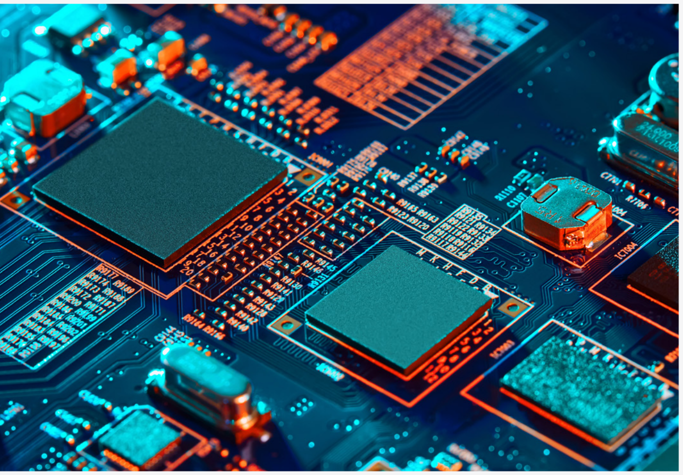
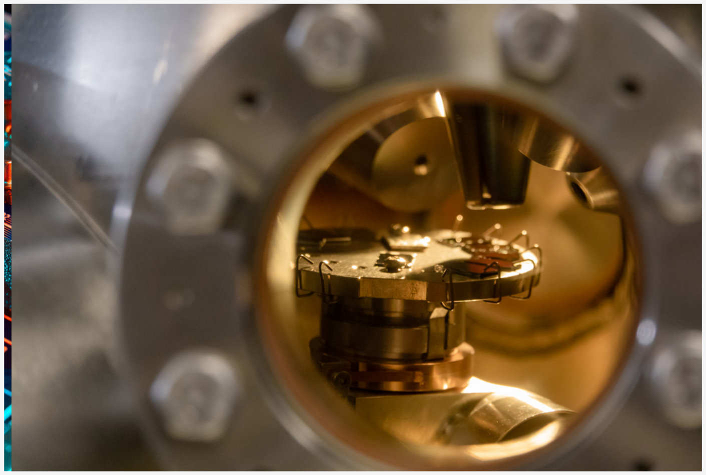


# IMPROVED PROFILE ACCURACY USING **POINT-BY-POINT CORRECTED-SIMS.** A TECHNOLOGY EXCLUSIVE TO EAG.

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## What is PCOR-SIMS℠?

PCOR-SIMS℠ is a technique that can measure layer thickness, composition, and doping profiles more accurately than a regular SIMS analysis. It uses the simple idea that composition in a multi-layer system can be determimed by the SIMS measurement itself. If composition can be determined then the correct sputter rates and sensitivty factors for impurities can be applied at every point.

## Where did PCOR-SIMS℠ Originate From?

It was commonly assumed that Secondary Ion Mass Spectrometry (SIMS) could not quantify matrix-level concentrations with sufficient accuracy, and calibrating dopant intensities continuously, with respect to varying matrix compositions, as it would be prohibitively time consuming. Scientists at Eurofins EAG Laboratories recognized these challenges, and the need for a deeper level of accuracy, so they perfected the methodology and technique to birth PCOR-SIMS℠, or **P**oint-by-Point **COR**rected-SIMS.

## How is Composition Measured?

Standards need to be prepared covering the range of expected composition for a given material system. From profiles on these standards, calibration functions for composition and sputter rate can be determined.

## Calibration Functions for Impurities

Known amounts of impurities are introduced into a set of composition standards. Sensitivity factors for impurities can then be determined as a function of composition.



## What is SIMS?

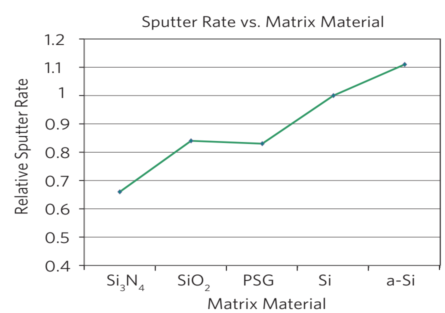
SIMS is a powerful depth profiling tool with unmatched sensitivity to all elements. However if the composition of the system changes with depth, then concentration profiles become less accurate due to 'matrix effects'.

## What are Matrix Effects?

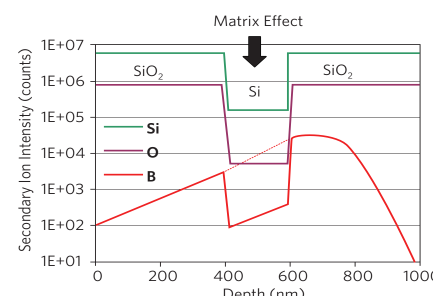
In SIMS, a primary ion beam sputter etches a surface. Only a fraction of the sputtered material is ionized during sputtering. The ion fraction depends on the element and also on the surface chemistry - the matrix material. Change the matrix material and the ion yields change.

