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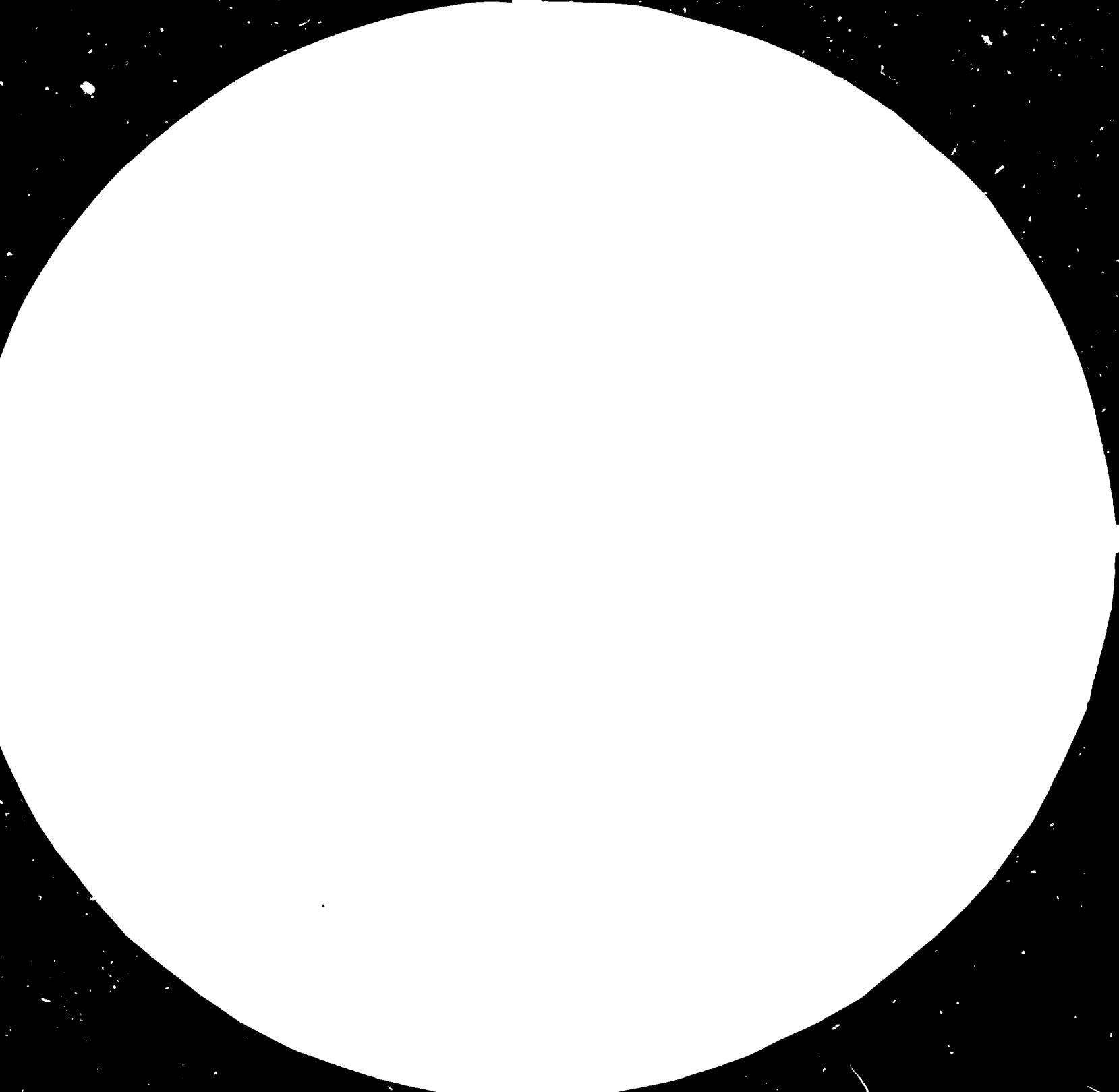

