

# Physics of Semiconductor Devices

PROCEEDINGS OF THE  
INTERNATIONAL WORKSHOP  
NOVEMBER, 1981  
NEW DELHI, INDIA



EDITORS  
**S C JAIN**  
**S RADHAKRISHNA**

A HALSTED PRESS BOOK

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## PREFACE

The activity in the field of science and technology of silicon and other semiconductors started late in India. However, it grew rapidly in the last decade. Considerable work has been done in this field at the Solid State Physics Laboratory of the Ministry of Defence, Delhi. Technologies of Space Quality Solar Cells, Gunn Diodes, Semiconductor Laser Diodes and Integrated Circuit Chips up to the level of MSI have been developed at the Solid State Physics Laboratory. Notable work has also been done at IIT Delhi, IIT Kanpur, Tata Institute of Fundamental Research, Bhabha Atomic Research Centre, Central Electronics Engineering Research Institute, and other institutions in India. Apart from the technological achievements, important contributions have been made by the scientists of the Solid State Physics Laboratory and by other scientists in India in the understanding of the physics of semiconductor materials and devices. The year 1981 was, therefore, an appropriate time to hold an International Workshop on the Physics of Semiconductor Devices in India.

International Conferences on semiconductor devices are held every year in developed countries. In fact, three such conferences are held every year in the USA. This is the first time that International Workshop on the Physics of Semiconductor Devices was held in India. The workshop was sponsored by COSTED (Committee on Science and Technology in Developing Countries). Among those Indian scientists who supported the idea and provided encouragement are Dr. P.P. Gupta, Prof. M.G.K. Menon, Prof. R. Ramanna, Prof. S. Sampath and Dr. G.S. Sidhu. Several distinguished scientists from other countries were members of the International Advisory Committee and helped in evolving a good technical programme for the Workshop. Names of some of them are given on page xii, and the names of others are H. Beneking, R.W. Brander, D.L. Feucht, H.L. Hartnagel, H.J. Hovel, W.G. Oldham, Z.J. Staszak, T. Sugano, W. Winstel and A.E. Yunovich.

A total of 365 scientists and technologists participated in the Workshop. These included 66 scientists from Australia, Belgium, Canada, France, Italy, Japan, Netherlands, Poland, Romania, Sweden, Spain, UK, USA, USSR and West Germany. Several scientists from developing countries like Bangladesh, Malaysia, Singapore and Vietnam also participated.

A questionnaire was circulated to the participants and they were asked to send replies to assess the success of the Workshop. All replies were unanimous in that the Workshop was well organised and was very useful to the scientists from both the developing as well as the developed countries. One of the delegates said 'I consider the Workshop a rare event in the scientific activity of this country'. Similar sentiments were expressed in the Press.

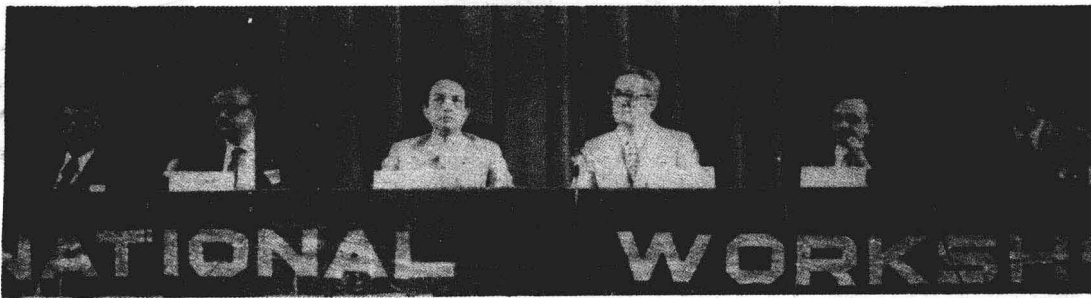
A major part of the Workshop was devoted to VLSI, MOS, Bipolar Devices and Photovoltaic Devices. While answering the

questionnaire, some delegates said that the Workshop should have been restricted to fewer topics, whereas others said that some topics like Opto-electronics, Amorphous Silicon and Microwave Devices should also have been included. One criticism that has been made of the Workshop is that the programme was too crowded. There should have been more free time for informal discussions. One of the reasons that the programme became crowded was that the response to my invitation was overwhelming, beyond our expectations.

