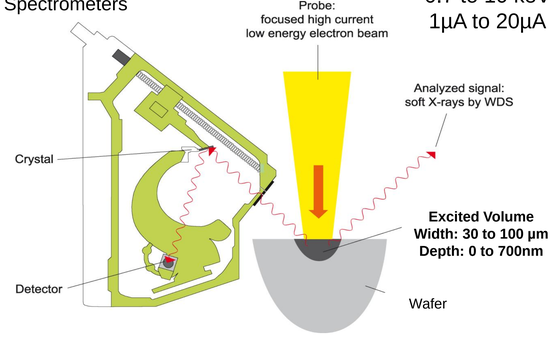
TH22 Shallow Probe : non-destructive compositional metrology for films and structures

Mona P. MORET, Anna MEURA, Anne-Sophie ROBBES, Michel SCHUHMACHER

Shallow Probe *Compositional Metrology by LEXES*

*L*ow energy
*E*lectron induced
X-ray
*E*mission
*S*pectrometry

Detection
3 Wavelength
Dispersive Spectrometers



0.7 to 10 keV
1µA to 20µA

Possibility to measure all elements heavier than Be
Dopants and / or main matrix elements

Direct
Non-contact
Buried layers
Patterned wafers

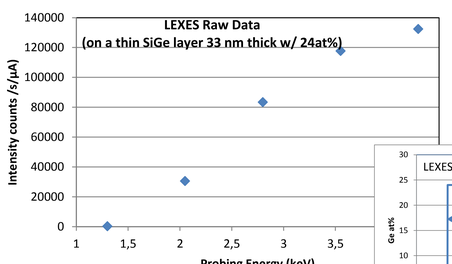
Elemental composition
Dopant dosimetry
Layer thickness

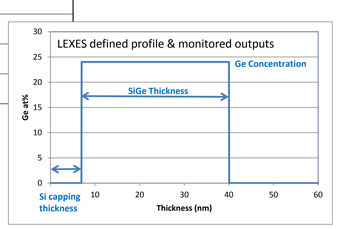
Direct quantitative measurements performed in two ways

a. **Single energy probing** : dose monitoring
b. **Multiple energies probing**: dose and depth information available

Raw data
+
Theoretical intensity
+
Defined profile
+
Fitting algorithm

= depth + thickness
+ composition outputs





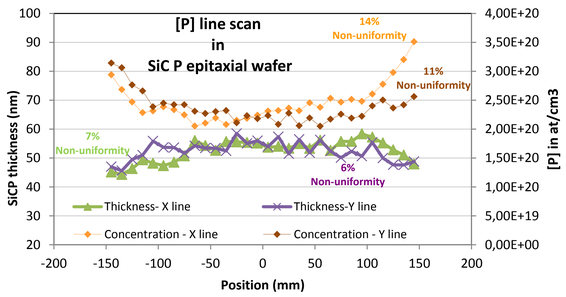
Epitaxial layers : Stack Metrology on B: SiGe and SiCP

SiGe: depth information on SiGe layers non-homogenous in thickness
Measured SIMS profiles and LEXES simulated profiles

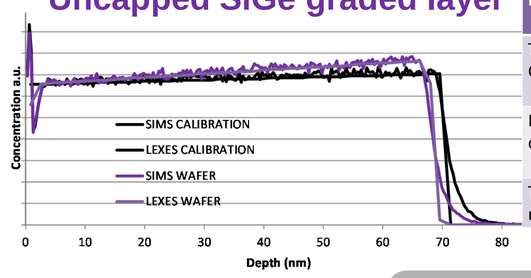
Phosphorous

LEXES unique capability to measure P concentration and Si(C)P thickness

Phosphorous Precision: Better than 1% on dose Better than 2% for concentration and thickness

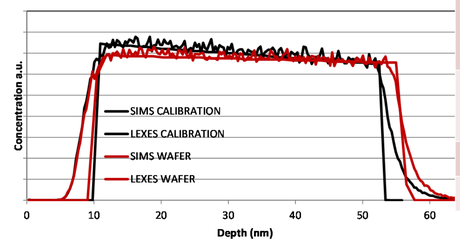


Uncapped SiGe graded layer



Parameter	LEXES Accuracy vs SIMS
Top Concentration at%	0.2%
Bottom concentration at%	-0.2%
Thickness nm	0.7%

Capped SiGe graded layer



Parameter	LEXES Accuracy vs SIMS
Top concentration at%	1.3%
Bottom concentration at%	-2.6%
Thickness nm	-3.0%
Capping nm	0.0%

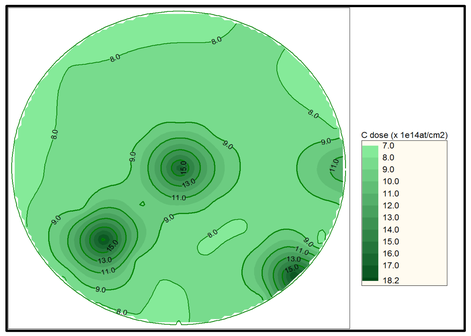
Precision obtained on capped and uncapped graded profiles. Better than
- 2% for top concentration
- 2.5% for bottom concentration
- 1% on thickness
- 2% on depth

Carbon

Global Carbon dose monitoring

Total C dose signature in a SiCP/SiP stack on 300 mm wafer.
The non-uniformity is 27%

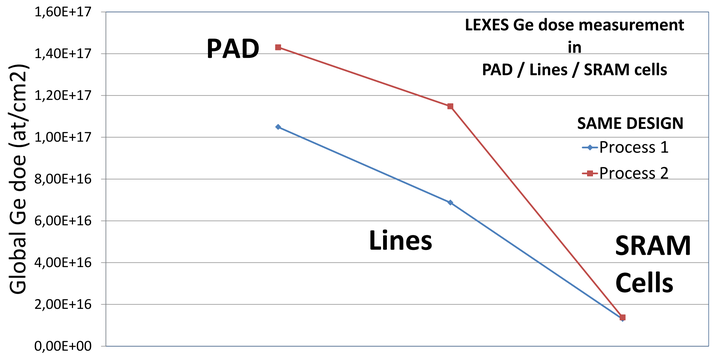
Carbon Precision is better than 1%



Average Metrology on Structures: lines or cells

A LEXES 30 µm by 30 µm beam covers

- Full SiGe layers in a pad
- ~ 60 to 50 % of SiGe layers
- ~ 300 by 600 transistors in SRAM



AVERAGE LEXES SIGNAL ANALYSIS
Comparative Global Dose from PAD to LINES to MEMORY CELL

Dose Ratio	Process 1	Process 2
Pad/Line	1.5	1.3
Pad/SRAM	8	10

- The two process are clearly different and behave in different manners on SRAM and lines
- In both process: possible loading effect is observed from Pad to Line

Work on-going to develop depth profiling capabilities on average signal