## Why are Matrix Effects Important?

If composition changes with depth, then dopant and contaminant ion yield can change. Concentration profiles may not be accurate.  Sputter rate can also change resulting in a less accurate depth scale.



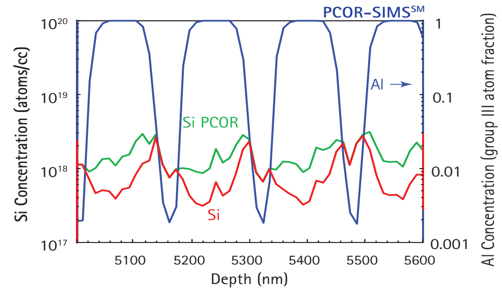

**Sputter Rates in Silicon Based Materials**
Sputter rates vary by a factor of 1.7  Data are normalized to 1 for silicon.




**SIMS Matrix Effect**
Ion yield for silicon is lower in Si than in $SiO_2$. The profile shows Si ion counts decrease from $SiO_2$ to Si even though concentration is actually 3x higher!

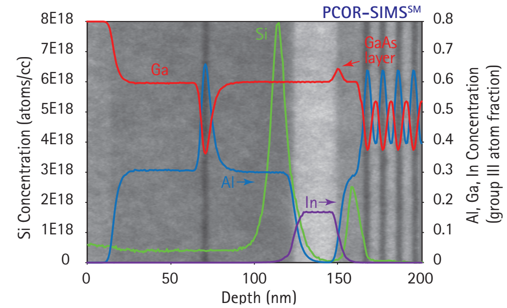
The boron profile shows a drop-out in the Si layer but the actual boron implant is continuous as indicated by the dotted line.

# Applications of PCOR-SIMS℠ for Multi-Layer Systems



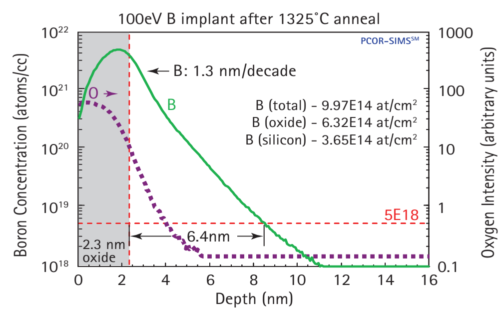

## VCSEL n-DBR Layers

PCOR-SIMS℠ can determine the layer composition at every data point. In this case we show a GaAs/AlGaAs multi-layer structure. We can then plot a silicon dopant profile using the correct silicon sensitivity factor for the composition at every data point (shown in green). Silicon plotted using a single GaAs sensitivity factor is shown in red.




## pHEMT

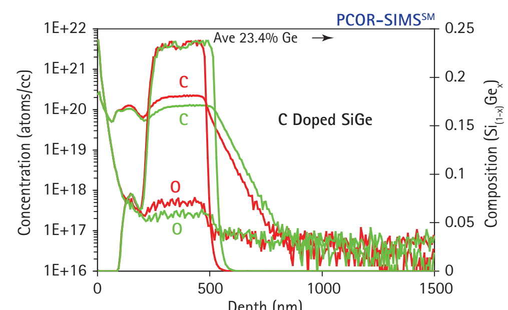
Many pHEMT structures benefit from PCOR-SIMS℠ depth profiling. Composition for the GaAs, AlGaAs, and InGaAs layer structure is determined at every data point. Accurate layer thickness is shown at every data point since sputter rate variations for each composition is taken into account. Silicon spike concentration and spacer thickness can be accurately measured. Comparison with TEM shows the alignment of the dopant spikes with the sample structure.




## Ultra-Shallow Implants

Very shallow-high dose implantation results in a significant portion of the dopant residing with a surface modified layer. This dopant is not available for activation.

PCOR-SIMS℠ shows the thickness of the surface modified layer, measures oxygen content, and determines the correct sensitivity factor at each data point for the dopant. The result is an accurate dopant profile shape and dose, and a more realistic measure of junction depth, defined by the distance from the oxide/Si interface to the point where the boron profile crosses 5E18 at/cc.



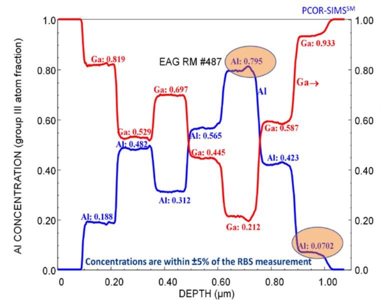

## SiGe

PCOR-SIMS℠ plotted in green shows the correct SiGe composition profile, the correct carbon dopant and oxygen contaminant profiles, and the correct thickness at every data point. The red plot shows uncorrected composition, carbon, oxygen and layer thickness where carbon and oxygen are 2x too high and layers are 20% too thin.



