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INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
I.C.T.P., P.O. BOX 586, 34100 TRIESTE, ITALY, CABLE: CENTRATOM TRIESTE



UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION



INTERNATIONAL CENTRE FOR SCIENCE AND HIGH TECHNOLOGY

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS 34100 TRIESTE (ITALY) VIA G. GIUGNANO, 9 (ADRIATICO PALACE) P.O. BOX 586 TELEPHONE 040-234572 TELEFAX 040-234573 TELEX 40040 ICPH I

co-sponsored by International Union of Crystallography (IUCr)

19408

FINAL REPORT

on the

SCHOOL ON MATERIALS FOR ELECTRONICS: Growth, Properties and Applications (18 November - 6 December 1991)

The activity consisted in a presentation of the various aspects of semiconductor technology, i.e. :

- i) materials growth and characterization ;
- ii) electronic and lattice dynamical properties of semiconductors ;
- iii) applications to transport and optical devices.

Most of the activity has been devoted to epitaxial materials and the recently fabricated low-dimensional (2D, 1D and 0D) semiconducting quantum structures. Growth and characterization of bulk semiconducting materials has also been covered.

Most of the activity was held in the Main Lecture Room of the Adriatico Guest House and its programme consisted of several series of lectures on the most fundamental topics, seminars on advanced topics and short presentations by the participants of their current research activity. Globally, seventy hours were covered by lectures and seminars. Fourteen presentations were delivered by the participants.

The participants were sixty-seven (of which twelve cost-free and the remaining fifty-five fully or partially subsidized by ICTP), coming from twenty-eight different nations. Many participants were visiting ICTP for the first time. They were selected from about four hundred applications and therefore their scientific level was very high. This was demonstrated by the fact that some of the presentations given by the participants were of such quality as to raise the sincere interest of the lecturers working in the same field.

Considering the number of applications and of participants, the number of lecturers and seminar speakers (thirty-six altogether) and the high density of the scientific programme provided every day by the School to the participants, one can imagine the organizational effort that was necessary to bring the activity to a constructive happy end. Such impressive effort was provided with competence, skill and high professionalism by Ms Marina de Comelli. The helpful guidance supplied by Ms D. Buranello is also acknowledged. Due to their effort, the whole organization went on smoothly and perfectly from beginning to end.

The School included some activity outside the lecture hall, such as the visits to the four laboratories existing in the Trieste area and scientifically relevant to the topic of the School, i.e. :

- i) the TASC-INFN laboratory at the Trieste Research Area in Padriciano, including the MBE-Growth and the Surface Characterization laboratories ;
- ii) the ICTP Laser laboratory ;
- iii) the ICTP Superconductivity laboratory ;
- iv) the ICTP Microprocessor Laboratory.

However, no laboratory practice could be done during the School due to the lack of the necessary structures and the short duration of the School itself.

On average, the scientific programme of the School covered about six hours per day. On top of this, each participant was expected to strengthen his knowledge of special topics by working individually on the lecture notes provided by the lecturers. This pace was practically accepted by all participants during the first week but it was considered too heavy by most of them in the long run. It should also be noticed that most participants thought that the duration of the School (three weeks) was too long. The topics covered by the School being relatively advanced, future organization of similar activities should consider one of the following two solutions:

- i) breaking the global programme of the School into parts and organizing one-week or two-week long Schools on each one of the subjects separately, or
- ii) keeping the whole programme as it is but distributing it over a longer period (six weeks ?).

Discussions with the participants indicated that scheme (i) is the preferred one.

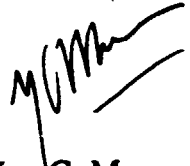
During the School a questionnaire was distributed to the participants in order to obtain an accurate picture of their research interests and of the instruments available to them. The answers have shown that the field of epitaxial semiconductors is developing at a fast rate in the Third World. The picture which resulted from the

questionnaire in 1991 shows considerable progress and development with respect to the situation which emerged in 1986 on the occasion of a similar School held at ICTP (Winter School on Technology Characterization and Properties of Epitaxial Electronic Materials, 13-24 January 1986). In the Third World, the field of epitaxial materials was at its very beginning in 1986. Good quality work is currently being done in some of the developing countries.

