MEIS
Medium Energy Ion Scattering
University of Huddersfield

Case study 1

UKNIBC
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MEIS analysis of PLAD implanted As in Si 1

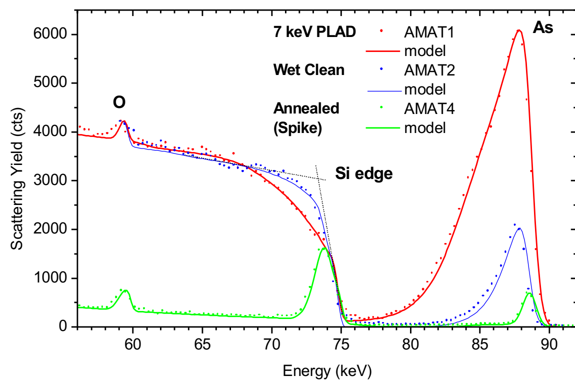
Plasma doping ion implantation (PLAD) is becoming increasingly important for the manufacture of advanced micro-electronic devices as it enables low energy, high fluence and/or conformal implants in Si. PLAD involves implantation, deposition, sputtering and ion beam mixing as well as post-PLAD passivation, cleaning and annealing. The understanding and modelling of the build-up of the implanted layer requires reliable information regarding the implant depth profile after each stage or processing.

Medium energy ion scattering (MEIS) depth profiling analysis in conjunction with energy spectrum simulation can provide quantitative elemental depth profiles with high resolution. Using 100 keV He^+ ions and 90° scattering, MEIS has determined the changes in the near-surface layer of the Si wafer after 3 process stages:

i) the PLAD process of a Si(001) wafer in a 5% AsH_3/H_2 plasma, pulse biased to – 7kV, nom.

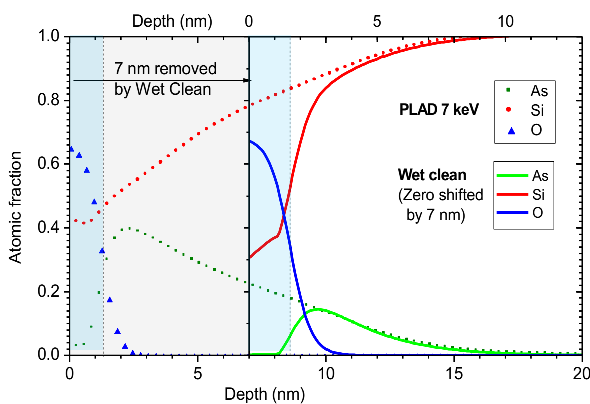
ii) chemical wet clean (non-oxidizing) and

iii) spike annealing in a N_2 atmosphere.



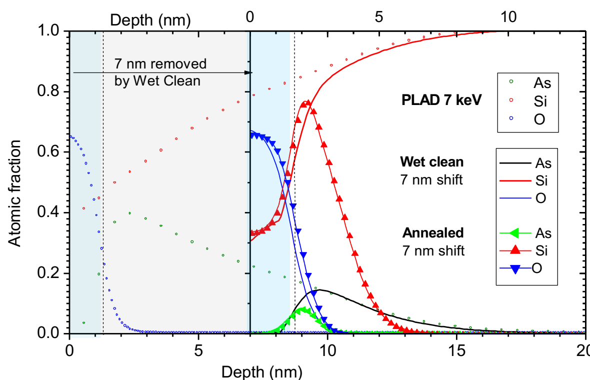
MEIS energy spectra recorded after the 3 stages (.) and best fit model simulations (--). Nominal As ion dose 10^{16}cm^2.

- As peak, Si edge and O peak are marked
- PLAD has produced a near-triangular As spectrum
- The loss of Si yield near the Si edge is due to the implanted As, indicative of an intermixed Si/As layer
- This layer is unstable, losing 25% As over 4 months in air



Fractional best fit depth profiles of Si, As and O after PLAD & Wet (chemical) clean

- **PLAD** results in a near-triangular As profile, ~ 17 nm deep, total dose 1.5 x 10^{16}As/cm^2 under a 1.1 nm oxide
- **Wet clean (chemical etch)** removes the top 7 nm of the mixed As/Si layer and **80%** of near surface As
- Remaining profile of **3 x 10^{15} As cm^{-2}** represents tail of original implanted As profile, now under an oxide of 1.6 nm



Fractional best fit depth profiles of Si, As and O after spike anneal

- **Annealing** restores crystallinity and As activation through Solid Phase Epitaxial Regrowth
- Active As is now no longer "visible" to the aligned beam due to Channelling & Blocking conditions used
- A narrow segregated As surface peak remains visible, containing **~4 x 10^{14} As/cm^{-2}** under a 1.5 nm oxide

Conclusion: MEIS depth profiling analysis has yielded important quantitative elemental depth profiles after each process stage with nm depth resolution, not obtainable using alternative analytical techniques.

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

Contact: Jaap van den Berg (j.vandenberg@hud.ac.uk) or Andrew Rossall (a.rossall@hud.ac.uk)
MEIS Lab, Ion Beam Centre, University of Huddersfield, HD1 3DH