

Ultra Shallow Depth Profiling

Type of analysis

- Depth of interest $< 50\text{nm}$
- Analyze dopants in Silicon
- Requires optimum depth resolution

Considerations

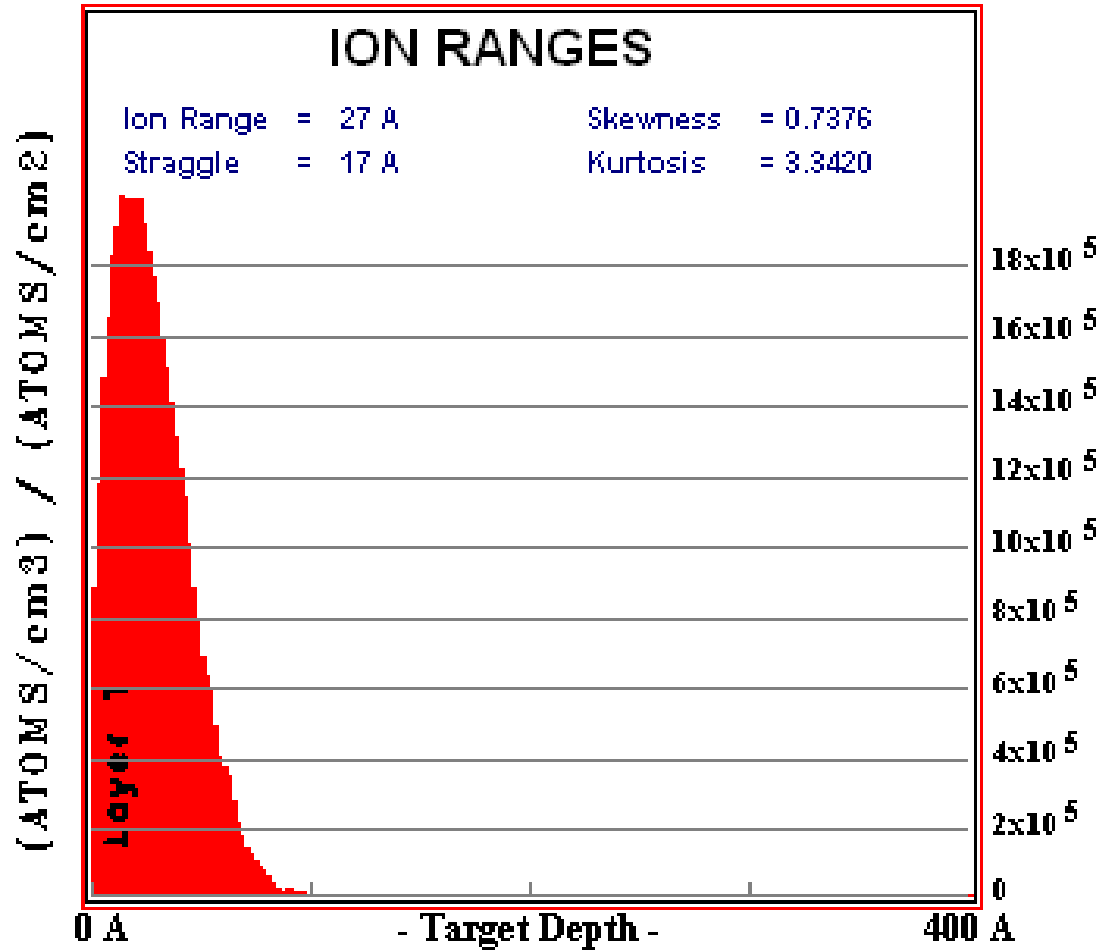
- Pre-equilibrium region
- Reduce ion penetration
- Surface roughening
- Analysis time

Ultra Shallow Depth Profiling

- O or Cs not at equilibrium value until sputter to reach projected range (R_p) of probe species
- Need probe energy less than implant energy
- However, O_2^+ less than 150eV has low sputtering yield
- Sputter rate changes from surface into the material
- Compare results with other techniques
(ERDA, HRBS, MEIS)

