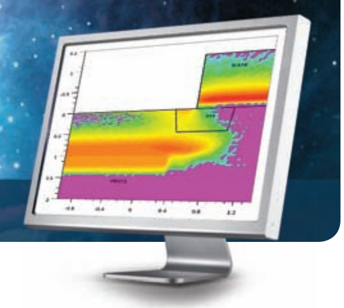
MC Implant

Advanced Monte-Carlo Implantation Simulator

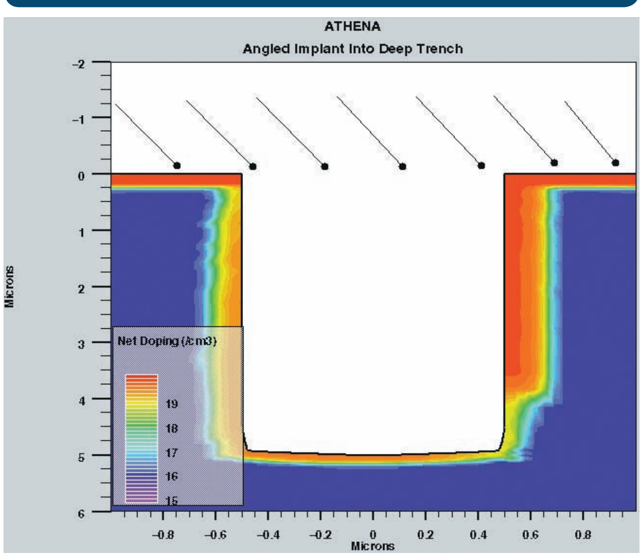


MC Implant is a generic ion implantation simulator, which models ion stopping, defect generation, and ion implantation distributions in amorphous and crystalline materials. Extensive comparisons with measured profiles have shown that MC Implant is highly accurate and predictive. The simulator can be used for a variety of ion/material combinations, arbitrary geometries, different substrate orientations, implant doses, energies and angles.

Advanced Ion Implantation Simulation Solutions

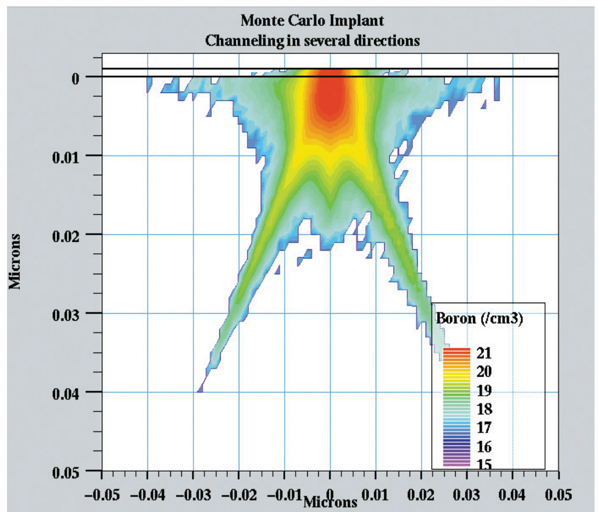
- MC Implant gives highly accurate ion distribution profiles in crystalline and multi-layered materials
- MC Implant predicts ion penetration depths for a wide range of initial energies starting from as low as 200 eV and spanning to the MeV range
- By using aggressive variance reduction statistical techniques, MC Implant provides a time efficient and cost effective solution of problems encountered in modern implantation processes
- The comprehensive capabilities of MC Implant enable accurate simulation of critical process issues such as shallow junction implants, multiple implants and pre-amorphization, HALO implants and retrograde well formation
- Advanced damage accumulation algorithms allow investigation of novel defect driven diffusion models of implanted species
- The internal object-oriented engine and generic 3D solution of related physics allow MC Implant to account for complex effects such as reflection and re-implantation, deep trenches and voids, arbitrary implant direction and wafer rotation

Angled Implant into Deep Trench

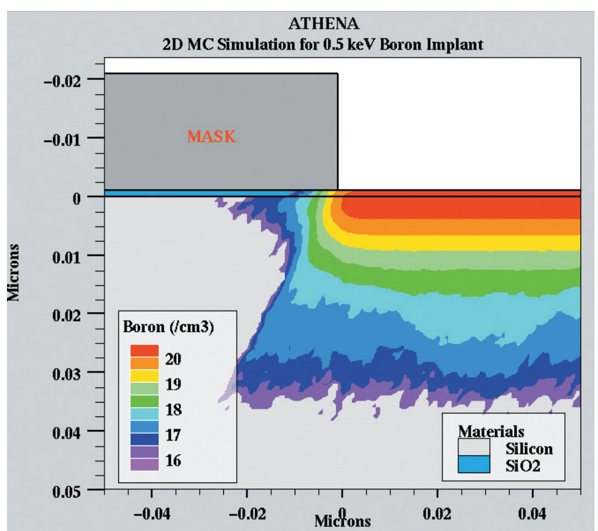


Angled implantation into a deep trench is shown in the figure above. Note implants in shadow regions resulting from ion reflected at the directly implanted trench wall.