Finally, most participants before going back to their country at the end of the School, explicitly expressed their full satisfaction for the constructive time spent at ICTP in Trieste and for the many scientific relationships established during the School with colleagues from other nations.



Alfonso Baldereschi



Jan C. Maan



Carlo Paorici

Trieste, December 1991



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INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS 34100 TRIESTE (ITALY) VIA GRIGIANO, 9 (ADRIATICO PALACE) P.O. BOX 586 TELEPHONE 040-224572 TELEFAX 040-224575 TELEX 40040 IAPH I

co-sponsored by International Union of Crystallography (IUCr)

**School on Materials for Electronics:
 Growth, Properties and Applications**

(18 November - 6 December 1991)

FINAL PROGRAMME

Lectures held in the Adriatico Main Lecture Room
 Lower Level 1 (unless otherwise specified)

Monday, 18 November

- 8.30 - 9.30 **REGISTRATION**
- 9.30 - 10.00 **OPENING AND WELCOME ADDRESSES**
 (Professors Baldereschi, Bertocchi, Denardo, Paorici)
- 10.00 **I. MARKOV** Atomistic mechanisms of crystal growth and epitaxy - Part I
- 11.00 *Break*
- 11.30 **J.B. MULLIN** Chemical vapour deposition I : Fundamentals

Tuesday, 19 November

- 9.00 **M. MASI** Growth modelling - Part I
- 10.00 **I. MARKOV** As above - Part II
- 11.00 *Break*
- 11.30 **J.B. MULLIN** Chemical vapour deposition II : Vapour phase epitaxy
- 12.30 *Lunch break*
- 15.00 **T. DUFFAR** Growth phenomenology - Part I
- 16.00 **E. KUPHAL** Liquid phase epitaxy - Part I
- 17.00 *Break*
- 17.30 **T. DUFFAR** As above - Part II

Wednesday, 20 November

9.00	M. MASI	As above - Part II
10.00	I. MARKOV	As above - Part III
11.00	<i>Break</i>	
11.30	J.B. MULLIN	Chemical vapour deposition III : Metalorganic vapour phase epitaxy
12.30	<i>Lunch break</i>	
15.00	G. MÜLLER	Melt growth of semiconductors - Part I
16.00	E. KUPHAL	As above - Part II
17.00	<i>Break</i>	
17.30	G. MÜLLER	As above - Part II

Thursday, 21 November

9.00	J. WALKER	Molecular beam epitaxy - Part I
10.00	G. MÜLLER	As above - Part III
11.00	<i>Break</i>	
11.30	U. MERKT	Quantum dots on semiconductors - Part I
12.30	<i>Lunch break</i>	
15.00	C. RAZZETTI	Materials for non-linear optics
16.00	B. DEVEAUD	Ultrafast dynamics of quantum wells by time resolved luminescence
17.00	<i>Break</i>	
17.30	F. GENOVA	Metal-organic molecular beam epitaxy

Friday, 22 November

9.00	J. WALKER	As above - Part II
10.00	U. MERKT	As above - Part II
11.00	<i>Break</i>	
11.30	S. FRANCHI	Quantum structures by MBE
17.00	<i>"Get to-gether drink" at the Adriatico Guest House Cafeteria</i>	

Monday, 25 November

9.00	A. FRANCIOSI	Local probes of semiconductor interfaces - Part I
10.00	R. RESTA	Microscopic theory of heterostructures: electronic properties - Part I
11.00	<i>Break</i>	
11.30	M. VITTORI	Materials characterization by transmission electron microscopy - Part I
12.30	<i>Lunch break</i>	
15.00	A. FASOLINO	Effective-mass theory of quantum structures - Part I
16.15	<i>GROUP VISIT TO THE TASC - INFM LABORATORY - Area di Ricerca of Trieste, Padriciano (Trieste)</i>	

