ANALYTICAL INSIGHT
MARCH 2006
BALAZS ANALYTICAL SERVICES

Return to Main Page

Dose Measurement via SIMS Becomes Obsolete as use of Ultra Low Energy Grows

By Dr. Fuhe Li and Dr. Scott Anderson

As geometry size enters the 65nm and 45nm technology nodes and ultra low energy (ULE) ion implantation becomes standard, there are needs for an alternative dose analysis methodology. Although typically the domain of SIMS, the coupling of laser ablation (LA) for sampling and detection via inductively coupled plasma (ICP) mass spectrometry (MS) as SARIS^{TM} LA-ICP-MS permits advantages and functionality not previously available. Measurement of dopant doses by SARIS is not based on depth profiling. Advantages include consistent ion yields regardless of the near-surface transient region or co-implanted ion species as well as extremely fast sample analysis and the simultaneous availability of all metallic contamination concentrations without ion source modification.

SARISTM LA ICP-MS

SARIS (see Figure 1) has been applied diversely in the semiconductor, electronics and disk drive industries. When it is used for total implant dose confirmation, its measurement approach is not based on depth profiling, thus its dose data reliability is no longer dependent upon depth resolution. The reduction in implantation energy and junction depth has little and no negative effect on its dose measurement capability. In fact, ULE implants make the SARIS analysis even less challenging because laser sampling does not have to penetrate very deep and ICP-MS signal for the same implant at a given dose is actually more intense because of less signal dilution by silicon.

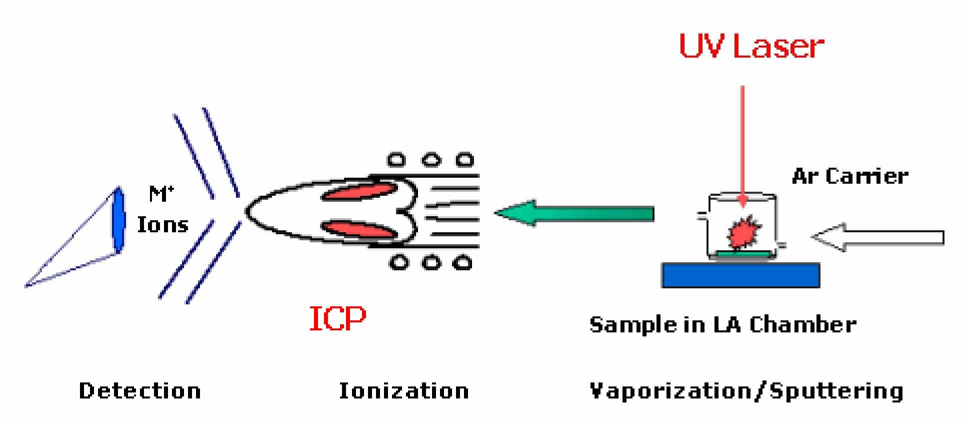


Figure 1. Conceptual diagram of laser ablation ICP mass spectrometry (LA ICP-MS).

Figure 2 shows a schematic diagram of laser sampling process on a wafer and a representative ICP-MS signal profile obtained with a ULE boron shallow implant. The laser sampling depth chosen for the dose measurement is typically a little bit deeper than implant depth to ensure that nearly 100% of the dopant in silicon is ablated within the selected sampling area. As shown, the 11B$^+$ signal begins rising immediately after the pulsed laser beam is applied, reaching a maximum signal and then leveling off to form a plateau while the laser continuously rasters across the wafer surface. After the laser is switched off, the signal quickly decays to baseline without showing signal tailing.