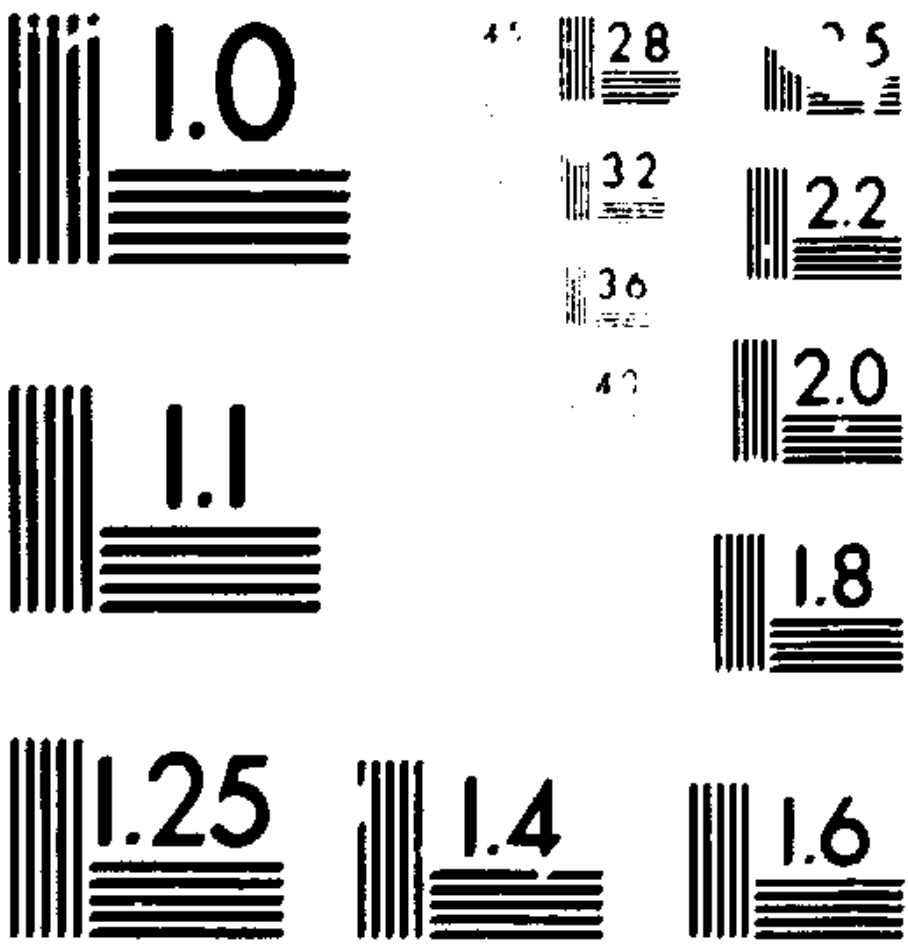

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SEMICONDUCTOR DEVICES AND ELECTRONIC SUB-SYSTEMS FOR TRANSPORTATION

DP/IND/84/015

INDIA

Technical Report: Semiconductor Devices for Transportation Equipment*

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

Based on the work of H.L. Hartnagel,
Expert in Semiconductor Devices

United Nations Industrial Development Organization
Vienna

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1. Introduction

Since I was involved with a previous UNDP project at CEERI as CTA (IND/72/047), it was easily possible to immediately involve myself effectively with all the parts of the present UNDP project, particularly because I was engaged in its initial formulation discussions in 1981. It was therefore also a great pleasure to see that further significant progress has been made in all the relevant areas during the intermediate period. Therefore I am convinced that also this project will become a very successful effort for the important Indian requirement of electronics towards an efficient transportation system.

2. Briefing in Delhi

My flight from Frankfurt in W. Germany brought me to Delhi very early (at 6.00 a.m.) on Sunday morning, the 17 February, 1985 with the possibility to adjust myself to the time change during that Sunday.

It was a great pleasure to meet on that afternoon at CSIR Science Centre (where I was lodged in) Dr. Amarjit Singh, with whom I had collaborated very closely during the previous UNDP project to CEERI, and who on that day was being felicited by several associations in Delhi in connection with the National Award of Padam Bhusan, announced on the Republic Day by the President of India. We were able to have initial discussion in connection with the present status of CEERI's work concerning transportation electronics.

On Monday morning, I was then with the UNDP Office in Delhi for briefing from where I obtained further details regarding my work as Consultant with CEERI.

