



AN 438

Measuring Ultra-low Energy Boron Implants using PCOR-SIMSSM

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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-SIMSSM** 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-SIMSSM** 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-SIMSSM** protocol correctly accounts for any sensitivity changes as the profile cross the SiO₂/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.

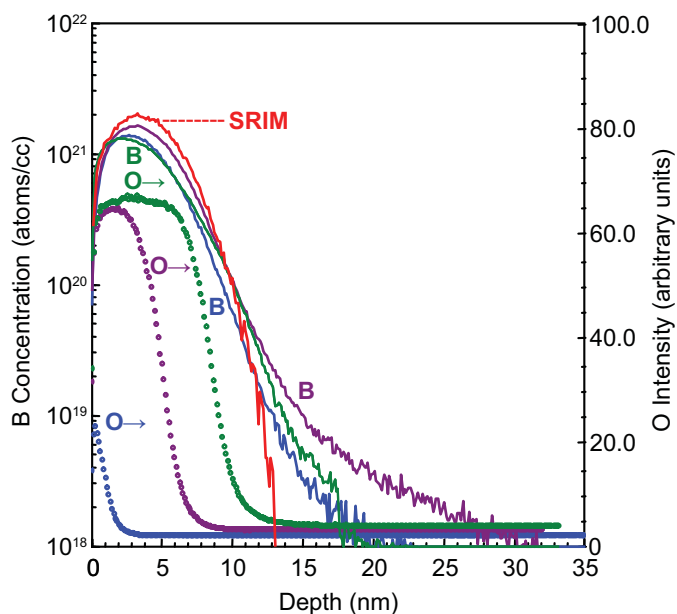


Figure 1. Comparison of SRIM (red) and **PCOR-SIMSSM** analysis of 500eV Boron ion implantation into 3 samples with a native oxide (blue), a 5nm oxide (purple) and a 10nm oxide (green).

* The new PCOR-SIMSSM for ULE B protocol is the result of extensive development efforts by EAG. The "PCOR-SIMSSM" 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-SIMSSM** (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-SIMSSM** 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-SIMSSM**.

Figure 3 compares profiles with implant energies of 500eV, 250eV and 112eV net energy measured by **PCOR-SIMSSM**. 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-SIMSSM** incorporates corrections that yield accurate B concentrations up to 1×10^{22} atoms/cm³ (20 atomic %).

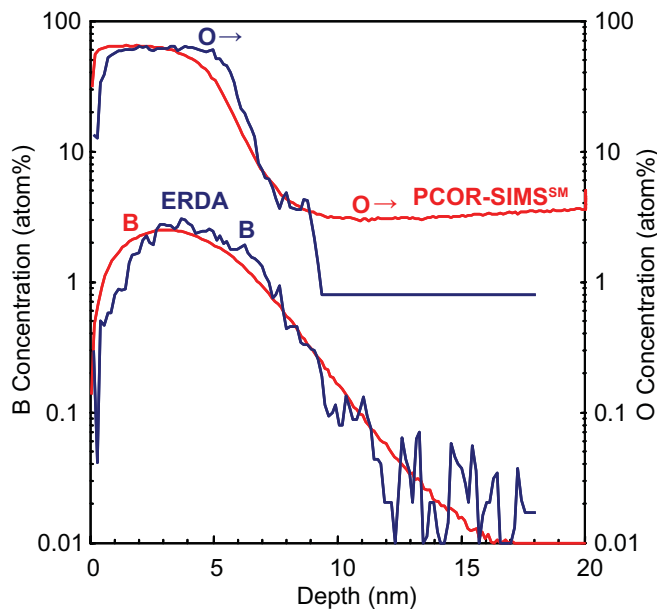


Figure 2. **PCOR-SIMSSM** and Elastic Recoil Detection Analysis (ERDA) data comparison of 500eV Boron implant into 5nm SiO₂ on Si. Boron data from both techniques match in the oxide, Si and especially across the SiO₂/Si interface

1 ERDA courtesy of Prof. Wilfried Vandervorst at IMEC

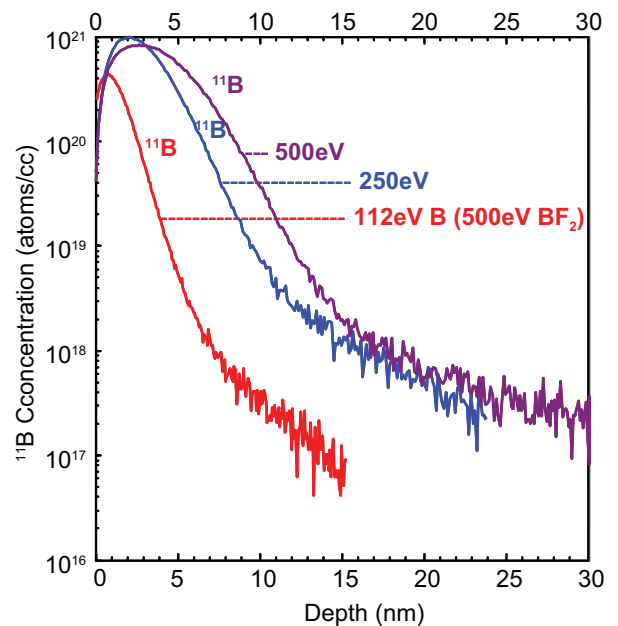


Figure 3. **PCOR-SIMSSM** analysis provides more realistic ion implant energy comparison. All implants peak below the surface as expected by implant simulation.

United States Locations

Tempe, Arizona
 +1 480 239 0602 info.az@eaglabs.com
 +1 602 470 2655 fax

Sunnyvale, California
 810 Kifer Road
 +1 408 530 3500 info.ca@eaglabs.com
 +1 408 530 3501 fax

1135 E Arques Avenue
 +1 408 738 3033
 +1 408 738 3035 fax

785 Lucerne Drive
 +1 408 737 3892
 +1 408 737 3916 fax

Peabody, Massachusetts
 +1 978 278 9500 info.ma@eaglabs.com
 +1 978 278 9501 fax

Chanhassen, Minnesota
 +1 952 828 6411 info.mn@eaglabs.com
 +1 952 828 6449 fax

East Windsor, New Jersey
 +1 609 371 4800 info.nj@eaglabs.com
 +1 609 371 5666 fax

Syracuse, New York
 +1 315 431 9900 info.ny@eaglabs.com
 +1 315 431 9800 fax

Raleigh, North Carolina
 +1 919 829 7041 info.nc@eaglabs.com
 +1 919 829 5518 fax

Round Rock, Texas
 +1 512 671 9500 info.tx@eaglabs.com
 +1 512 671 9501 fax

International Locations

Shanghai, China
 + 86 21 6879 6088 info.cn@eaglabs.com
 + 86 21 6879 9086 fax

Tournefeuille, France
 + 33 5 61 73 15 29 info.fr@eaglabs.com
 + 33 5 61 73 15 67 fax

Frankfurt, Germany
 + 49 (0) 693053213 info.de@eaglabs.com
 + 49 (0) 69307941 fax

Tokyo, Japan
 + 81 3 5396 0531 info.jp@eaglabs.com
 + 81 3 5396 1930 fax

HsinChu, Taiwan
 + 886 3 5632303 info.tw@eaglabs.com
 + 886 3 5632306 fax

Uxbridge, United Kingdom
 + 44 (0) 1895 811194 info.uk@eaglabs.com
 + 44 (0) 1895 810350 fax