Advances in 3D Atom Probe for nanoscale elemental analysis.

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Laser-assisted evaporation in the Tomographic Atom probe (3D-AP) technique has been shown to be well suited for the nanoscale elemental analysis of many materials including semi-conductors.

With the help of Focused Ion Beam (FIB) techniques, it is now possible to extract and prepare a sample ready for 3D-AP analysis from a selected site-specific location of a bulk sample or from a piece of wafer.

In this study, we demonstrate the interest of using ultra-short (400fs) Laser pulses and the effect of wavelength on atom evaporation and mass spectrum quality. A flexible configuration is necessary in order to ensure optimized conditions depending on the nature or structure of the sample.

Field-effect atom evaporation occurs with near 100% ionization yield and atoms are projected onto a position sensitive detector (Advance Delay-Line type) with a detection efficiency approaching 60%. Mass identification is achieved by a Time of Flight mass spectrometer, including cases where multiple hits occur on the detector. The combination of the high atom ionization yield and high detection efficiency ensures detection limits of tenths of atomic percent at ultra high spatial resolution. For example, only about 50 000 atoms are present in a 10x10x10nm volume of silicon. Looking at a 0.1at% dopant with a nominal detection efficiency of 60%, 30 dopant atoms (ions) will be detected by 3D-AP. And for each detector “hit”, the position information is given on the source surface with typically a lateral resolution of < 0.4nm and a depth resolution of < 0.2nm as can be demonstrated by observing the silicon (111) atomic planes.

This presentation will review the very latest developments and applications of Atom Probe Tomography in the semiconductor field (such as localized dopant profiling, III-V layer homogeneity, thin insulating layers (fig. 1),…) which have become possible along with instrumentation developments. These data will be compared to SIMS data in terms of depth resolution (fig. 2) and concentration measurement. In conclusion, potentials and limits of the 3D-AP technique for nano-scale materials analysis will be discussed.

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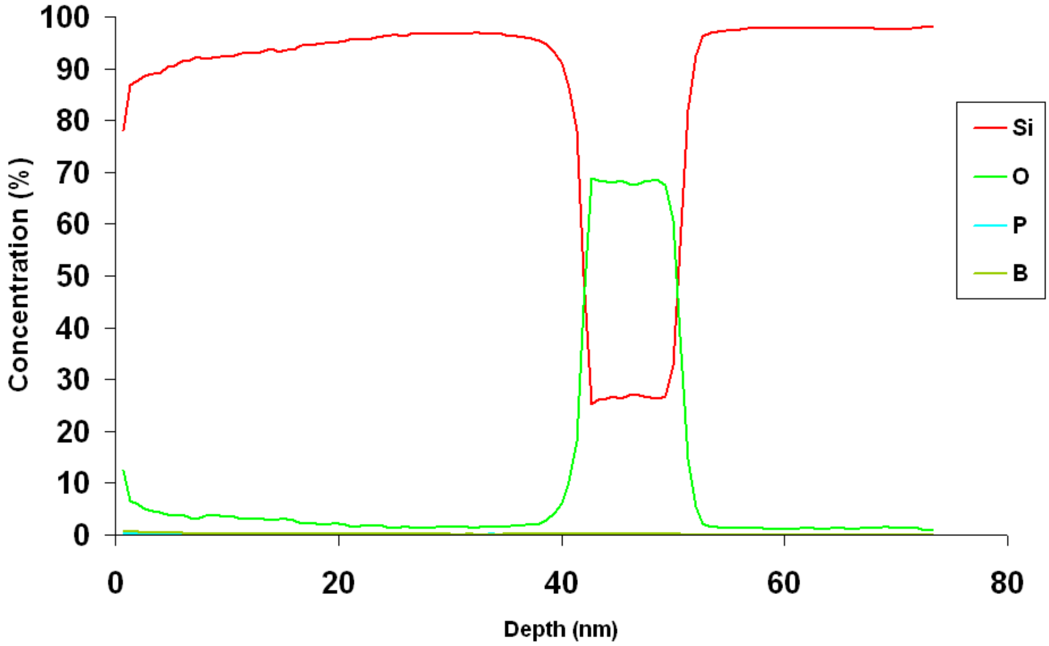

Figure 1: quantitative analysis of a SiO2 layer of 12 nm thickness.

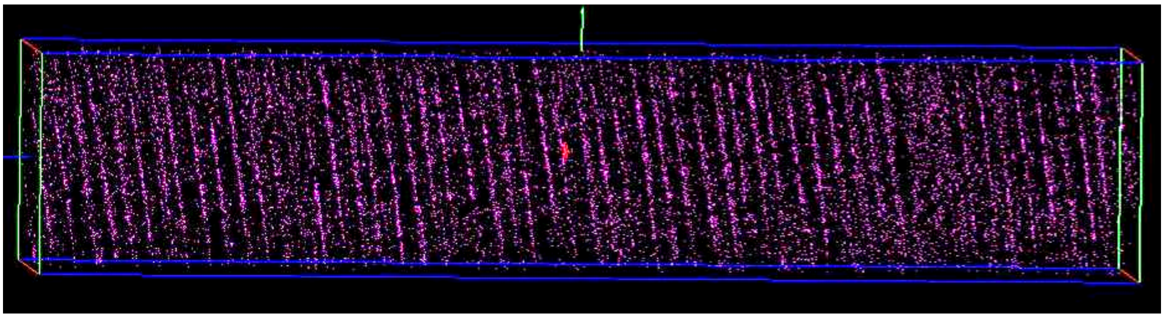

Figure 2: atomic planes in silicon along (111) direction.

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