FIFTH INTERNATIONAL WORKSHOP ON THE MEASUREMENT, CHARACTERIZATION, AND MODELING OF ULTRA-SHALLOW DOPING PROFILES IN SEMICONDUCTORS

Research Triangle Park, NC USA
March 28-31, 1999

TECHNICAL PROGRAM

Sponsored by:
American Vacuum Society

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You are invited to participate in the Fifth International Workshop on the Measurement, Characterization, and Modeling of Ultra-Shallow Doping Profiles in Semiconductors to be held March 28-31, 1999 at the Sheraton Imperial Hotel in Research Triangle Park, North Carolina, USA. A reception and early registration for the Workshop will take place on the evening of March 28th at the Sheraton.

The goal of the workshop is to provide an international forum for thorough and broad-ranging discussion of the techniques for measurement, characterization and modeling of the one and two-dimensional aspects of ultra-shallow junctions, primarily in silicon devices. The focus of the workshop is on the limitations of present-day analytical techniques and on progress towards more advanced capabilities for analysis of ever shallower and more abrupt doping profiles. This forum provides a review of techniques that probe atomic composition and electrical activation of ultra-shallow junctions. Additional discussions will review the status of techniques for analysis of lattice damage profiles and analytical models that relate two-dimensional dopant distributions to enhanced dopant diffusion from the production of point defects. Papers are presented on the interpretation and correlation of device characteristics with two-dimensional dopant profiles. Special emphasis will also be on bringing together specialists in analytical methods with those who are developing atomic-level models of transient-enhanced dopant diffusion and activation. In addition, we encourage the participation of device engineers who are developing advanced technologies where two-dimensional profile control is critical. The goal here is to build a closer link between the data requirements for advanced silicon process and device modeling, the capabilities of analytical techniques, and the characteristics of ULSI devices.

A short course will be held on the afternoon of Sunday, March 28th covering the topics of PN Junction Profile Engineering, Basics of Process Simulation, Basics of 1D Profile Measurements, and Basics of 2D Profile Measurement.
The workshop consists of invited review papers, contributed papers (in both oral and poster formats), and focused topical discussions.

Sputter Depth Profiling: SIMS, techniques for enhanced depth resolution and dynamic range with and 2D profiling.
Spreading Resistance Measurements and Other Characterization Methods: Contact modeling, ultra-shallow beveling, extraction of carrier concentrations, C-V profiling, Hall profiling.
Process Characterization and Modeling: Atomic profiles, implant damage, electrical activation, impurity, cluster and point defect modeling with an emphasis on lattice damage effects on 2D diffusion.
Microscopy: SEM, TEM, AFM, SCM, SSRM, electrochemical etching methods, qualitative and quantitative 2D-carrier profiling.
Device Characterization: methods for determining effective channel length, 2D profile extraction from device characteristics, impact of 2D dopant profiles on devices.

Invited Speakers:

Trudo Clarysee, IMEC
Rinn Cleavlin, SEMATECH
G. Cooke, University of Warwick
Peter De Wolf, Digital Instruments
Paul Packan, Intel
Chandra Mouli, Micron
Carl Osburn, North Carolina State University
Bill Richards, TTI
Hong-Ha Vuong, Lucent Technologies

REGISTRATION PROCEDURES
(Form on Back Cover)

The conference fee includes all meals, proceedings, and registration materials. If you chose to register, you have a few options, on-line registration is available via our home page at www.vacuum.org, or you may complete the form on the back cover and fax or mail it to the following address no later than **March 22, 1999**.

American Vacuum Society
ATT: USJ99
120 Wall Street 32nd Floor
New York, NY 10005-3993
Fax: 212/248-0245

Please register early as the Workshop will only accommodate 150 participants. Registrations will not be accepted without the registration fee and **NO PURCHASE ORDERS WILL BE ACCEPTED**. If you cancel your registration by **March 22, 1999**, half of your registration fee will be refunded. No refunds will be made after March 22.