# How Do We Know PCOR-SIMS℠ is Correct?

At EAG we continuously validate PCOR-SIMS℠ against reference materials calibrated using other techniques.



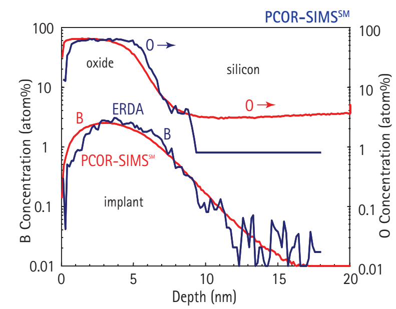

## GaAs/AlGaAs Layers

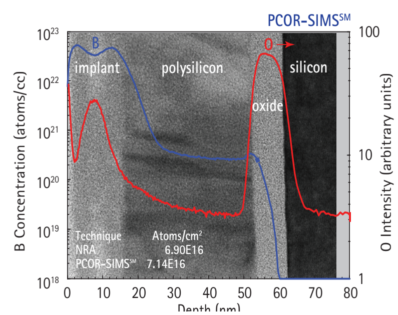
Measurement of composition is the first step in PCOR-SIMS℠. Here we compared PCOR-SIMS℠ to RBS (Rutherford Backscattering Spectrometry), a technique that is not matrix dependent and does not need standards. The results agree to within 5%.

## B High Dose Implant Through Surface Oxide

PCOR-SIMS℠ is needed to extend accurate dopant quantification into percent level. Here we compare to ERDA (elastic recoil detection analysis) with PCOR-SIMS℠. ERDA provides a quantitative depth profile in the high concentration portion of the profile that is not matrix dependent and does not need standards. ERDA confirms the PCOR-SIMS℠ profile is correct.

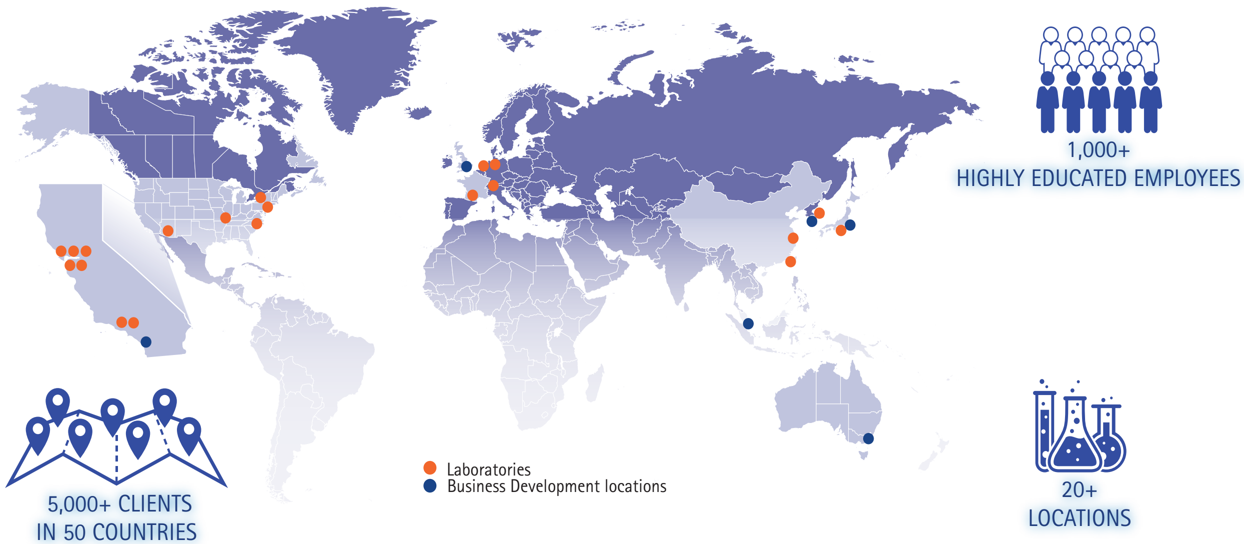
ERDA data courtesy of Dr. Wilfried Vandervorst.




## B Plasma Implant into Polysilicon

PCOR-SIMS℠ is needed to accurately measure dopants in multiple layers and blended composition layers. Here we compare PCOR-SIMS℠ with TEM and NRA (nuclear reaction analysis). TEM confirms the location and thickness of layers and NRA confirms that total boron is correct.

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