AN 438

Measuring Ultra-low Energy Boron Implants using **PCOR-SIMS**^{SM}

May 9, 2007 (Version 2.0)

Introduction

Today, leading edge chipmakers are fabricating transistors with source/drain extensions of 11nm. For future devices the source/drain extensions are expected to be less than 7nm. Fabrication of these shallow implants requires implant energies as low as 100eV (net impact). Characterization of these implants requires accurate profile shape and oxide layer thickness within the upper several nanometers of the wafer surface. **PCOR-SIMS^{SM}*** represents the latest improvements in ULE B characterization that incorporates point-by-point data corrections for all regions of the profile. This method avoids near-surface profile distortions introduced by the older oxygen flooding and normal incidence techniques and yields the most accurate junction depth measurements due to direct measurement of surface oxide thickness.

Figure 1 shows a comparison of **PCOR-SIMS^{SM}** profiles from three separate 500eV B implants made into Si substrates with different oxide thicknesses. One sample has a native oxide (blue), one has a 5nm oxide (purple) and one has a 10nm (green) oxide. In addition, a SRIM simulation (red) for a 500eV implant is superimposed for reference. Note the good agreement between the profile shapes and the SRIM calculation (Figure 1). This agreement indicates the **PCOR-SIMS^{SM}** protocol correctly accounts for any sensitivity changes as the profile cross the SiO_2/Si interface, regardless of oxide thickness. The longer tails within the substrate are due to channeling in the crystalline silicon; SRIM assumes an amorphous substrate.

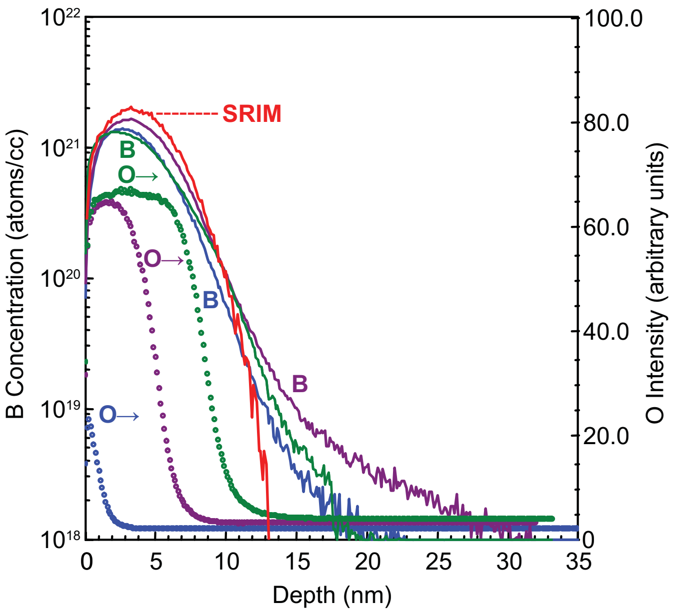

Figure 1. Comparison of SRIM (red) and **PCOR-SIMS^{SM}** analysis of 500eV Boron ion implantation into 3 samples with a native oxide (blue), a 5nm oxide (purple) and a 10nm oxide (green).

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* The new PCOR-SIMS^{SM} for ULE B protocol is the result of extensive development efforts by EAG. The "PCOR-SIMS^{SM}" name describes, in part, EAG's proprietary methodology that includes point-to-point correction resulting in the most accurate SIMS profiling yet for ultra shallow implants.

Discussion

Figure 2 shows a comparison of a **PCOR-SIMS**^{SM} (red) with Elastic Recoil Detection Analysis (ERDA) profile (blue) for a 500eV B implant in a wafer with a 5nm surface oxide layer.[1] The ERDA technique is known to be accurate in both the oxide and Si substrate, but suffers from poor detection limits and dynamic range. This comparison demonstrates that the **PCOR-SIMS**^{SM} B profile matches the ERDA profile both within the oxide layer and in the Si substrate. In addition, the thickness of the oxide layer is measured well by **PCOR-SIMS**^{SM}.

Figure 3 compares profiles with implant energies of 500eV, 250eV and 112eV net energy measured by **PCOR-SIMS**^{SM}. All of these profiles have the Gaussian distribution typical of more energetic implants, even for these extremely low energies. In addition, the high peak concentrations are accurately plotted. **PCOR-SIMS**^{SM} incorporates corrections that yield accurate B concentrations up to 1x10^{22} atoms/cm^3 (20 atomic %).

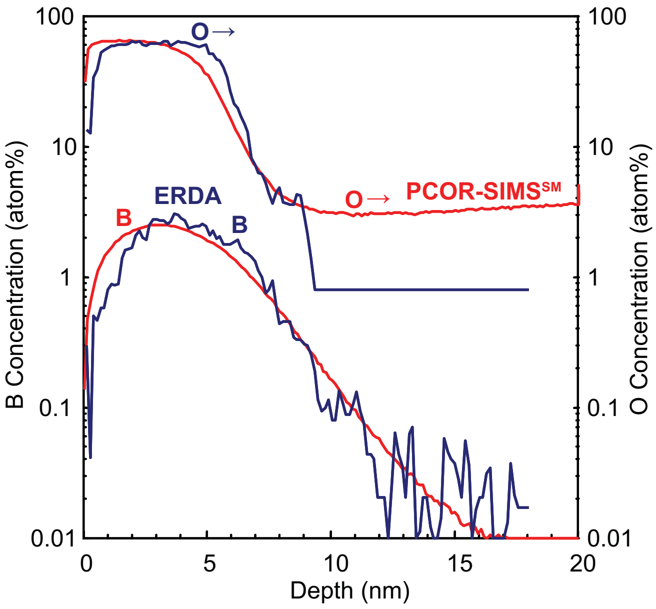

Figure 2. **PCOR-SIMS**^{SM} and Elastic Recoil Detection Analysis (ERDA) data comparison of 500eV Boron implant into 5nm SiO$_2$ on Si. Boron data from both techniques match in the oxide, Si and especially across the SiO$_2$/Si interface

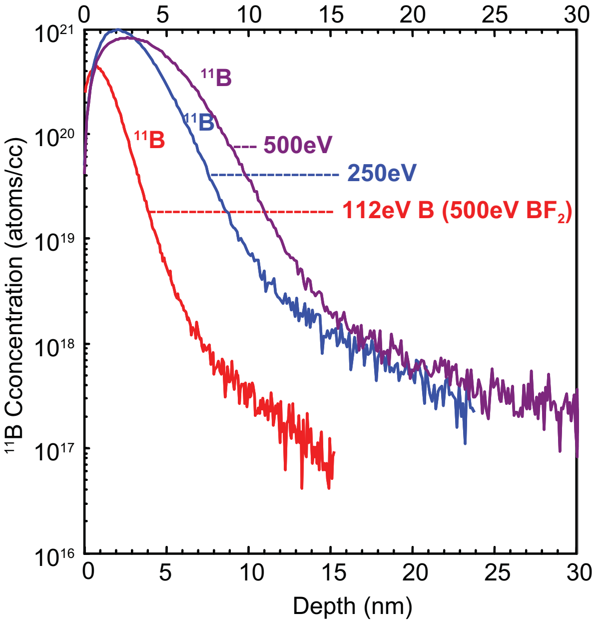

Figure 3. **PCOR-SIMS**^{SM} analysis provides more realistic ion implant energy comparison. All implants peak below the surface as expected by implant simulation.

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[1] ERDA courtesy of Prof. Wilfried Vandervorst at IMEC

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