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Silicon Front-End Technology—Materials Processing and Modelling

Editors: Nicholas E. B. Cowern, Dale C. Jacobson, Peter B. Griffin, Paul A. Packan

and Roger P. Webb

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**Silicon Front-End
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Silicon Front-End Technology—Materials Processing and Modelling

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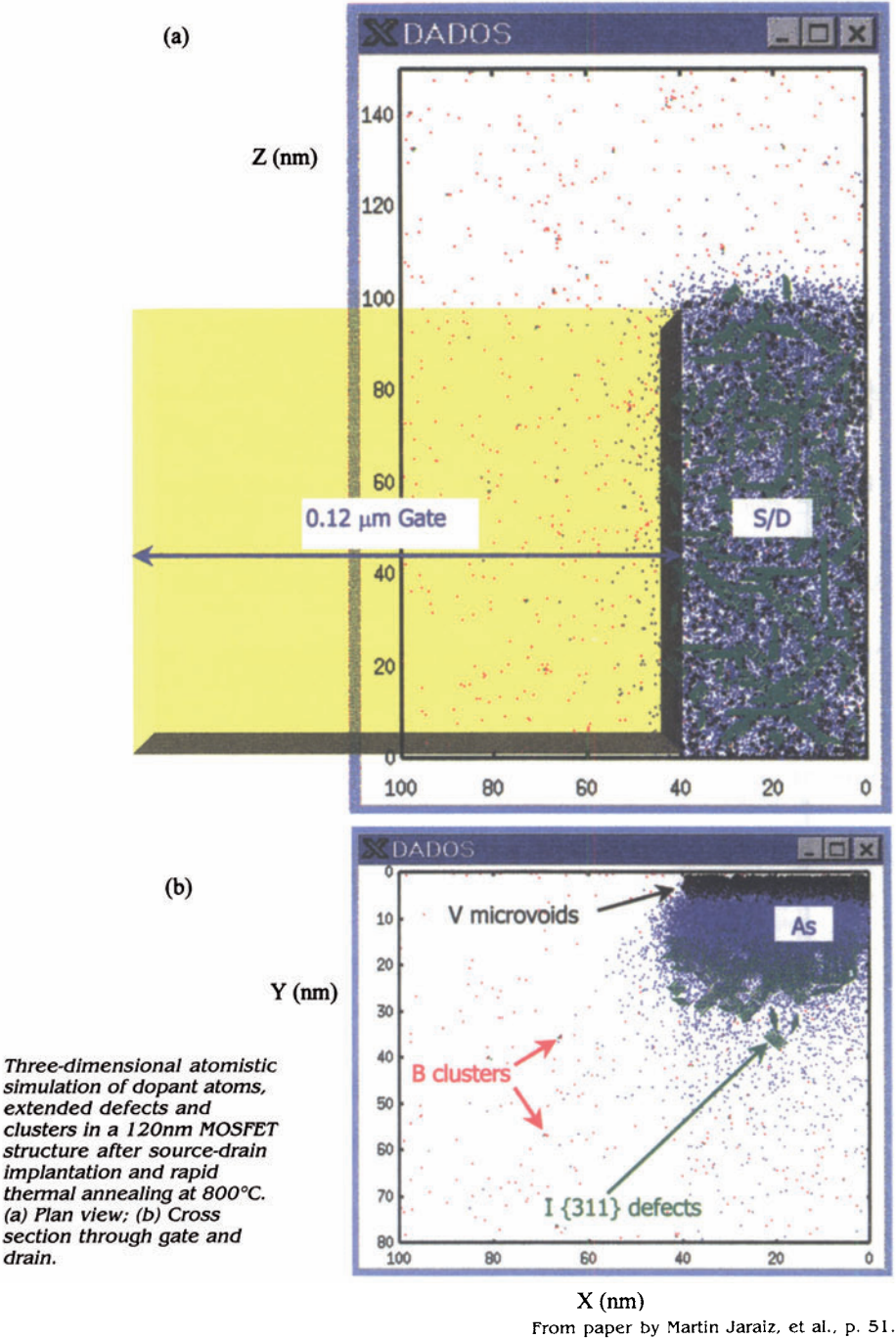
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PREFACE

This volume contains the proceedings of the symposium on 'Silicon Front-End Technology—Materials Processing and Modelling,' held April 13–15 as part of the 1998 MRS Spring Meeting in San Francisco, California. The symposium was the second in a new series devoted to understanding the physical phenomena governing front-end processing of silicon integrated circuits and devices. The subject matter is strongly based on that of the previous symposium, held in Spring 1997, entitled 'Defects and Diffusion in Silicon Processing.' However, it also includes important contributions on plasma processing, nitridation of gate oxide, and other issues involved in front-end processing. Contributions were organized into five oral sessions, including a joint session with the symposium on 'Diffusion Mechanisms in Crystalline Materials.' The program included nine invited talks and 41 contributed oral presentations. The symposium was well attended and had a strong international participation. Experimental and theoretical work carried out at universities, research laboratories, and semiconductor manufacturing sites was presented, illustrating the cross-disciplinary nature of this field, with its essential interactions between physics, materials science and technology.

Symposium topics included ultra-shallow junction formation, transient enhanced diffusion, defect properties, physical models for the evolution of dopant-defect clusters, dopant activation, deactivation and out-diffusion during processing, and advanced process modelling by continuum and Monte Carlo techniques.

A number of highlights have emerged from the presentations and discussions during the meeting:

- Low-energy implantation offers a promising route to shallow-junction formation for ultra-large scale integrated circuits. Transient enhanced diffusion is almost completely suppressed, owing to the proximity of the silicon surface, which, on annealing of implantation damage, acts as a powerful sink for excess interstitial atoms. Further suppression of diffusion, and enhancement of dopant activation, appears to be possible with the use of very high heating rates during rapid thermal annealing. The use of cluster ion implants, based on decaborane, appears to be an effective alternative to low-energy boron implantation.
- The role of the silicon/oxide interface as sink for interstitials may depend on the processing history of the surface, in particular, whether the surface has been exposed to ion implantation. This has importance for reverse short-channel effects in MOS transistors.
- Composition and strain effects play an important role in impurity diffusion in SiGe-based heterostructures. Experimentally determined

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strain effects in silicon are larger than expected from current first-principles calculations.

- Atomistic Monte Carlo modelling of diffusion and defect aggregation in silicon, combined with appropriate experimental studies, offers a new and interesting route to improve our understanding of dopant activation and diffusion in silicon. An atomistic simulation of dopant and defect distributions in an n-channel MOSFET with a 120nm gate length is shown in the Frontispiece.

As silicon integrated circuit technology enters the sub-100nm realm, there is an even more pressing need for a fundamental understanding of the physics of materials processing. The high cost of processing experimental lots and the speed at which new devices must be brought to the market have created a new emphasis on realistic physical models incorporated in technology CAD (TCAD) simulation tools. This symposium presented results of research on the physical mechanisms involved in silicon device processing, from both experimental and theoretical viewpoints, as well as the application of this fundamental research to TCAD process simulation models. The symposium successfully brought together materials scientists, TCAD researchers and silicon technologists to review recent research developments in the integrated-circuit community and identify the key issues for future research in this field. We hope these symposium proceedings will be a useful stimulus to researchers and technologists wishing to pursue further investigations in this field.

Nicholas E.B. Cowern

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Shuichi Saito
Conor Rafferty
Kevin Jones
Martin Jaraiz
Hans J. Gossmann
Salvatore Coffa
Tomas Diaz de la Rubia
Aditya Agarwal
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