HOTEL RESERVATIONS:

The Workshop Hotel is the Sheraton Imperial Hotel in Research Triangle Park. Please make your hotel reservation directly through the **Sheraton Hotel at 919/941-5050 before March 8,** and mention that you are attending the **USJ99 Workshop**. These rooms are available on a first-come-first-serve basis. The rate for a single or double room is $99 plus local tax. The airport closest to the Sheraton is Raleigh-Durham International and transportation between the Sheraton and the airport is provided by the Sheraton.

QUESTIONS?

Technical questions -- Richard Fair, 919/660-5277; email: rfair@ee.duke.edu; Wilfried Vandervorst, 32-16281-286; email: vdvorst@imec.be; Administrative -- Marion Churchill, 212/248-0327; email: marion@vacuum.org; Registration -- Angela Mulligan 212/248-0200; email: angela@vacuum.org

TECHNICAL PROGRAM -- SUNDAY, MARCH 28, 1999

Time	Event	Location
12:30- 1:15 p.m.	**Short Course Registration**	**Foyer**
	Short Course Session	**Auditorium**
1:15 - 2:15 p.m.	PN Junction Profile Engineering *R. Fair, Duke University*	
2:15 - 2:30 p.m.	**BREAK**	
2:30 - 3:30 p.m.	Basics of Process Simulation *P. Packan, Intel Corp*	
3:30 - 3:45 p.m.	**BREAK**	
3:45 - 4:45 p.m.	Basics of 1D Profile Measurements: SRP, SIMS *W. Vandervorst, IMEC*	
4:45 - 5:00 p.m.	**BREAK**	
5:00 - 6:00 p.m.	Basics of 2D Profile Measurements *P. De Wolf, Digital Instruments*	
6:00 - 9:00 p.m.	**Program Registration and Reception**	**Empire DE**

TECHNICAL PROGRAM -- MONDAY, MARCH 29, 1999

Time	Program	Location
8:00 - 8:30 a.m.	**Registration and Continental Breakfast**	**Auditorium**
8:30 - 8:35 a.m.	**Welcome, Opening Remarks** *W. Vandervorst and R. Fair*	
	Plenary Session	
8:35 – 9:15 a.m.	Design and Integration Considerations for End-of-the Roadmap Ultra-Shallow Junctions **(I)** *C.M. Osburn, I. De, K.F. Yee, and A. Srivastava*	
9:15 – 9:55 a.m.	FEOL Considerations for Progression Beyond the 100nm Node Ultra-Shallow **(I)** Junction Requirement *R. Cleavelin*	
9:55 – 10:25 a.m.	**BREAK**	
10:25 – 11:05 a.m.	Developing Technologies with TCAD Tools **(I)** *P. Packan*	
11:05 – 11:45 a.m.	Models and Methods: Effective Use of TCAD in the Industry **(I)** *C. Mouli*	
11:45 – 12:25 p.m.	Status and Review of 2-D Carrier Profiling Using Scanning Probe Microscopy **(I)** *P. De Wolf*	
12:25 – 2:00 p.m.	**Lunch**	**Empire ABC**
	Tabletop Exhibition and Poster Viewing	**Empire DE**
	SIMS Calibration Session	
2:00 – 2:30 p.m.	The Establishment of Accuracy in Ultra-Shallow SIMS Depth Profiles **(I)** *G. Cooke*	**Auditorium**
2:30 – 2:55 p.m.	Accurate Dose Calibration in SIMS Depth Profiling of Shallow Through-Oxide Implantation Distributions with Only One Sensitivity Factor K. Wittmaack, *J.J. Lee, and S.B. Patel*	
2:55 – 3:20 p.m.	Quantification Method for Elements in Silicon at the Surface or Near Surface Region *F.A. Stevie, R.F. Roberts, M A. Decker, J.M. McKinley, C N. Granger, and R. Santiesteban*	
3:20 – 3:50 P.M.	**BREAK**	
	Process Session	
3:50 – 4:20 p.m.	Dopant Dose Loss at the Si-SiO2 Interface **(I)** *H. Vuong*	
4:20 – 4:45 p.m.	Cluster Formation During the Annealing of Very Low Energy Boron and Arsenic Implanted Silicon *E.J.H. Collart, A.J. Murrell, A.G. Cullis , T.-S. Wang, J.A. van den Berg, S. Zhang, and R.D Goldberg*	
4:45 - 5:10 p.m.	Transient Enhanced Diffusion in Ultra Low Energy (ULE) Arsenic Implanted Si *K.S. Jones, D. F. Downey, H. Miller, M.E. Law, and J. Chen*	
5:10 – 6:30 p.m.	**Social hour, networking opportunity, Tabletop Exhibition**	**Empire DE**
6:30 – 8:00 p.m.	**Dinner**	**Empire ABC**
8:00 – 10:00 p.m.	**Poster Session I (SIMS Calibration, Process, and New Techniques)**	**Empire DE**