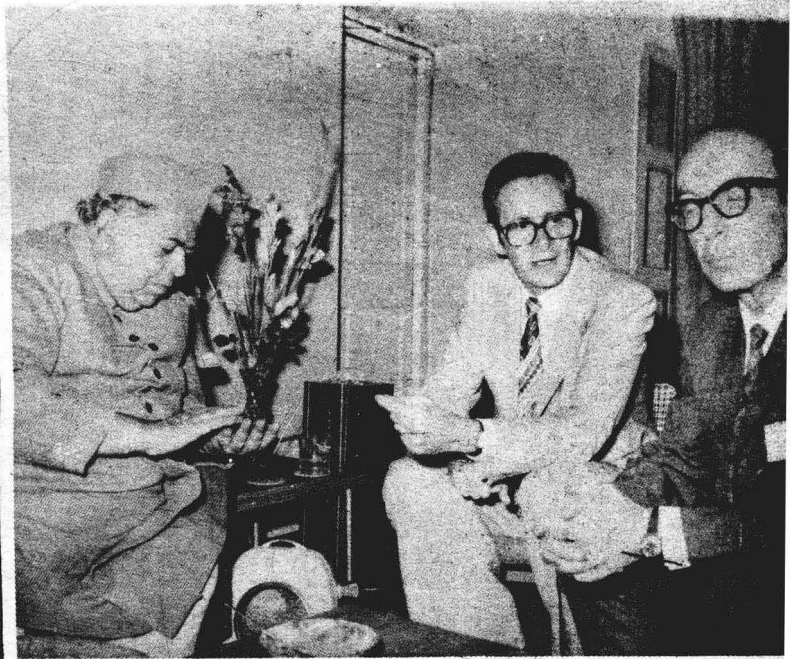
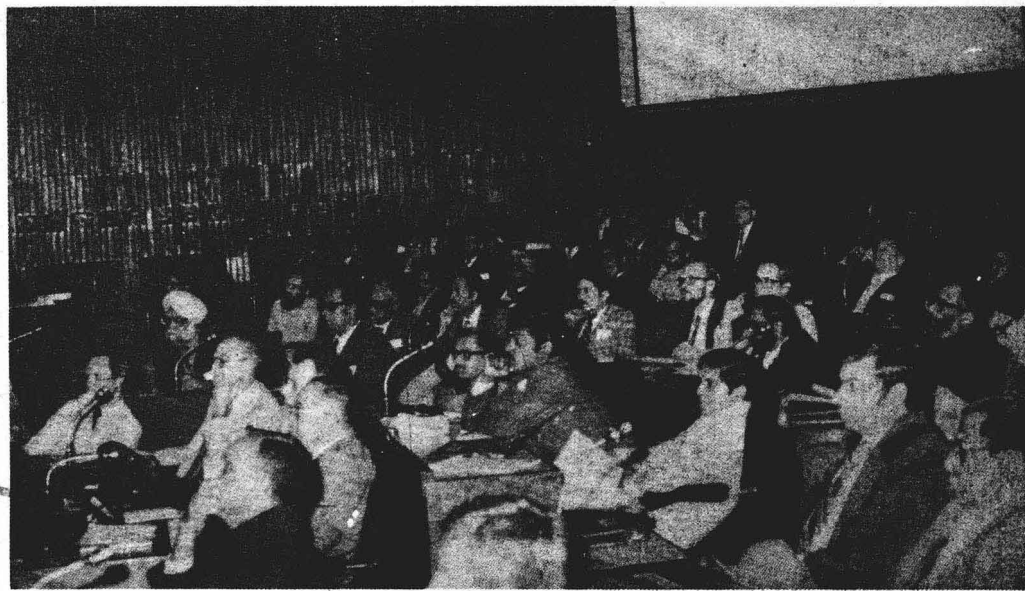
I am glad that the Workshop was successful and that Prof. S. Radhakrishna and I are able to edit and bring out these proceedings. It is hoped that the proceedings will be useful to researchers in the field of semiconductor devices.

