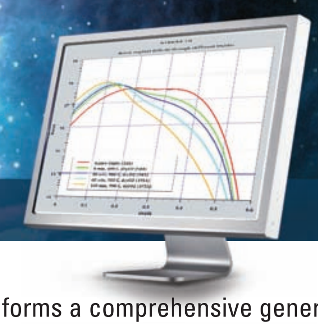
Athena 1D

1D Process Simulator

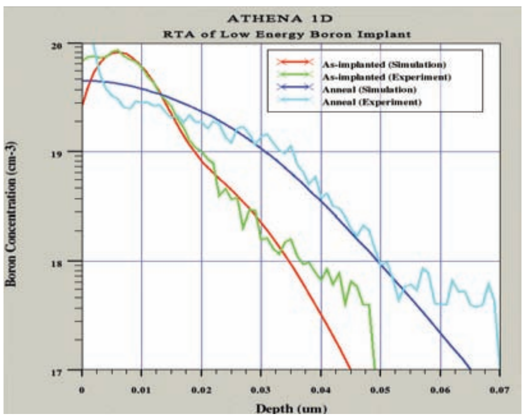


Athena 1D is a 1D mode of operation of the industry standard Athena 2D Process Simulator. Athena 1D forms a comprehensive general purpose one-dimensional (1D) process simulator used in the prediction of doping profiles and thicknesses produced by semiconductor processing. It uses the same physical models as Athena, Silvaco 2D process simulator widely used in semiconductor industry for design and optimization of various fabrication technologies. Athena 1D is thus very accurate and extremely fast. Athena 1D is able to simulate a complete process flow in a matter of minutes. Athena 1D is also very user friendly since it comes with a copy of DeckBuild runtime environment and TonyPlot graphics package. Thus Athena 1D benefits of all DeckBuild features like input files editing as well as build-in optimizer and Design Of Experiment capability.

Advanced Diffusion Simulation

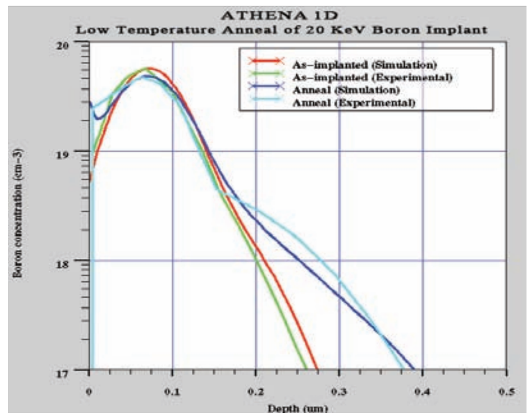
Successful use of low thermal budget processes and ultra-shallow junctions are key manufacturing issues for 90nm and smaller technology nodes. Accurate simulation of low-energy implants with subsequent rapid thermal annealing (RTA) or very low-temperature furnace annealing can be done in Athena 1D using advanced diffusion models including point defect and defect cluster generation and recombination.

RTA Diffusion



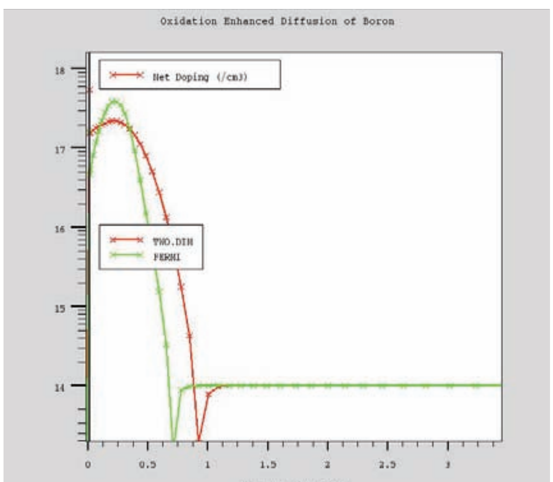
Simulation of 10 seconds boron diffusion at 1000 ºC after ion implantation at 2 keV with a dose of 1.0 x 10^{14} cm^{-2} (Experiment is from B. Colombeau's doctoral thesis). This type of simulation is extremely difficult because it needs to take into account several competing phenomena including strong defect recombination at the surface and very fast generation and recombination of various pairs and defect clusters. Nonetheless, advanced diffusion models in Athena 1D show quite good agreement with experimental profiles.

Low-Temperature Transient Enhanced Diffusion

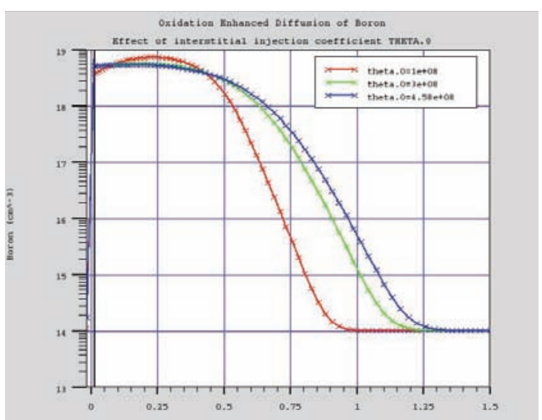


Simulation of 35 minutes boron diffusion at 800°C after ion implantation at 20 keV with a dose of 1.0 x10^{14} cm^{-2} (Experiment is from S.Solmi et.al). This simulation and experiment show that even below the solid solubility level substantial portion of dopant remains inactive due to formation of mixed dopant-defect clusters. Due to inclusion of a sophisticated Boron Interstitial Cluster (BIC) model Athena 1D accurately predicts this important effect.