(I) = Invited Speaker

TECHNICAL PROGRAM -- TUESDAY, MARCH 30, 1999

8:00 - 8:30 a.m.	**Registration and Continental Breakfast**	**Auditorium**
	SRP Session	
8:30 – 9 :00 a.m.	Qualification of Spreading Resistance Probe Operations (Part I) **(I)** *T. Clarysse and W. Vandervorst*	
9:00 – 9:25 a.m.	Modeling of Ultra-Shallow SRP Calibration Curves *R.J. Hillard, S.M. Ramey, and C.W. Ye*	
9:25 – 9:50 a.m.	The Need to Incorporate the Real Micro-Contact Distribution in Spreading Resistance Probe Correction Schemes *T. Clarysse and W. Vandervorst*	
9:50 – 10:20 a.m.	**BREAK**	
	Focussed Discussion Session on SIMS Depth Profiling (Discussion & Posters available)	
10:20 – 10:35 a.m.	Crater Bottom Roughening: A Study by AFM on the Effects of Primary Beam Energy and Angle, Both with and without Oxygen Flooding *G.R. Mount, G. Chao, C. W. Magee, S. M. Baumann, V.K.F. Chia, and M. J. Edgell*	
10:35 – 10:50 a.m.	Depth Scale Distortions in Shallow Implant SIMS Profiles *B. Schueler and F. Reich*	
10:50 – 11:05 a.m.	The Occurrence and Absence of Early Surface Roughening of Si(100) and Si(111) by sub-keV O_2+ Beams at Oblique Iincidence *P.F.A. Alkemade, E. Algra, and Z. X. Jiang*	
11:05 – 11:20 a.m.	Study of Pre-Equilibrium Sputter Rates for Ultra-Shallow Depth Profiling with SIMS *P.A. Ronsheim and R.J. Murphy*	
11:20 – 11:35 a.m.	Ultrashallow Depth Profiling SIMS using Polyatomic Primary Ion Bombardment *G. Gillen, M. Walker, J. Bennett, and P. Thompson*	
11:35 – 12:00 p.m.	Discussion Session: SIMS Depth Profiling *W. Vandervorst + Speakers*	
12:00- 2:00 p.m.	**Lunch**	**Empire ABC**
	Tabletop Exhibition and Poster Viewing	**Empire DE**
	2-D Session / Device Characterization	
2:00 – 2:30 p.m.	Extraction of 2-D MOSFET Structural Information from Electrical Characteristics **(I)** *W.R. Richards and M. Shen*	
2:30 – 2:55 p.m.	Intercomparison of 2-D Carrier Profiles in MOSFET Structures Obtained with Scanning Spreading Resistance Microscopy and Inverse Modeling *P. De Wolf, W. Vandervorst, H. Smith, and N. Khalil*	
2:55 – 3:20 p.m.	Effective Channel Length and Base Width Measurements by Scanning Capacitance Microscopy *V. Raineri*	
3:20 – 3:50 p.m.	**BREAK**	