*Solid State Physics Laboratory  
Lucknow Road, Delhi-110007  
India*

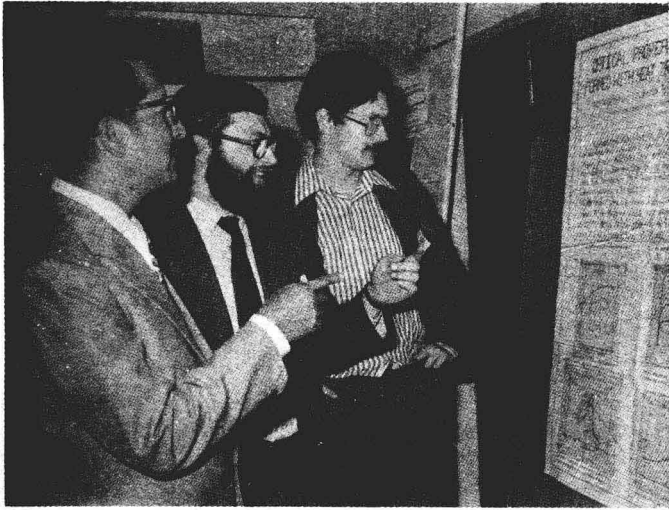
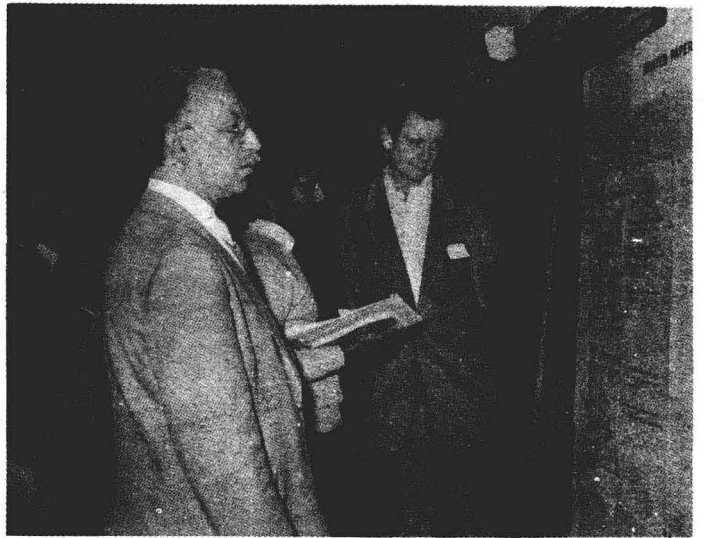
S.C. JAIN  
Workshop Chairman











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Committee on Science & Technology in Developing Countries (COSTED) of International Council of Scientific Unions (ICSU)

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	1430-1800 Hrs.	PLENARY SESSION	R.P. MERTENS V.M. TUCHKEVICH*
TUESDAY 24-11-81	0845-1100 Hrs.	PLENARY SESSION	J.L. MOLL B.D. NAG CHAUDHURI
	1130-1330 Hrs.	SESSION I SESSION II SESSION III	L.S. KOTHARI A. SILARD D. REDFIELD*
	1430-1730 Hrs.	SESSION IV SESSION V SESSION VI	CHATAR SINGH PREM SWARUP K.R. PARAMESVAR
WEDNESDAY 25-11-81	0845-1100 Hrs.	PLENARY SESSION	S. RADHAKRISHNA K.W. BOER
	1130-1330 Hrs.	PLENARY SESSION	S. DEB B.A. JOYCE
	1430-1615 Hrs.	PLENARY SESSION	J. NISHIZAWA R. KASSING*
THURSDAY 26-11-81	0845-1100 Hrs.	PLENARY SESSION	K.N. MATHUR J.J. LOFERSKI
	1130-1330 Hrs.	PLENARY SESSION	S. SAMPATH T.J. COUTTS
FRIDAY 27-11-81	0830-1300 Hrs.	POSTER SESSIONS	SORIN CRISTOLOVEANU R. SHARAN S.K. KRAWCZYK
	1430-1815 Hrs.	PLENARY SESSION	E.L. HEASELL* A.K. SREEDHAR
SATURDAY 28-11-81	0845-1100 Hrs.	PLENARY SESSION	R. VAN OVERSTRAETEN* AMARJIT SINGH
	1130-1330 Hrs.	PLENARY SESSION	A.W. PENN M.G. RAO

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\*Members of International Advisory Committee.

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Effect of Heavy Doping Drift Field, High Injection and Photo Generation of carriers on the Open Circuit Voltage Decay and Switching Time of p-n junction diodes.

S. C. Jain  
Solid State Physics Laboratory,  
Lucknow Road, Delhi-110007, India

#### ABSTRACT

The results of the Open Circuit Voltage Decay experiments show large discrepancies with the theory applicable to a base dominated diode. There are four important effects which modify the Open Circuit Voltage Decay plots. These are heavy doping effects, drift field effects, photo generation of carriers and high injection effects. The heavy doping effects increase the dark saturation current of the emitter. The diode does not remain base dominated and recombination of carriers during the transient processes in the emitter and the base become coupled. The mathematical theory shows that the quasi-static approximation in the emitter is valid to a good approximation but does not hold in the base. The heavy doping effects make the voltage decay faster in the early stages. For large values of time however, decay rate becomes practically independent of heavy doping effects. The drift field also modifies the voltage decay considerably. The retarding drift field in the base pushes both majority and minority carriers into the emitter during the voltage decay process. The number of recombinations in the emitter increases and the voltage decay becomes faster. The effect of photo generation makes the decay of the voltage some-what slower, particularly if the wavelength of the exciting light is long. At high injections, a plateau in the voltage decay curve has been observed for many years. Recent theoretical work to explain this plateau is described.