Tuesday, 26 November

9.00	A. FRANCIOSI	As above - Part II
10.00	R. RESTA	As above - Part II
11.00	<i>Break</i>	
11.30	M. VITTORI	As above - Part II
12.30	<i>Lunch break</i>	
15.00	A. FASOLINO	As above - Part II
16.00	A. STELLA	Optical properties of epitaxial films and quantum structures
17.00	<i>Break</i>	
17.30	<u>SEMINARS</u>	
	P. RAMASAMY (Madras, India)	Crystal growth activities at the "Crystal Growth Centre, Anna University, Madras, India"
	V. GAIDAROVA (Sofia, Bulgaria)	Laser-assisted deposition of Pb chalcogenide films
	V. TUNCHEVA (Sofia, Bulgaria)	Optical characterization of PbO films

Wednesday, 27 November

9.00	A. FRANCIOSI	As above - Part III
10.00	R. RESTA	As above - Part III
11.00	<i>Break</i>	
11.30	P. LUGLI	Simulation of semiconductor device performance - Part I
12.30	<i>Lunch break</i>	
15.00	P. LUGLI	As above - Part II
16.00	S. BARONI	Microscopic theory of heterostructures: lattice dynamical properties - Part I
17.00	<i>Break</i>	
17.30	<i>GROUP VISIT to the ICTP SUPERCONDUCTIVITY LABORATORY (Adriatico Guest House - Lower Level O.s.e., Grignano, Trieste)</i>	

Thursday, 28 November

9.00	L. TAPPER	Structural study of heterostructures by X-ray diffraction
10.00	V.A. BORODIN	Growth of shaped crystals
11.00	<i>Break</i>	
11.30	P. LUGLI	As above - Part III
12.30	<i>Lunch break</i>	
15.00	H. SALEMINK	Microscopy and spectromicroscopy of heterostructures by STM - Part I
16.00	S. BARONI	As above - Part II
17.00	<i>Break</i>	
17.30	<u>SEMINARS</u>	
	R. DHANASEKARAN (Madras, India)	Theoretical aspects of crystal growth
	KONG Mei Ying (Beijing, China)	MBE in China
	S. CHAKRAVARTY (Bombay, India)	Characterization of Sn-Dx centers in LPE-grown AlGaAs:Sn

Friday, 29 November

9.00	H. SALEMINK	As above - Part II
10.00	L. SCANDELLA	Atom deposition by STM
11.30	S. BARONI	As above - Part III
14.00	<i>GROUP VISIT to the ICTP LASER LABORATORY (Main Building, Miramare, Trieste)</i>	
15.00	A. FASOLINO	As above - Part III

Monday, 2 December

9.00	L. EAVES	Physics of resonant tunnelling: high magnetic field and optical studies - Part I
10.00	R. NICHOLAS	Electronic properties of the two-dimensional electron gas in high magnetic fields - Part I
11.00	<i>Break</i>	
11.30	F. EVANGELISTI	Amorphous semiconductor interfaces and multilayer structures - Part I
12.30	<i>Lunch break</i>	
15.00	A. WIECK	Ion beam writing of small structures
16.00	J.M. GERARD	Fundamental optical properties of heterostructures - Part I
17.30	<u>SEMINARS</u>	
	S. CHANDVANKAR (Bombay, India)	Investigation of mismatch behaviour between epitaxial layer and the substrate in LPE InGaAsP:InP system"
	WEI Xiao-Li (Beijing, China)	The characterization of strained-layer superlattice by TEM and CBED (Convergent-Beam Electron Diffraction)
18.15	<i>"Get to-gether drink again" Adriatico Guest House Cafeteria</i>	

