MEIS
Medium Energy Ion Scattering
University of Huddersfield

Case study 2

MEIS analysis of PLAD implanted As in Si 2

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Plasma doping ion implantation (PLAD) is becoming increasingly important for the manufacture of advanced micro electronic devices as it enables low energy, high fluence and/or conformal implants in Si. PLAD involves implantation, deposition, sputtering and ion beam mixing as well as post-PLAD passivation, cleaning and annealing.

Case study 1 described the determination of the As profile build-up and redistribution after each stage of the PLAD process using **Medium energy ion scattering (MEIS).**
This study describes how recording **MEIS spectra** in Double alignment (channeling & blocking**)** as well as Random configurations using 100 keV He$^+$ ions and 90° scattering has been able to determine activated As doses and their depth profiles.
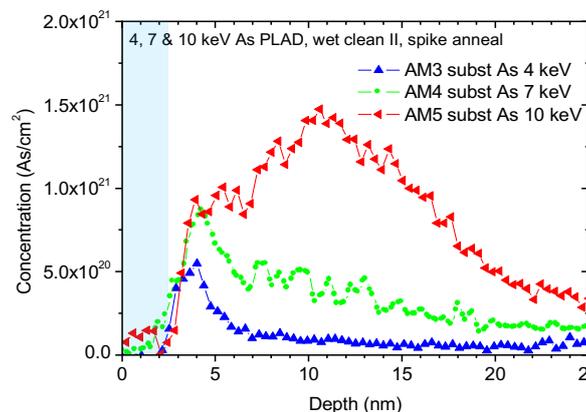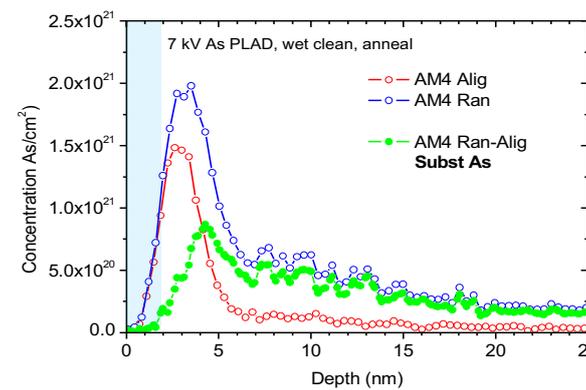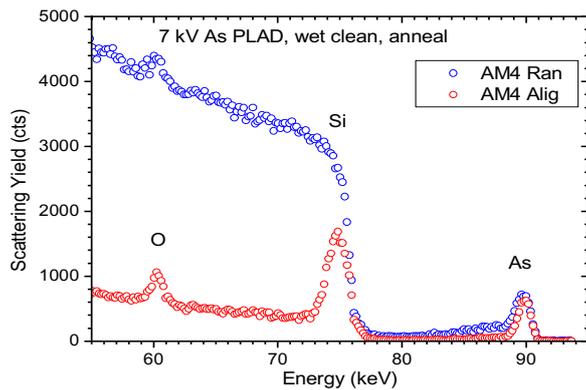
MEIS energy spectra taken in Double Aligned and Random directions on Si(001) after 7 keV As PLAD to nominal ion dose of 1x 10^{16} cm^{-2}, wet clean and spike anneal.

- As peak, Si edge and O peak are marked

- Spectra show surface segregated As peak & deeper As

- Aligned vs. Random energy spectra. Substitutional As is visible in the Random spectrum but not in the Aligned

- NB. Obtaining a Random spectrum is not straightforward in MEIS on X-talline materials

- **Concentration depth profiles of As** obtained by converting spectra using the surface approximation. Good match with IGOR based modelling (used in Case study 1)

- Evaluate amount of substitutional As from the difference of the depth profiles
  o "Random" As dose: 1.35 x 10^{15} cm^{-2}
  o "Aligned" As dose: 5.5 x 10^{14} cm^{-2}
  o Substit. As dose: 8.0 x 10^{14} cm^{-2}

- The MEIS determined substitutional doses scale with R$_S$ measurements

- **Substitutional As depth profiles** taken by MEIS after PLAD implants at 4, 7 and 10 kV bias, wet cleaning and annealing

- At 4 kV the balance in PLAD between As deposition and implant only produces a very shallow (~2nm) implanted layer with a peak subst. As concentration of 1 x 10^{21} cm^{-3}.

- At 10 kV bias a higher subst. As concentration profile is produced, rising to a 1.5 x 10^{21} cm^{-2} extending over a much greater depth is produced.

- Subst As dose strongly on energy due to the increased range

Conclusion: Exploiting channelling and blocking, MEIS has provided both as-implanted and substitutional As concentration depth profiles and doses. Substitutional As doses are primarily Bias (energy) dependent.

Work carried out as an industrial collaboration with AMAT Plasma Doping Group (Jon England, University of Surrey)