Hints, Tips and Solutions

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Q. If there are multiple implants in my process does the order of these implants have an influence on the result ?

A. Yes. When an implant occurs there will be some level of damage to the crystal structure of the silicon. If this damage is not annealed out then any subsequent implant will have a different penetration depth compared with the crystal that has no damage. The reason this occurs is due to the crystallographic nature of silicon. This means that there are some "channels" along certain crystallographic directions where ions can move much more freely.

When damage to the crystal occurs the material becomes amorphous and these channels no longer exist. If these effects are not modelled or taken into account then significant error could result.

In ***ATHENA*** we simulate implantation with two different methods; an analytical look-up table approach and with a monte carlo binary collision approach (BCA). The analytical tables are well calibrated for the case of individual implants into single crystal silicon but not for cases where channeling may exist (although this effect has been implemented into the tables) or where surfaces become damaged. Alternate tables could be produced for these effects but this would rapidly become extremely difficult and knowledge of the condition of the silicon surface would have to be user controlled.

The monte carlo BCA approach, however, can simulate all these effects. The BCA module in ***ATHENA*** has been described earlier in this issue but due to its 3D based approach and its calculation of damage, multiple implants are simulated extremely accurately.

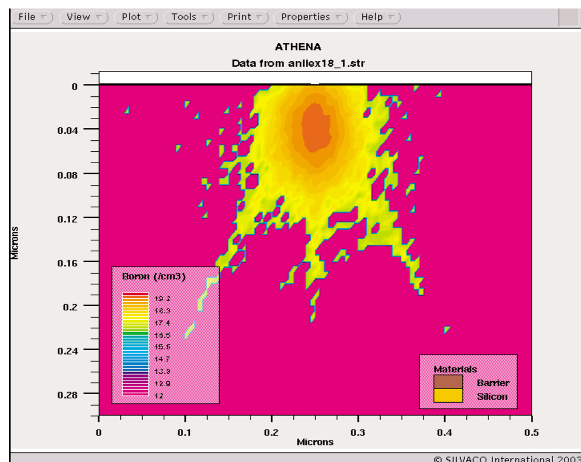

Figure 1. Simulation of two sequential implants; arsenic followed by boron. Damage to the silicon surface results in channelling in different directions and a the boron to be closer to the surface.

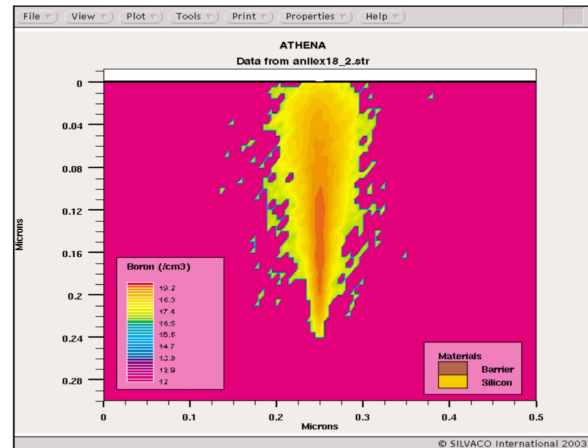

Figure 2. Simulation of two sequential implants; boron followed by arsenic. The boron is implanted into single cystal silicon wioth no damage with the result that the ions channel deeper into the silicon.

To illustrate this we can simulate the following two cases:

Case 1.
arsenic implant of 9.27e12 cm-2 ions at 10KeV
boron implant of 9.27e12 cm-2 ions at 10KeV

Case 2.
boron implant of 9.27e12 cm-2 ions at 10KeV
arsenic implant of 9.27e12 cm-2 ions at 10KeV

Figure 1 shows the results when the Athena BCA monte carlo model is used for Case 1. The arsenic implant partially disorders the silicon near the surface which means that in a boron implant immediately following the aresnic, the boron ions have a higher probability of channeling in secondary directions. The secondary directions are clearly seen in this figure.

Figure 2 shows the results when the ***ATHENA*** BCA monte carlo model is used for Case 2. The boron implant now is into well ordered single cystal silicon with only one predominant channeling direction which is normal to the surface. As a result the boron penetrates much deeper into the silion than in Case 1.

The ***ATHENA*** Monte Carlo BCA module provides users with extremely accurate profiles for single and multiple ion implants. The 3D nature of the implant is taken care of, damage effects are modelled and all this with one ***ATHENA*** command line

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imlant arsenic dose=9.27e12 energy=10 bca
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Call for Questions

If you have hints, tips, solutions or questions to contribute, please contact our Applications and Support Department
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