(I) = Invited

TECHNICAL PROGRAM -- TUESDAY, MARCH 30, 1999

	2-D Session / Etch	
3:50 – 4:15 p.m	The Relationship between Lateral and Vertical Components of Diffusion in Arsenic Doped Silicon *R. D. Venables, D. Ottaviani, and D. Venables*	**Auditorium**
4;15 – 5:00 p.m.	2D dopant profile of 0.2 micron gate MOSFETs *X.-D. Wang, R. Mahaffy, K. Tan, and C.K. Shih*	
5:00 – 6:00 p.m.	**Social hour and networking opportunity**	**Empire DE**
6:00 –8:30 p.m.	**Conference Banquet** **Speaker: Dr. Allan Johnson, Duke Univ. Medical Center "In Vivo Microscopy"**	**Empire ABC**
8:30 – 10:00 p.m.	**Poster Session II (SRP, SIMS Profiling, 2-D, and SCM)**	**Empire DE**

TECHNICAL PROGRAM -- WEDNESDAY, MARCH 30, 1999

8:00 - 8:30 a.m.	**Registration and Continental Breakfast**	**Auditorium**
	New Techniques Session	
8:30 – 8:55 a.m.	High-Resolution Two-Dimensional Dopant Characterization Using SIMS *V.A. Ukraintsev, P. J. Chen, J.T. Gray, C.F. Machala, L K. Magel and M.-C. Chang*	
8:55 – 9:20 a.m.	Two-Dimensional Mapping of the Electrostatic Potential in Deep Submicron Transistors by Electron Holography *W.D. Rau, P. Schwander, and A. Ourmazd*	
9:20 – 9:45 a.m.	New Aspects of Nanopotentiometry for CMOS Transistors *T. Trenkler, R. Stevenson, P. Jansen, and W. Vandervorst*	
9:45 – 10:10 a.m.	Quantitative Two-Dimensional Carrier Profiling Using Scanning Schottky Capacitance Microscopy *D.J. Thompson, J.N.Nxumalo, Y. Li, and T. Tran*	
10:10 – 10:35 a.m.	**BREAK**	
	SCM Session	
10:35 – 11:00 a.m.	Non-monotonic Behavior of the Scanning Capacitance Microscope for Large Dynamic Range Samples *R. Stephenson, A. Verhulst, P. DeWolf, M. Cayma, and W. Vandervorst*	
11:00 – 11:25 a.m.	Carrier Concentration Profile Dependence of Scanning Capacitance Microscopy Signal in the Vicinity of p-n Junctions *J. Kopanski, J.F. Marchiando, J. Albers, and B.G. Rennex*	
11:25 – 11:50 a.m.	pn-Junction Delineation in Si Devices Using Scanning Capacitance Spectroscopy *H. Edwards, V.A. Ukraintsev, R. San Martin, F. S. Johnson, P. Menz, S. Walsh, S. Ashburn, K.S. Wills, K. Harvey, and M.-C. Chang*	
11:50 - 12:15 p.m.	Quantitative P-N Junction Delineation by Scanning Capacitance Microscopy *V. V. Zavyalov, J. S. McMurray, and C. C. Williams*	
12:15 p.m.	**Closing Remarks** *R. Fair, W. Vandervorst*	

POSTER SESSION I (SIMS Calibration, Process, New Techniques -- MONDAY, MARCH 29, 1999

SIMS Calibration

A Delta Layer Reference Structure for Shallow and Ultra Shallow Profiling
M.G.Dowsett, G.A.Cooke, C.Parry, J.M.McKinley, F.A.Stevie, and C.N.Grainger

Dose Reproducibility with Low Energy SIMS
S.B.Patel and J.L.Maul

Accuracy of SIMS in Determining Ion Implanted B Doses as Confirmed by Nuclear Reaction Analysis
Charles W. Magee, Dale Jacobson, and Hans-J. Gossmann

The Use of Two Beam Energies in SIMS Analysis of Shallow Implants: Resolution Matched Profiling
G.A. Cooke, M.G. Dowsett, A. Murrell, and E.J.H. Collart

Establishing an Accurate Depth Scale in Ultra Shallow Profiles
M.G.Dowsett, D.P.Chu, T.J.Ormsby, and G.A.Cooke