TRIM Simulation of Primary Beam Penetration

Si substrate



O₂⁺

CAMECA IMS-6F

3keV source

1.75keV sample

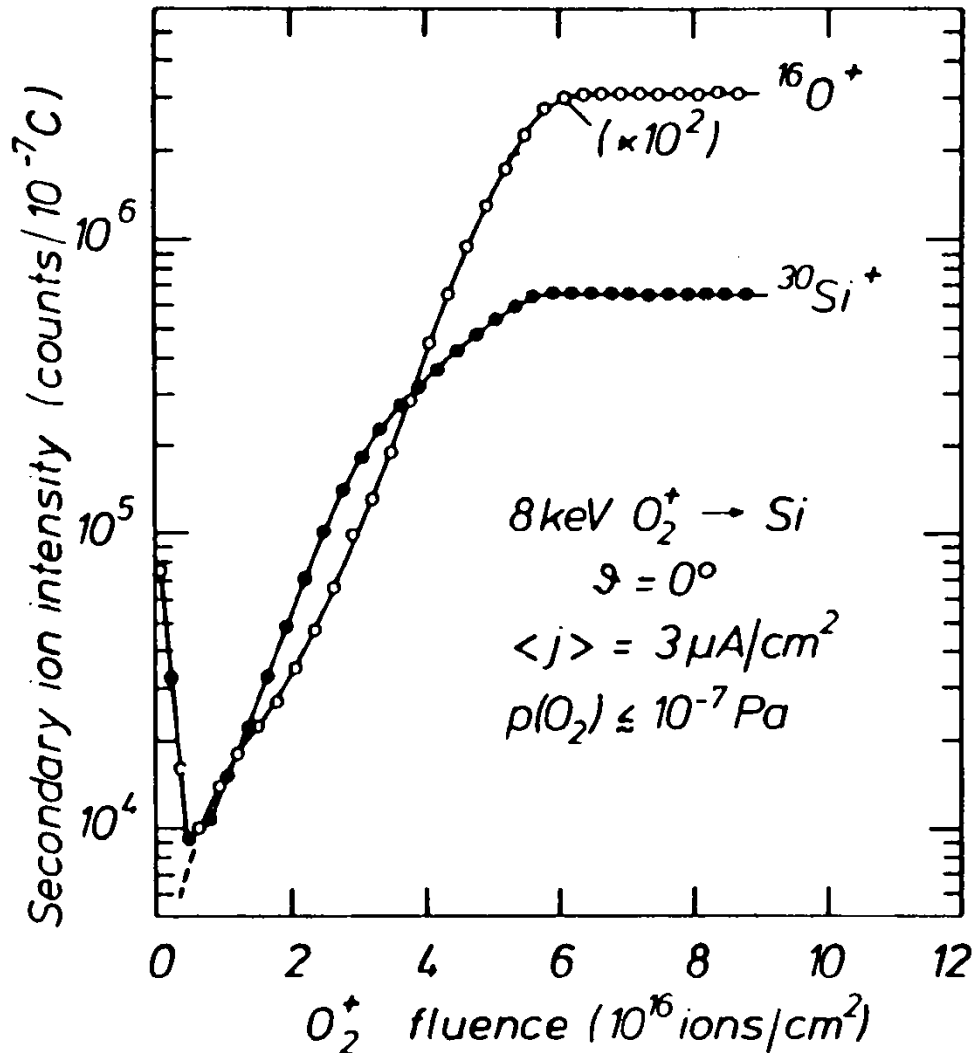
1.25keV impact energy

49° incidence angle

O at 0.625keV and 49°

R_p 2.7nm

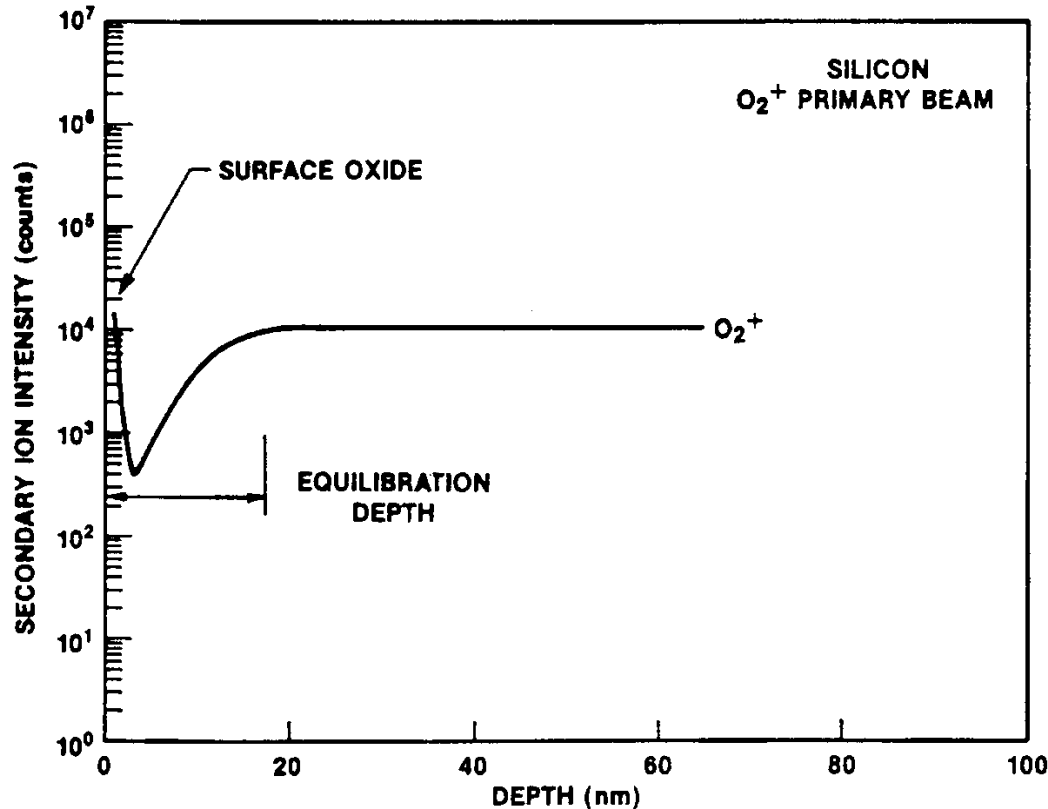
Surface Equilibration Region



