Combining Medium Energy Ion Scattering measurements with TRIDYN dynamic modelling to characterise a plasma doping process

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MEIS (Medium Energy Ion Scattering) analysis has the great advantage over other profiling methods such as SIMS and dynamic XPS and in that it can measure the absolute number of atoms in a sample without the complications of sputtering and matrix dependent effects, which are particularly important in shallow samples. Profiling by TEM/EDS does not suffer from these effects, but can only quantify profiles as atomic fractions. MEIS spectra can be transformed into depth profiles in terms of layers containing a number of atoms per unit area; converting such data to report layers of different thicknesses and atomic concentrations requires knowledge of the local density in each layer which is information strictly not contained in a straightforward MEIS energy spectrum.

Plasma doping ion implantation (PLAD) is important to enable the processing of advanced semiconductor device structures and is simple in concept: a negatively biased substrate is immersed in a plasma and doped by ions and neutrals from that plasma. The fundamental understanding of PLAD is complicated because implantation, deposition, sputtering and ion beam mixing all have to be taken into account and then additional passivation, cleaning and annealing steps have to be considered. A model of PLAD processes into planar substrates has been constructed that uses the computer code TRIDYN [1] to calculate collision cascades and hence substrate compositional changes during implantation. Rules have been proposed for how the post implant profiles are modified in the passivation and cleaning steps based on TEM/EDS measurements. A particular model prediction is that PLAD should produce a surface layer of low, graded density.

To characterise a PLAD process, several wafers were implanted with As and measured by MEIS at Huddersfield, using He at 100 keV, and at UFRGS, with H and H_2 beams at 200 keV/amu. The As, Si and O profiles for each sample were extracted from the MEIS spectra using IGOR [2] and POWERMEIS [3] based spectrum simulations. The profiles were compared for consistency with

the TRIDYN based model and were converted to atoms/cm^3 vs depth using TRIDYN model density predictions. This comparison showed that the TRIDYN based model gave a reasonable representation of PLAD but could be improved. It also suggested at which step an observed process variation had occurred. This fundamental understanding of PLAD was only possible using absolute elemental profiles measured by MEIS in combination with the TRIDYN based model.

References

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