Characterization of Ultra-Shallow BF_2 Implants by SIMS: A Study to Determine the Most Accurate Profiling Conditions
G.R. Mount, V.K.F. Chia, M.J. Edgell, S.P. Smith, and S. Biswas

Process Session

Oxide Thickness Determination by XPS, AES, SIMS, RBS and TEM
J.R. Shallenberger, D.A. Cole, S.W. Novak, R.L. Moore, M.J. Edgell, S.P. Smith, C.J. Hitzman, J.F. Kirchhoff, W. Nieveen, E. Principe, S. Biswas, R.J. Bleiler, and K. Jones

Shallow Junctions Formation by Decaborane Molecular Ion Implantation
M.A Foad, R. Webb, R. Smith , J. Matsuo, A. Al-Bayati, T.-S. Wang, and T. Cullis

Dynamic Simulation Model for 3D As-Implanted and Point Defect Profiles Generated by Ion Implantation into (100) Single-Crystal Silicon
M.S. Son and H.J. Hwang

Process Characterization of Low-Dose, Threshold-Voltage Adjust Channel Implants Using Mercury-Probe Capacitance-Voltage Measurements in the Giga-Bit Era
J.C. Sherbondy, R.J. Hillard, and M. Wilson

Production Shallow Ion Implanted Layers using Rapid Electron-Beam Annealing under the Condition of Transient Enhanced Outdiffusion
V.A. Kagadei and D.I. Proskurovsky

Damage Modeling and Atomic Simulations of Ultra-Low Energy Processes to Form Ultra-Shallow Junction
J.W. Kang, E.S. Kang, M.S. Son, and H.J. Hwang

Fabrication of 90-150nm Junctions with Conventional Furnace Equipment by Using Silicon Pre-Implants
H. Puchner, S. Aronowitz and V. Zubkov

Shallow Junction Formation in Surface Damage Region (SDR) by Electron-Volt Ion Implantation and Spike Rapid Thermal Anneal
S. Moffatt, V. Privitera, F. Priolo, K. Truman, and A. Murrell

Process Interactions between Low Energy Ion Implantation and Rapid Thermal Annealing for Optimised Ultra-Shallow Junction Formation
A.*J. Murrell, E.J.H. Collart, M.A. Foad, and D. Jennings*

Process Integration Issues for Ultra-Shallow Junctions
M.I. Current, M.A. Foad, G. De Cock, A.J. Murrell, E.J.H. Collart, and D. Jennings

Oxygen Enhanced Diffusion from Low Energy Knock-On Implanted SiO_2
M..J. Rendon, R.W. Murto, and K.S. Jones

POSTER SESSION I (SIMS Calibration, Process, New Techniques -- MONDAY, MARCH 29, 1999

New Techniques Session

Application of Focused Ion Beams for Ultra-Shallow Depth Profiling on Beveled Semiconductor Structures
D. Krueger, R. Kurps, U. Ewald, and M. Trapp

Electrochemical Etching of Silicon: A Powerful Tool for Delineating Junction Profiles in Silicon Devices by Transmission Electron Microscopy
C. Spinella

Non Destructive Profile Measurements of Annealed Shallow Implants
P. Borden and R. Nijmeijer

Electrical Profiling of Ultra-Shallow Junctions
S. Felch, A. Oberhofer, M. Goecker, V. Chia, M. Poulakos, W.A. Keenan, and B. Gordon

Characterization of Ultra-Shallow Junctions Using SIMS, SRP, TGP And Anodic Oxidation
S. Prussin, D.F. Downey, and C.M. Osburn

Arsenic Doped Buried Plate Characterization in Deep Trenches for A 0.25 µm CMOS Technology by Chemical Etching
D. Krueger, P. Gaworzewski, R. Kurps, K. Schmidt, and C. Luhmann

POSTER SESSION II (SRP, SIMS Profiling, 2-D, SCM) -- TUESDAY MARCH 30, 1999

SRP Session

Qualification of Spreading Resistance Probe Operations
T. Clarysse and W. Vandervorst