Tuesday, 3 December

9.00	L. EAVES	As above - Part II
10.00	R. NICHOLAS	As above - Part II
11.00	<i>Break</i>	
11.30	F. EVANGELISTI	As above - Part II
12.30	<i>Lunch break</i>	
15.00	L. SORBA	Microscopic control AlAs/GaAs heterostructures
16.00	J.M. GERARD	As above - Part II
17.00	<i>Break</i>	
17.30	<u>SEMINARS</u>	
	R. HOUDRE' (Lausanne, Switzerland)	Monolayer island formation in narrow InAs/InP single quantum well
	L.P. BIRO (Budapest, Hungary)	Effects of ion implantation on the corrugation periodicity of highly oriented pyrolythic graphite

Wednesday, 4 December

9.00	L. EAVES	As above - Part III
10.00	R. NICHOLAS	As above - Part III
11.00	<i>Break</i>	
11.30	F. BELTRAM	Heterostructure and quantum electronic devices - Part I
12.30	<i>Lunch break</i>	
15.00	C. HARMANS	Classical and quantum transport in mesoscopic systems - Part I
16.00	J.M. GERARD	As above - Part III
17.00	<i>Break</i>	
17.30	<u>SEMINARS</u>	
	NGUYEN HONG QUANG (Hanoi, Vietnam)	Light absorption by excitons and biexcitons in quantum wells: influence of a resonant electromagnetic field
	V.V. POPOV (Saratov, USSR)	Two-dimensional plasmon dispersion in semiconductor-dielectric structure with metal grating: strict theory

Thursday, 5 December

9.00	R. CINGOLANI	Electronic and optical properties of ultra narrow GaAs/AlAs and InAs/GaAs quantum wells down to the monolayer limit
10.00	F.K. REINHART	Optoelectronic devices - Part I
11.00	<i>Break</i>	
11.30	F. BELTRAM	As above - Part II
12.30	<i>Lunch break</i>	
14.00	GROUP VISIT to the ICTP MICROPROCESSOR LABORATORY	
15.00	C. HARMANS	As above - Part II
16.00	S. SOLMI	Planar technology - Part I
17.00	<i>Break</i>	
17.30	<u>SEMINARS</u>	
	U. OESTERLE (Lausanne, Switzerland)	Growth and characterization of surface emitting lasers
	XU Feng-Lan (Changchun, China)	GaAs/GaAlAs travelling-wave laser amplifier with tilted facet

Friday, 6 December

9.00	S. SOLMI	As above - Part II
10.00	F.K. REINHART	As above - Part II
11.00	<i>Break</i>	
11.30	F. BELTRAM	As above - Part III
12.30	C. HARMANS	As above III
13.30	CLOSING REMARKS	

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
Trieste, Italy

**School on Materials for Electronics:
Growth, Properties and Applications**

Trieste, 18 November- 6 December 1991

UNIDO Project US/GLO/89/104

UNIDO Contract No. 91/160/VK

FINANCIAL STATEMENT

(in US\$)

1 DIRECTORS

Maan, J.C.	Netherlands	1,066.88
Paorici, C.	Italy	1,638.35
	<i>Subtotal</i>	2,705.23

2 LECTURERS

Baroni, S.	Italy	125.00
Beltram, F.	Italy	1,321.83
Borodin, V.A.	USSR	734.92
Cingolani, R.	Italy	603.50
Deveaud, B.	France	720.69
Duffar, T.	France	308.74
Eaves, L.	United Kingdom	760.08
Evangelisti, F.	Italy	202.33
Fasolino, A.	Italy	766.62
Franchi, S.	Italy	241.63
Franciosi, A.	Italy	871.95
Genova, F.	Italy	162.60
Gerard, J.M.	France	952.47
Harmans, C.	Netherlands	998.00
Kuphal, E.	Germany	1,039.40
Lugli, P.	Italy	648.85
Markov, I.	Bulgaria	1,028.83
Masi, M.	Italy	391.85
Merkt, U.	Germany	1,366.78
Muller, G.	Germany	778.00
Mullin, J.B.	United Kingdom	1,159.51
Nicholas, R.	United Kingdom	782.62
Razzetti, C.	Italy	424.55
Reinhart, F.K.	Switzerland	561.24
Resta, R.	Italy	121.95
Salemink, H.	Netherlands	971.02
	To be carried fwd:	18,050.96