In the afternoon, I was able to visit CEERI Extension Centre, New Delhi, where the facility of the Applicon CAD system for IC circuit and pattern generation was installed under the last UNDP project. This represents an important item of equipment also for the present project. It was useful for me to see that the software developments there have reached quite a mature stage.

I had the honour then in the evening to be driven by Dr. Amarjit Singh personally in his own car to Pilani.

3. Total Project Co-ordination

After a systematic review of all the activities underway in connection with the UNDP project with Dr. Amarjit Singh, and Dr. G.N. Acharya, the Acting Director of CEERI, a detailed framework for my consultancy period was drawn up. A first concern was to particpate at meetings where the total UNDP effort was continually co-ordinated. Such co-ordination has of course already been an ongoing concern at CEERI. It was decided that the members of these meetings are Dr. Amarjit Singh, any UNDP consultant who is at Pilani, the Director of CEERI (Dr. Acharya), and all the group leaders involved in the UNDP project or their representatives. The capabilities of CEERI have reached a significant level of competence, to a large extent due to the previous UNDP project. These are Si power Darlingtons for 100A whose development work is almost completed. The CAD group and the MOS technology group completed successfully ICs such as counters and ring oscillators consisting of /up to around 500 transistors. The thick film technology group has obtained the space-quality certificate from ISRO (Indian Space Research Organization) for their various hybrid circuits of substantial sophistication. All this is now to be co-ordinated as an ongoing effort with the electric-motor control development for transportation of the relevant control group, which has achieved a full realization of an electronic system using printed circuits. This first realization is at present under test in collaboration with Indian Industry. It needs to be reduced of course in size to make it attractive for the many applications in transport vehicles, and thus miniaturisation is to be undertaken by the above groups within the UNDP effort.

The first meeting for co-ordination made a number of important decisions regarding the next stages of each of the participating groups. The Hybrid IC realization is now to be undertaken by the

n-MOS CAD and technology groups concerning several dedicated monolithic chips (where the imminent consultancy of Prof. P. Jesper will be of great value), the thick film group (particularly after the development which is still required for a power thick film technology) and the control groups. Simultaneously, various other types of power semiconductor devices are under consideration, as required for the motor-control circuits.

4. Advice on Problem Cases

A major part of my activity was of course concerned with specific help concerning various problem cases. It is understandable that particularly in every good research establishment such problems are uncovered and subsequently solved regularly and it may be said that CEERI's staff is very effective to use their consultants to assist in finding the necessary solutions. Among other items, the following examples are to be mentioned here. Dr. S. Ahmad has achieved very promising silicide films by alternate layer evaporation in an ultra-high vacuum system (Silicide films are important to obtain fine geometry in Very Large Scale Integrated Circuits). We considered the question of microstructures occurring there which would not be observable with the averaging Auger technique he employed for the analysis.

Similarly, he had interesting results of Cu inclusion into Al by this layer evaporation for the prevention of electron-wind effects and we discussed further extensions of this work. For example, for GaAs electrodes when, however, Cu has to be replaced by some suitable other material. Simulation studies took a large place during my discussions with Dr. Ahmad concerning spreading resistance configurations and possible further extensions.

Another example of advice given was a discussion of the thick film circuit development for the difficult frequency range from 0.1 to 1 GHz.

On the other hand, it might also be appreciated that there can be particular difficulties in a country of rapid development, such as occasional power failures, problems of the speedy supply of relevant gases such as silane and ultrapure oxygen.

Regarding overcoming the problem of power interruptions, CEERI has installed a standby capacity of 1 MW; concerning delays in clearance of gas cylinders at Bombay Docks, CEERI sends its own representatives to Bombay to expedite delivery. This can cause unfortunate delays in the development work. The help provided by the local UNDP Office being able to place expeditious orders and to follow up is much appreciated.

5. Formal Presentations

I was asked to give formal lecture presentations to the CEERI staff in connection with my particular experience. My first talk concerned therefore the problem of metal-electrode stabilities in transistors and ICs concerning high device reliabilities. This presentation triggered a lively discussion. It stimulated the thick film group in particular to show me afterwards the problems of some ISRO temperature testing on some purchase UD ICs which were incorporated here into their thick film circuits. It is hoped that the suggestions made concerning a systematic evaluation approach of this phenomenon will help this group to clarify this complex problem.

