Dopant Profiling Needs: an Update

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Goals of Presentation

Brief review of current guidelines.

Update, and add some additional constraints.

Point out alternative (electrical) approaches.

Review of Current Guidelines

2D dopant profiling remains a high priority for TCAD and Process Integration (*with the caveat that they have lived without it for a long time*).

Current targets were established assuming LDD devices, that is, a relatively broad transition region from the highly doped source/drain to the channel.

Current Trends in Device Scaling

Power supply has dropped faster than predicted, and S/D "extensions" (former LDD region) are very highly doped.

> i.e., transition is sharper and hot-electron effects are less of a concern.

Therefore, junction location may be sufficient !

Missing from Current Guidelines

It was not explicitly stated that the junction location needs to be known *with respect to* the gate edge (affects overlap capacitance and transient performance).

Initial guidelines focused on S/D doping, although channel doping is equally important.

> RSCE - Reverse Short Channel Effect - the *increase* in Vt with shorter channel lengths, resulting from the redistribution of the channel profile due to defects from the S/D implants.

Dose Loss

A substantial amount of S/D dopant is “lost,” or at least inactive, very near the surface.

Strong need for profiling high concentration active and inactive dopant in top 10 nm of silicon (1D, not 2D).

Dose Loss (Examples and Keywords)

SISPAD '97, Simulation of Semiconductor Processes and Devices, September 8-10, 1997, Cambridge.

Session 3: Transient Enhanced Diffusion and Dose Loss

"Physical Modeling of Transient Enhanced Diffusion and Dopant Deactivation via Extended Defect Evolution"

A. H. Gencer, S. Chakravarthi and S. T. Dunham,
Boston University, Boston, MA

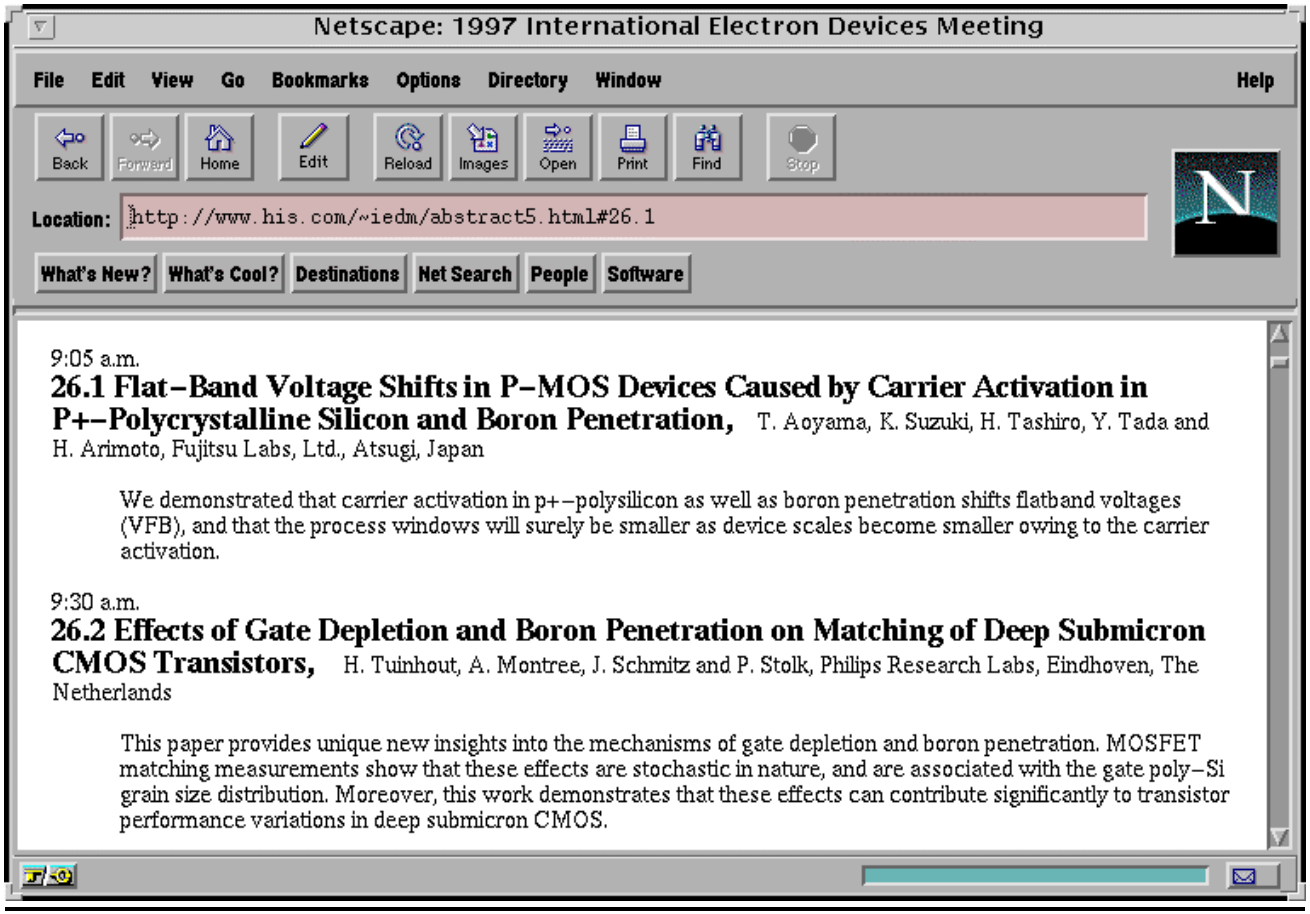
"A New Diffusion Algorithm during Oxidation which can Handle Both Phosphorous Pile-Up and B Segregation at Si-SiO2 Interface"

