

The Facility is equipped with a Czochraliski silicon puller which has a capacity to grow a single crystal of 6 in. diameter and 20 Kg in weight.

- GaAs Crystal Growth Facilty

The Facility houses a horizontal Bridgman (HB) grower, a research Vapor Phase Epitaxial (VPE) reactor and a Metalorganic Chemical Vapor Deposition (MOCVD) growth system.

- Wafer Processing Facility

The Facility is equipped with a surface grind machine, ingot slicer and wafer polishing machine. In addition, processing equipments used for wet etching, chemo-mechanical polishing, bonding, annealing and cleaning have been installed.

- Materials Characterization Facility

The facility is furnished with up-to date instruments for measurements and analysis for physical, electrical and optical properties of grown crystals. These include:

- C-V plotter
- Spreading-resistance measurement system
- Non-contact thickness meter
- Non-contact resistivity meter
- Optical microscopes
- Electrical conductivity and Hall measurement system
- X-ray single crystal analyzer

All equipment was carefully selected in light of potential elctronic-device requirements by Korean industries. Installation of the above facilities, modification of the existing facilities, and acquistion of new equipment were absolutely necessary for the implementation and success of the materials growth program.

C. Silicon Semiconductor Materials

In order to develop single crystal silicon growth technology, KAIST-SML installed the Czochralski Silicon Puller and made successful test runs in November, 1980.

Four test runs were made. These were the first silicon single crystals grown in Korea and two 3-in. diameter single crystals were free of crystalline defects.

Since the first test runs, the staff of SML has been routinely pulling Si boules of 3-4 in. diameter. As of 30 April 1984, about 50 boules of varying sizes and lengths were produced.

D. GaAs Materials

The crystal growth facility for the HB technique has been completed in December, 1981 and by December 1982, the eight growth runs of undoped GaAs using a 1-in. boat had been made.

Though many difficulties were encountered during the course of crystal growth, the problems were resolved one by one and the growth technique was perfected. One of the difficulties was the breackage of the grown crystals and silica boats at the end of the run due to boat wetting. The causes of boat wetting were traced and undoped GaAs bouls of 2-in diameter are now routinely grown in the laboratory. As of June 30, 1984, about 5 boules of 2-in diameter have beeen grown.

In recent years, metal organic chemical vapor deposition (MOCVD) to grow epitaxial compound semiconductors has generated great interest and activity because of many advantages such as flexibility, high purity, ease of fabrication of multilayer structres, sharper junction abruptness, larger area and adaptability to mass production.

The MOCVD reactor system were delivered in July, 1981 and has been operational since the spring of 1983. Epitaxial layers of uniform thickness were obtained. As of June 30, 1982, a total of about 70 runs have been made.

The vertical vapor phase epitaxy (VPE) reactor, which can provide epitaxial layers of GaAs1-x Px for LED fabrication, has been installed and tested. The reactor is based on the hydride VPE technique ($Ga-HCl-AsH_3-PH_3-H_2$).

The system was delivered in July, 1981. However, many parts in the reactor were damaged or missing during shipping. Full operation of this reactor was delayed until damage/missing parts were repaired/replaced. The final test run was made in April, 1984.

E. Cooperative Efforts

The purpose of the project was to acquire and develop the technologies needed for the production and processing of Semiconductor materials by domestic industry. The transfer of semiconductor materials and processing technology to industry was strongly emphasized.

Efforts to transfer semiconductor materials and processing technology to industry has been intensified. In addition contacts have been made regarding utilization of the KAIST grown materials, devie processing and fabrication. Wafers from KAIST were made avilable in reasonable quantities to all interacting organizations -- universities, research institutes, and industries--for evaluation and use. Flow of information amond the interacting organizations were established.

Feedback of information, from materials characterization to crystal growth and from device processing and testing and, in the opposite direction, from crystal growth to materials characterization to device processing and testing will form an essential basis for future activities regarding technology transfer.

III. SUMMARY AND RECOMMENDATION

In the UNDP project document, ROK/75/019, the need for establishing local semiconductor was justified. To develop a more sophisticated technology intensive electronic industry from the simple assembly-type industry, it was stressed that the new materials technology program in Si and GaAs should be initiated as quickly as possible. If the Korean electronics industry is to remain competitive in the world market, it is imperative that the domestic industry become self-sufficient in the production and processing of semiconductor materials.

Since the initiation of the project in March 1979, the project has been progressing with the cooperative efforts of UNDP and KAIST personnel. Although some difficulties in the procurement of equipment and in the training of the personnel were encountered, impressive progress has been made in the growth of both Si and GaAs single crystals and the epitaxial layers of GaAs, in the establishment of material characterization facilities, in the transfer of materials growth and processing technologies to domestic industries, and in the collaborative efforts in the materials characterization and device fabrication activities with universities and research institutions.

For the first time in Korea, defect-free, high-quality silicon single crystals of 3-4 in. diameter and high-purity, GaA single crystals of 2 in. diameter and GaAs epitaxial layers by both Vapor Phase Epitaxial (VPE) and Metalorganic Chemical Vapor Deposition (MOCVD) techniques have been grown by KAIST scientists and technicians. The quality of Si and GaAs materials grown at KAIST is comparable to that of the crystals availabe in the world market.

Although the inital aim of the program has been brought to fruition, additional and continuing support from UNDP is needed in establishing adequate and competitive research efforts to cope with technical advances being made in advanced countries. The characterization capibilities at KAIST should be expanded strengthened. (Refer to recommendation of my report to UNDP dated November 1981.)