Effect of Channeling on Lateral Distributions



The figure above shows a single point implant illustrating the 3D simulation of all channeling directions. The same implant in a practical structure below shows the manifestation of 3D channeling effects under the gate which is enhanced by the presence of a very thin oxide (a counter intuitive result).



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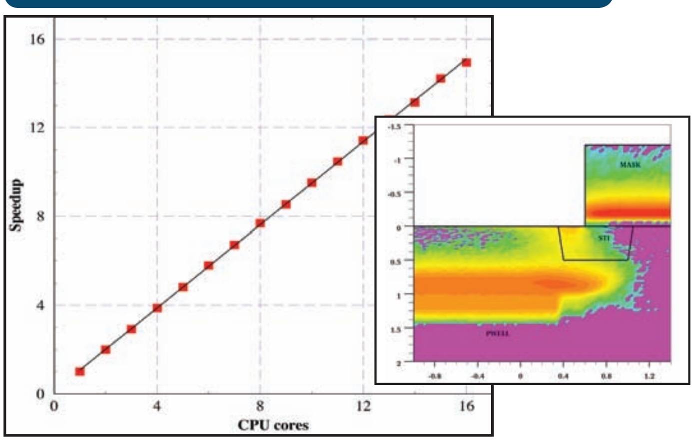
MC Implant Features and Models

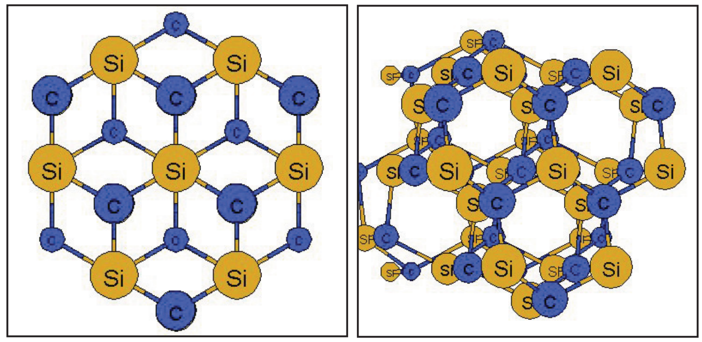
- 3D Binary Collision Approximation Monte-Carlo simulation technology fully integrated with the Athena process simulation framework
- MC Implant module is fully multi-threaded to take advantage of parallel computing. Run time reduction is almost linearly proportional with the number of CPUs
- Physically based electronic stopping additionally optimized for most widely used ion/target combinations
- Variance reduction technology giving an effective tenfold speedup in simulation time
- Precise damage accumulation model, allows accurate simulation of dose-dependent channeling of implants or pre-amorphization effects
- Accurate, experimentally verified down to 0.2 keV doping profiles
- Accurate calculation of de-channeling effects caused by:
    1. damage buildup and previous implant damage
    2. surface oxides polysilcon and other materials
    3. beamwidth variations
    4. implant angle and energy
    5. amorphous material in the structure
- Calibrated electronic stopping for <100>, <111>, and <110> Silicon substrate orientations
- 3-D Channeling effects included in the generic solution of ion propagation and stopping

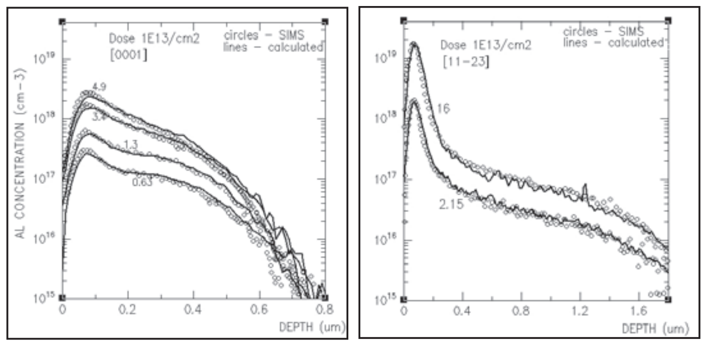
Multi-threaded MC Implant Performance



MC Implant Materials Support

- Implantation in any crystal structure for all supported materials in Athena, e.g., diamond (Si, Ge, SiGe), moissanite (4H-SiC, 6H-SiC), Zincblende (GaAs, InP, 3C-SiC)
- Anisotropic electronic stopping essential for the proper simulation of ion implantation in the most complex structures such as 4H- and 6H-SiC
- Temperature and crystal structure dependent damage model allows "hot" implant simulation





MC Implant simulated profiles of 60 keV Aluminium in 4H-SiC showing different doses for on-axis direction [1]. The strong dependence of Aluminium distributions on the crystallographic direction of ion implantation is evident. The two left figures are for [0001] crystallographic direction while the two on the right hand side are for the [11-23] direction showing two-fold increase in channeling.

[1] Experimental is taken from "Woug-Leung et al, Journal of Applied Physics, vol. 93, pp 8914-8916, 2003".

Multi-core computers significantly improve run times. This figure shows speedup achieved on 16 CPUs computer (Quad-Core AMD Opteron^{tm} Processor 8356 x 4). The Well Proximity Effect was analyzed in 6 hours and 40 minutes on 1 CPU and less than 27 minutes on 16 CPUs by running one million 300 keV Boron ion trajectories.

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