H. Sakamoto and S. Kumashiro,
NEC Corp., Kanagawa, Japan

"Modeling the Effect of Phosphorous Dose Loss at the SiO2 Interface on CMOS Device Characteristics"

H.-H. Vuong, C.S. Rafferty, J.R. McMacken, J. Ning and S. Chaudhry,
Lucent Technologies, Murray Hill, NJ and Orlando, FL

Poly Dopant (1997 IEDM Preview)



Recap of Missing Guidelines

Junction overlap of poly gate.

Channel doping profile (2D).

Dose loss/pile-up at silicon interface (1D).

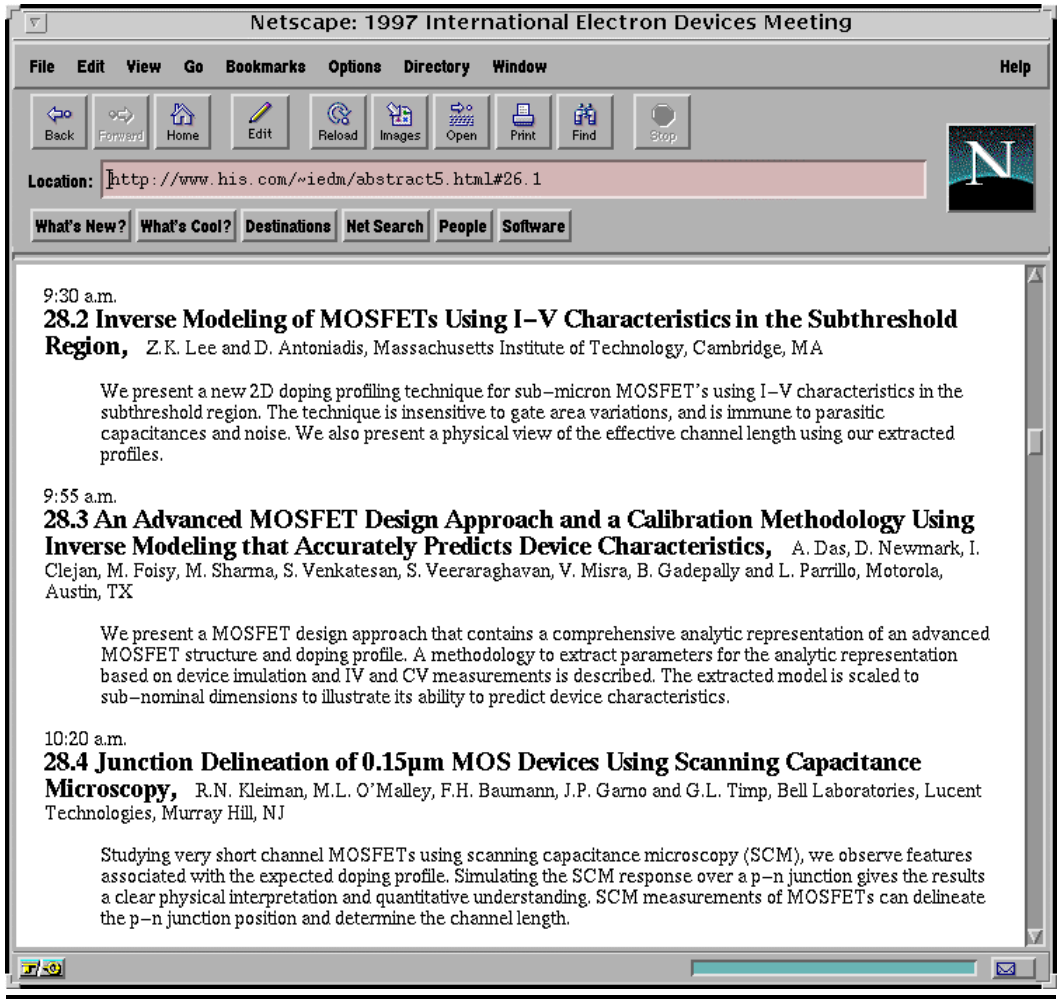
Poly dopant profiles (poly depletion and boron penetration).

Alternative Approaches

Although a “direct” physical measurement of dopant profiles is desirable, an indirect determination by inverse modeling of electrical results will satisfy many customers.

This has the strong advantage that across-the-wafer variations can be measured !

Inverse Modeling (1997 IEDM Preview)



Summary

Dynamic range requirement relaxed in S/D region, but added requirements for better channel and poly profiling.

High-concentration dose loss is an important new area.

Inverse modeling allows across-the-wafer mapping of dopant profiles.