Advanced SIMS Quantification in the first few nm of B , P and As Ultra Shallow Implants

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ABSTRACT

Newest semiconductor chip manufacturing and further scaling of CMOS devices push to junction depths below the 10nm range with profile steepness of 1-2 nm/dec. At such scale, the SIMS technique can be used to monitor in-depth distributions of dopants, provided that SIMS profiles can be measured with depth resolution better than 1 nm/dec. This can only be achieved by using very low energy primary ion bombardment (<150 eV). The use of Extreme Low Impact Energy (EXLIE) sputtering conditions can be limited by a dramatic drop in sputter yield observed below 250eV impact energy. Therefore, SIMS tool primary ion columns must deliver high current densities at low impact energies to maintain erosion speeds consistent with reasonable analysis throughput. New Cs^+ and O_2^+ ion source designs on the CAMECA IMS Wf tool have improved source brightness, thereby giving access to sputter rates of 1 and 2nm/min for the Cs^+ and O_2^+ primary beams, respectively.

Analytical value of EXLEI sputtering conditions have been evaluated for B, P, and As ultra shallow implant profiles. The preferred protocol for As shallow profiles is Cs^+ 150eV in combination with O_2 oxygen backfilling. For B & P profiles, O_2^+ 150eV experimental conditions offer the best profile shape accuracy at the near surface. The overall results confirm that the use of EXLIE conditions minimizes near surface profiles artifacts. At the same time data quantification requires dedicated post-analysis data treatment to take into account transient sputtering at the near surface and matrix effects between Si and SiO_2. The capabilities of EXLIE conditions are further challenged when analyzing a structure with small lateral dimension such as test patterns. At very low energies, primary ion beam focusing on the surface is limited. High dynamic range depth profiles could suffer from crater edge effects during small-area analysis. However, sample preparation using the so-called MESA technique significantly improves the dynamic range in small pattern depth profiles. A trench around the pattern is removed using a higher energy for better throughput. A new software option enables fully automated MESA preparation prior EXLIE profiling on the CAMECA IMS Wf. Application examples of the use of EXLIE SIMS will be presented.

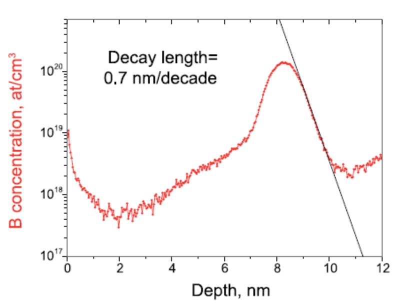

FIGURE 1. B delta layer profile measured under O_2^+ bombardment with 150eV impact energy

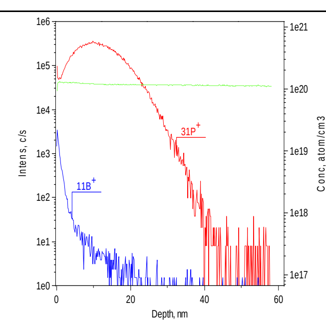

FIGURE 2. Phosphorous profile measured under O_2^+ bombardment with 150eV impact energy.