	Brought fwd:	18,050.96
Scandella, L.	Italy	402.34
Solmi, S.	Italy	299.50
Sorba, L.	Italy	41.67
Stella, A.	Italy	358.28
Tapfer, L.	Italy	692.75
Vittori, M.	Italy	264.23
Walker, J.	United Kingdom	83.33
Wieck, A.	Germany	674.55

Subtotal **20,867.61**

3 PARTICIPANTS

Almeida, J.M.M.	Portugal	768.29
Arivuoli, D.	India	1,296.60
Badila, M.	Romania	731.70
Bandeira, I.N.	Brazil	2,546.29
Bartos, J.	Czechoslovakia	695.12
Baya'a, D.	Syria	658.53
Belas, E.	Czechoslovakia	731.70
Bilo, L.P.	Romania	731.70
Chadrabaal, S.	Mongolia	695.12
Chakravarty, S.	India	1,216.52
Chandvankar, S.	India	1,190.17
Cunha, S.P.	Brazil	1,522.32
Faradjev, F.	USSR	768.29
Fatallah, M.	Tunisia	694.20
Franc, J.	Czechoslovakia	731.70
Gaidarova, V.S.	Bulgaria	731.70
Goldenberg, A.B.	USSR	773.04
Kanhere, R.S.	India	2,738.29
Kim Kun Ho	Korea	878.05
Kong Mei Ying	China	2,641.38
Kucharski, K.	Poland	768.29
Kumar, J.	India	1,824.90
La Scala, N.	Brazil	2,660.79
Lu Ganghua	China	731.70
Luby, S.	Czechoslovakia	695.12
Mani, V.N.	India	1,245.53
Mendonca, C.	Brazil	2,660.79
Meric, S.	Turkey	748.37
Mihai, G.D.	Romania	731.70
Morales-A., J.A.	Mexico	1,499.88
Nenkova, M.M.	Bulgaria	621.95
Nguyen Hong Quang	Vietnam	2,080.08
Nguyen Quang Bau	Vietnam	2,124.47
Nguyen Thi Qui Hai	Vietnam	2,124.46
Notari, A.C.	Brazil	2,629.47
Phatisena, S.	Thailand	2,604.88
Popov, V.V.	USSR	768.29
Premaratne, K.	Sri Lanka	2,078.62

To be carried fwd: **51,340.00**

	Brought fwd:	51,340.00
Ramasamy, D.	India	1,888.29
Ramasamy, P.	India	1,887.46
Reddy, D.R.	India	1,611.11
Shahidul, H.M.M.	Bangladesh	2,052.32
Sinha, R.K.	India	1,858.51
Sinha, S.	India	1,190.17
Slavova, D.	Bulgaria	621.95
Tuncheva, U.D.	Bulgaria	621.95
Vasilevskiy, M.I.	USSR	722.56
Villaflor, A.	Philippines	2,978.55
Vo Hanh Phuc	Vietnam	2,087.38
Wei Xiao-Li	China	2,641.38
Xu Feng-Lan	China	1,685.84
Yildirim, S.	Turkey	1,000.65
Zaidi, S.S.H	Pakistan	1,780.52
Zaluzny, M.	Poland	731.70
Zelaya-Angel, O.	El Salvador	585.36
	<i>Subtotal</i>	77,285.70

4 OVERHEADS (*)

UNIDO share of total overhead charges (inclusive of organization, supervision, technical assistance, secretariat, provision of facilities, etc.)

Total **100,858.54**

(*) Overhead costs are not being reported since direct costs do already exceed UNIDO's contractual contribution; they will be covered, together with the overexpenditure, by ICTP's budget.

ICTP Finance/am
1992-01-23