Another presentation concerned wave propagation characteristics for high-speed transistors and ICs. This is particularly relevant to several groups where such effects were observed and studied..

Towards the end of my time in Pilani, I was asked to give two review presentations with subsequent discussion on the different Si and GaAs technologies and on the various surface analytical techniques available.

Of course, it should also be mentioned here that a number of discussion meetings were held with several groups of people involved with more specialised aspects of research and development work or in connection with equipment selection. These concerned for example, Plasma assisted CVD and Epitaxy; Molecular Beam Epitaxy, Wave Diffraction of Submicron Photoresist Patterns; GaAs- Microwave Power FETs, etc.

6. Video Presentation of Selected Aspects of Technology

It was felt that the production of a series of video programmes for distribution to Universities concerning post-graduate studies to industrial laboratories to train their staff and to other government laboratories would be valuable since CEERI has now staff with excellent technology experience and a division concerned with video developments where complete T.V. studio facilities are available. I volunteered to explore the possibility of making a first of such films so that CEERI staff can be encouraged to subsequently produce other parts along similar lines.

I decided to select for this video talk the subject of the technology of etching since I have detailed experience on this. Drawings were sketched by me and made in colour by one of the Draftsmen of CEERI. The 20-minute program turned out to be quite successful, so that it is hoped that other CEERI staff can now follow the method of presentation chosen and produce similar programs on their speciality of technology.

7. Fellowship Placements

An important concern is the assistance in finding suitable placements for fellowship training under UNDP. In fact, help is required in connection with the following placements of CEERI staff members:

1. Dr. D.K. Thakur in Power Transistor Technology where various possibilities of my help were explored.

2. Dr. S.K. Bhatnagar in Power Hybrid Technology.
This is possibly to be combined with the training in the laser trimmer to be delivered soon. Also here, my help of telephonic enquiries in Europe is needed.

3. Dr. S.N. Gupta in Mask Making.
This placement will probably now be in the USA.

8. Discussion at CSIR Headquarters/and visit to Delhi University

Since Mr. K.N. Johry of the CSIR Headquarters in Delhi was interested in a discussion with me about the UNDP Project and a planned bilateral project between CEERI and my Institute in Darmstadt, I travelled to Delhi for the weekend of 2 and 3 March. This was a convenient time because CEERI works 5 days a week (Saturdays and Sundays are holidays) whereas the Saturday is a working day at CSIR headquarters. Additionally, it enabled me to have discussions with various staff members of the University of Delhi about their research and teaching work. There has been for many years now close collaboration with these University people, resulting in many joint publications and numerous visitors to my laboratories in Darmstadt, etc.

It was particularly interesting for me this time to discuss the new Faculty of Inter-Disciplinary and Applied Research on the South Campus of the University of Delhi, particularly in connection with the new Department of Electronic Science, staffed by some of the Professors and Readers from the old Department of Physics and Astrophysics. It is impressive to see the plans of substantial research acquisitions in the fields of an MSI - Monolithic IC Technology, Microwave Circuit Design and Analysis and others, with assistance of the Department of Electronics in India.

Concerning my meeting with Mr. Johry all the relevant aspects of the progress of the present UNDP project were discussed. The bilateral project is now worked out. It concerns the development of an advanced GaAs technology, particularly regarding power amplifiers and ICs at microwave frequencies. The German financial contribution will be made by the German Ministry of Research and Technology (BMTT).

9. Conclusions and Recommendations

The project is very competently pursued, its short-term aims are clearly defined now and the problems which still remain will most likely be solved in the course of the work.

It will be necessary for CEERI to continue the regular co-ordination meetings in order to ensure a well co-ordinated approach to its project of Transportation Electronics. Every effort must be made to avoid if at all possible, the delays in the provision of essential consumables such as the imported gases mentioned above.

I should like to wish CEERI and its staff further good success in their work and should like to thank them most sincerely for an enjoyable (although often tiring) consultancy period.