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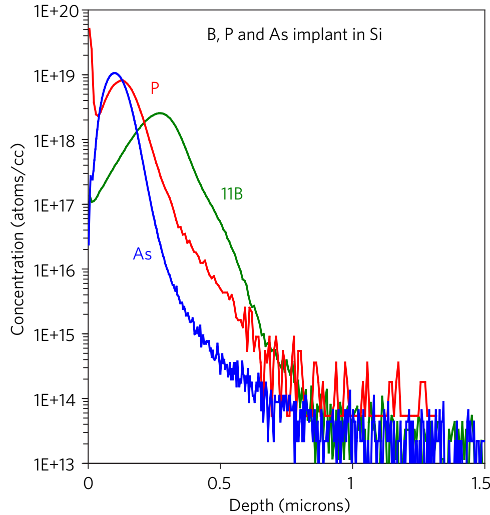
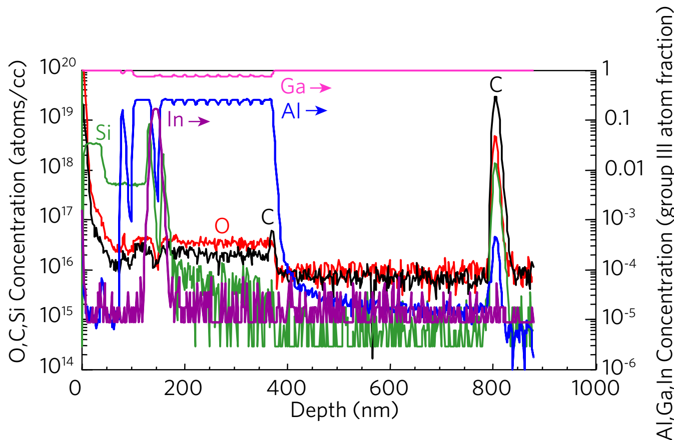
TECHNIQUE NOTE

Secondary Ion Mass Spectrometry (SIMS) Services

TYPICAL DATA



Profiles of B, P and As implant standards in Si. These standards are calibrated with NIST SRM. SIMS profiles provide accurate doping concentrations vs. depth, with excellent detection sensitivity and dynamic range.



Compound (III-V) semiconductor device characterization, complete with composition and dopant/impurity concentration quantification. The profile is optimized for C and O impurity detection and for good depth resolution.

PRINCIPLES

During a SIMS analysis, the samples are sputtered by a focused energetic primary ion beam (100 eV - 15 keV), either oxygen (O_2+) or cesium (Cs+). A fraction of sputtered materials is ionized during the sputtering process. These secondary ions are extracted from the surface, mass analyzed based on the unique mass-to-charge ratio of individual elements, and collected as secondary ion intensities. Since each element (and isotope) in the periodic table has a unique mass-to-charge ratio, this technique can detect every element in the periodic table. The secondary ion intensities can be converted into concentrations based on analysis of reference standards. In dynamic-SIMS mode, where the ions are continually monitored while sputtering target material, one can determine the concentration as a function of depth into the sample with minimum distortion to the true in-depth distribution and with very high sensitivity (ppma to ppba).

COMMON APPLICATIONS

The extremely high sensitivity and ability to depth profile make SIMS ideally suited to characterize semiconductors and other thin film materials. Selected applications include the following:

- Dopant and impurity depth profiling
- Composition and impurity measurements of thin films (SiGe, III-V, and II-VI)
- Ultra-high depth resolution profiling of shallow implants and ultra-thin films (ULE implants and gate oxides)
- Bulk analysis, including B, C, O, and N in Si
- High-precision matching of process tools (ion implanters & epi reactors)
- Composition and contamination profiles in thin films
- Interface contaminant profiles

STRENGTHS

- Excellent detection sensitivity for dopants and impurities, with ppma or lower detection sensitivity for most elements
- Depth profiles with monolayer depth resolution
- Small-area analysis (≥10 µm)
- Detection of all elements and isotopes, including H
- Excellent dynamic range (up to 7 orders of magnitude)
- Major element composition gradient quantification, in some applications

Secondary Ion Mass Spectrometry (SIMS) Services

LIMITATIONS

- Standards required for accurate quantification
- No chemical bonding information
- Destructive

TECHNIQUE COMPARISONS

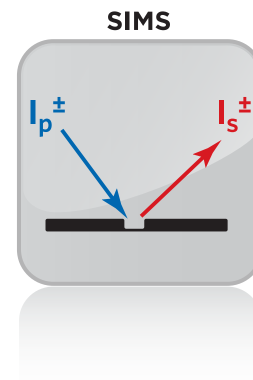
Other surface analytical techniques that can determine compositional depth profiles include X-ray Photoelectron Spectroscopy (XPS) and Auger Electron Spectroscopy (AES). Both have poor detection sensitivity (~0.1%) compared with SIMS. Glow Discharge Mass Spectrometry (GDMS) has good sensitivity but it is primarily a bulk technique. Static-SIMS, which typically uses a Time-Of-Flight spectrometer (TOF-SIMS), operates on the same basic principles as dynamic-SIMS, but experiments are typically limited to the outer monolayers of a sample and are generally not quantitative.

SIMS AT EAG

EAG is the industry standard for SIMS analysis, offering the best detection sensitivity along with accurate concentration and layer structure identification. No other analytical laboratory can match EAG's depth of experience, as well as dedication to research and development in the SIMS field. We have the highest number of SIMS instruments worldwide (more than 50 SIMS instruments), highly qualified scientists, and the world's largest reference material library of over 6000 ion-implanted and bulk-doped standards for accurate SIMS quantification. EAG has been doing SIMS for over 40 years; longer than any other commercial laboratory.

DESCRIPTION

Secondary Ion Mass Spectrometry (SIMS) is an analytical technique that detects very low concentrations of dopants and impurities. It can provide elemental depth profiles over a depth range from a few nanometers to tens of microns. SIMS works by sputtering the sample surface with a focused beam of primary ions. Secondary ions formed during the sputtering are extracted and analyzed using a mass spectrometer. These secondary ions can range from matrix levels down to parts-per-billion (ppba) levels.



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