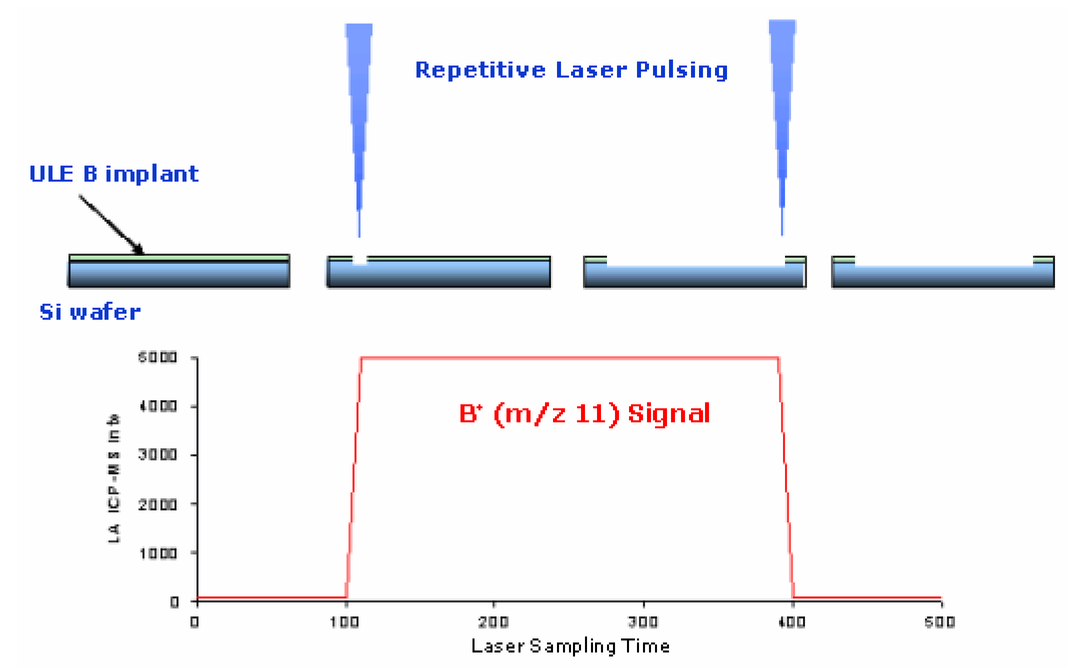
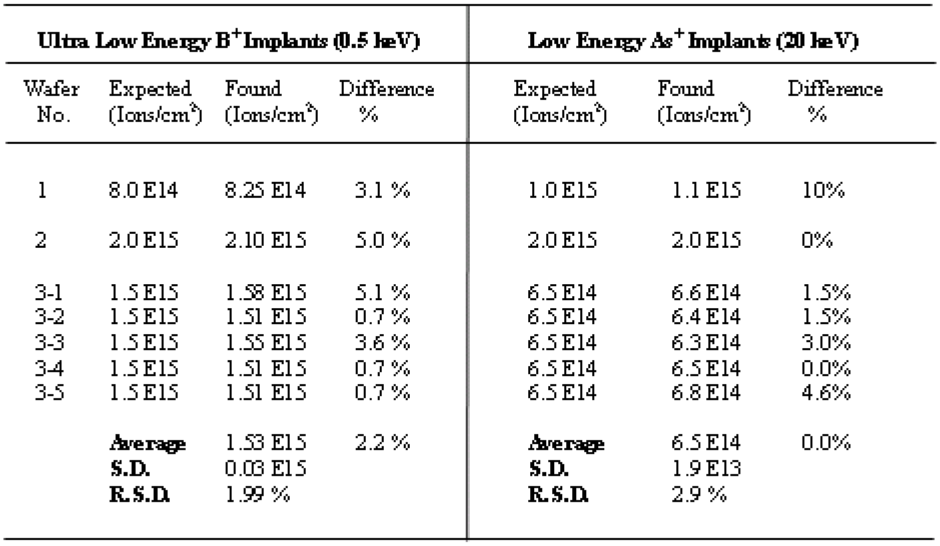


Figure 2. Schematic diagram of laser ablation wafer sampling process and representative ICP-MS signal profile obtained with a ULE shallow boron implant.

Accuracy and Precision Assessments

Sample wafers are analyzed under exactly the same condition as calibration standards. The accuracy and analytical precision of SARIS have been assessed using low energy and ultra low energy 11B$^+$ and 75As$^+$ implants. The representative results with 11B$^+$ implanted at 0.5 keV and 75As$^+$ implanted at 20 keV are presented in Table 1. As shown, the SARIS results are in excellent agreement with the theoretical doses based on ion implanter beam currents and the length of time for implant. The load to load repeatability or precision is around 2-3%.



	Ultra Low Energy B$^+$ Implants (0.5 keV)			Low Energy As$^+$ Implants (20 keV)		
Wafer No.	Expected (Ions/cm^2)	Found (Ions/cm^2)	Difference %	Expected (Ions/cm^2)	Found (Ions/cm^2)	Difference %
1	8.0 E14	8.25 E14	3.1 %	1.0 E15	1.1 E15	10%
2	2.0 E15	2.10 E15	5.0 %	2.0 E15	2.0 E15	0%
3-1	1.5 E15	1.58 E15	5.1 %	6.5 E14	6.6 E14	1.5%
3-2	1.5 E15	1.51 E15	0.7 %	6.5 E14	6.4 E14	1.5%
3-3	1.5 E15	1.55 E15	3.6 %	6.5 E14	6.3 E14	3.0%
3-4	1.5 E15	1.51 E15	0.7 %	6.5 E14	6.5 E14	0.0%
3-5	1.5 E15	1.51 E15	0.7 %	6.5 E14	6.8 E14	4.6%
	Average	1.53 E15	2.2 %	**Average**	6.5 E14	0.0%
	S.D.	0.03 E15		**S.D.**	1.9 E13	
	R.S.D.	1.99 %		**R.S.D.**	2.9 %	

Table 1. Total dose results obtained using SARISTM laser ablation ICP-MS

Summary

Utilizing a different solid sampling strategy and an efficient ionization process, SARIS is an alternative dose analysis methodology for quantitative measurement of ULE shallow implants. Although typically the domain of SIMS, the coupling of laser ablation for sampling and detection via ICP-MS as SARIS provides advantages and functionality not available with SIMS. These advantages include extremely fast sample analysis and the simultaneous availability of all metallic contamination concentrations without ion source modification. SARIS is not affected by surface oxides on the wafer, thermal annealing process, or the presence of co-implanted species such as high concentration fluorine, a feature very important when analyzing high dose BF^{2+} ion implants. More importantly, quantification of total dopant doses by SARIS does not depend on depth profiling resolution and surface condition, thereby ensuring the measurement accuracy for ULE implants.

Send Me More Information