Oxidation



Simulation of Boron diffusion in an oxidizing ambient. Point defects are injected into the silicon with a rate that is a function of the rate at which the silicon is oxidizing. This point defect injection gives rise to an increased diffusion that is commonly referred to as Oxidation Enhanced Diffusion (OED). TWO.DIM model captures this effect by coupling point defects (interstitial and vacancy), generated by the oxidizing Si-SiO2 interface, with the diffusing boron.



The figure above shows the effect of the interstitiel injection coefficient THETA.0 for calibration of Oxidation Enhanced Diffusion.

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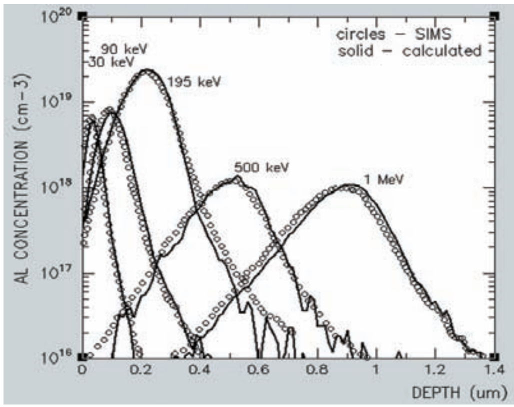
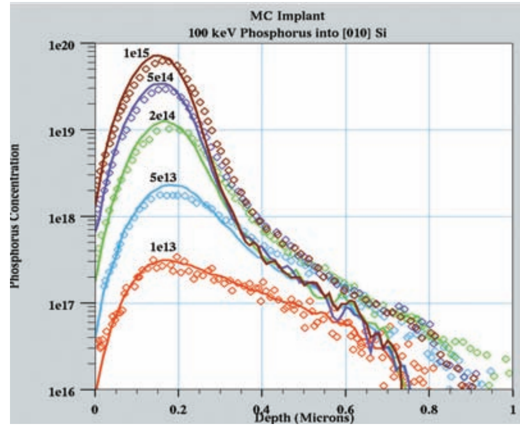
Ion Implant Simulation

A variety of analytical and Monte Carlo Implant models allow accurate simulation of ion implantation used in all modern semiconductor fabrication technologies.

Aluminium Implants into 6H-SiC

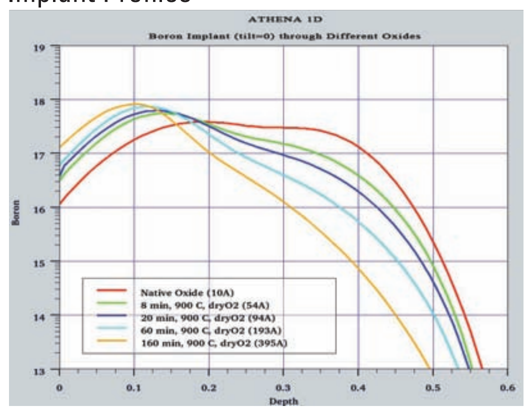


Monte Carlo simulation of Al implants into 6H-SiC at 30, 90, 195, 500 and 1000 keV with doses of 3.0 x 10^{13}, 7.9 x 10^{13}, 3.8 x 10^{14}, 3.0 x 10^{13} ions/cm^2. The implants were 9° off-axis to avoid channeling. SIMS data are taken from Hernandez-Mangas, et.al. Journal of Applied Physics, v.91, pp.658--667, 2002.



The figure above depicts simulation results using MC Implant and compares them to measured data. The lines are MC Implant simulation profiles; diamonds represent SIMS profiles. Experimental and calculated depth profiles of phosphorus implanted at 100keV, tilt = 0° and different doses in the range of 10^{13} cm^{-2} to 10^{15} cm^{-2}. Experiments are compiled from R.J. Schreutelkamp et al., "Channeling Implantation of B and P in Silicon", Nuclear Instruments and Methods, B55, pp. 615–619, 1991.

Effect of Oxide Thickness on Boron Implant Profiles



The figure above compares 35 keV, 1.0 x 10^{13} ions/cm^2, on-axis boron implantation performed through different thicknesses of grown oxide. These simulations use the SIMS-Verified Dual Pearson (SVDP) analytical model based on the tables from the University of Texas at Austin.

Physical Models and Features

Diffusion

- Impurity diffusion fully coupled with point defect diffusion
- Oxidation enhanced/retarded diffusion
- Rapid thermal annealing and Transient Enhanced Diffusion (TED)
- High concentration effects
- TED effects due to implant induced point defects, dopant-defect clusters, and {311} interstitial cluster
- Donor/acceptor co-diffusion effects

Oxidation

- Separate rate coefficients for silicon and polysilicon materials
- HCL and pressure enhanced oxidation models
- Impurity concentration dependent effects

Implantation

- Experimentally verified Pearson and dual Pearson implant models
- Non-Gaussian depth-dependent lateral implant distribution functions
- Extended implant moments tables with energy, dose, tilt, rotation and oxide thickness variations
- User-defined or Monte Carlo extracted implant moments
- Seamless interface with MC Implant module allows accurate simulation of 1D implant profiles for wide range of energies, doses, tilt and rotation changes

Athena 1D Includes:

- Athena 1D process simulator
- DeckBuild runtime environment
- TonyPlot graphics viewer
- 1D Examples, documentation and software updates

DOES NOT INCLUDE SUPPORT

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