A Comparison of Contact Radius Models for Ultra-Shallow Spreading Resistance Profiles
E. J. Hartford, S. M. Ramey, C.W. Ye, and C. L. Hartford

Modeling of Ultra-Shallow SRP Calibration Curves
R.J. Hillard, S.M. Ramey, and C.W. Ye

SIMS Depth Profiling

SIMS Depth Profiling of Ultra Shallow Phosphorus in Silicon
R. Loesing, G.M. Guryanov, J.L. Hunter, and D.P. Griffis

The Occurrence and Absence of Early Surface Roughening of Si(100) And Si(111) by Sub-keV O_2+ Beams at Oblique Incidence
F.A. Alkemade, E. Algra, and Z. X. Jiang

Automated SIMS Depth Profiling
C.J. Hitzman, F. Reich, and B.W. Schueler

Depth Profiling of Ultra-Shallow Implants using a Cameca IMS-6f
J. M. McKinley, T. Neil, C. Granger, L. Wu, D. Sieloff, F. A. Stevie, and D. Renard

Depth Profiling of Ultra-Shallow B Implants in Silicon using a Magnetic-Sector SIMS Instrument
E. Napolitani

Depth Scale Distortions in Shallow Implant SIMS Profiles
B. Schueler and F. Reich

Crater Bottom Roughening: A Study by AFM on the Effects of Primary Beam Energy and Angle, both with and without Oxygen Flooding
G.R. Mount, G. Chao, C.W. Magee, S.M. Baumann, V.K.F. Chia, and M. J. Edgell

Ultrashallow Depth Profiling SIMS Using Polyatomic Primary Ion Bombardment
G. Gillen, M. Walker, J. Bennett, and P. Thompson

A Delta Layer Reference Structure for Shallow and Ultra Shallow Profiling
M.G.Dowsett, G.A.Cooke, C.Parry, J.M.McKinley, F.A.Stevie, and C.N.Grainger

Optimization of Growth Conditions for Preparing Shallow B-Delta Layers in Si to Study Depth Resolution and Artifacts in SIMS Depth Profiling
K. Wittmaack, J. Griesche, H.J. Osten, and S.B. Patel

2-D Session / Device Characterization & Etch

Two Dimensional Dopant and Carrier Profiles Obtained by Scanning Capacitance Microscopy on an Actively Biased Cross-Sectioned MOSFET Device
V.V. Zavyalov, J. S. McMurray, S.D. Stirling, and C.C. William,

Comparison of Different Techniques for Two Dimensional Imaging of Integrated Circuit Implant Structures
K.-J. Chao, J.R. Kingsley, R.J. Plano, X. Lu, and I. Ward

Practicalities and Limitations of Scanning Capacitance Microscopy for Routine IC Characterisation
R. Stephenson, P. De Wolf, T. Trenkler, T. Hantschel, T. Clarysse, P. Jansen, and W. Vandervorst

POSTER SESSION II (SRP, SIMS Profiling, 2-D, SCM) -- TUESDAY MARCH 30, 1999

SCM Session

Evaluating Probes for "Electrical" Atomic Force Microscopy
T. Trenkler, T. Hantschel, R. Stephenson, P. De Wolf, W. Vandervorst, L. Hellemans, A. Malavé, D. Büchel, E. Oesterschulze, W. Kulisch P. Niedermann, T. Sulzbach, and O. Ohlsson

Comparative Study of 2-D Junction Profiling using a Dopant Selective Etching Method and the Scanning Capacitance Spectroscopy Method
R. Mahaffy, C. K. Shih, and H. Edwards

Control Mechanisms to Dopant Selective Etching Reproducibility
R. Mahaffy and C.K. Shih

1-Dimensional SCM Modeling and Dopant Profiling for the Quantitative 3-Dimensional Impurity Doping Profiling
E.-S. Kang, K.-R. Byun, H.-J. Hwang, and G.-Y. Lee

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Angela Mulligan
212/248-0200
angela@vacuum.org

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