Evolution of the O^+ and Si^+ signals during bombardment of silicon sample with 8 keV O_2^+ beam at normal incidence

K. Wittmaack, Nucl. Instr. and Meth. 168, 343 (1980)

Surface Equilibration Region



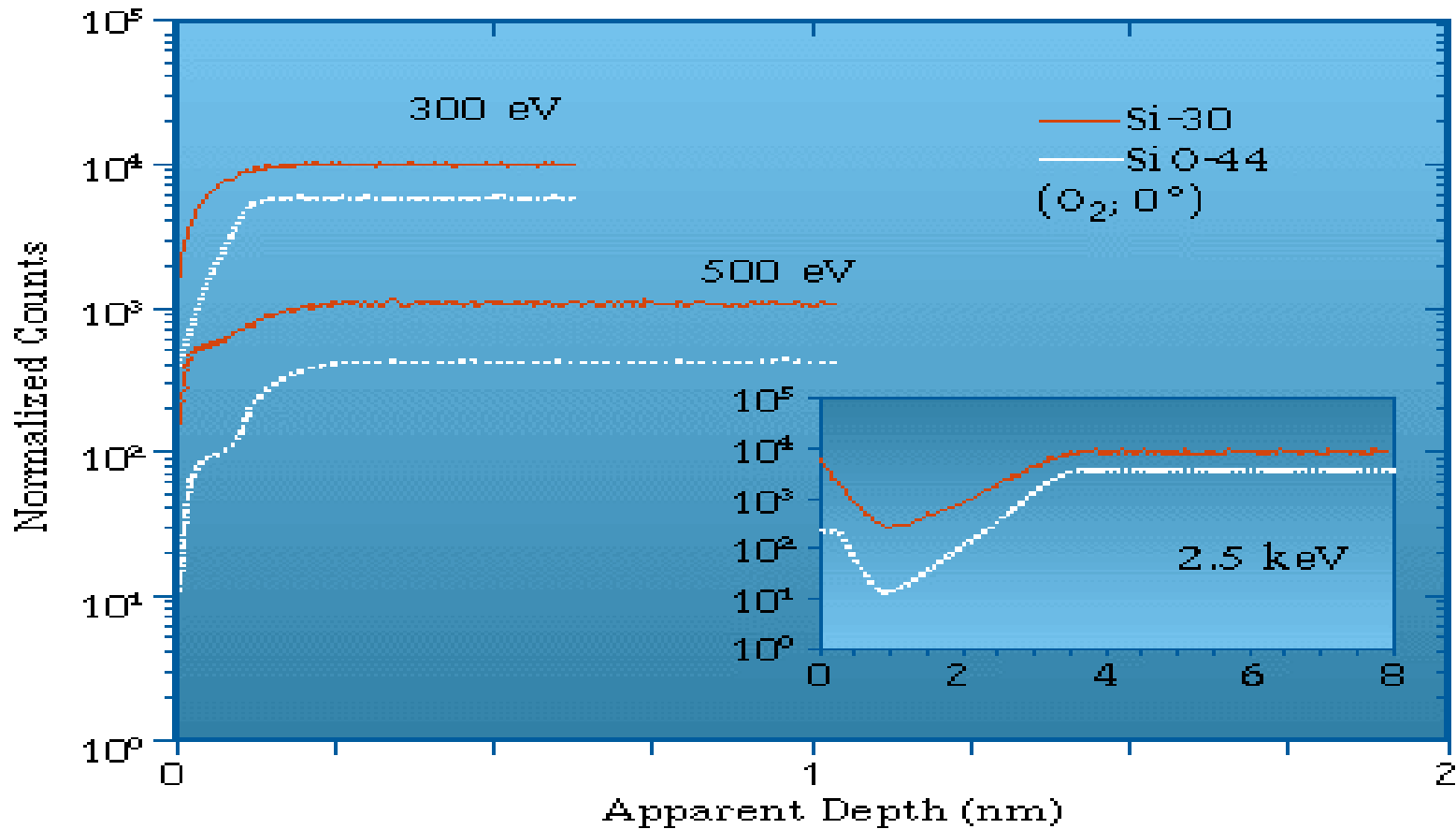
Profile of O in Si using O₂⁺

Surface oxide and equilibration depth show O nonuniformity at start of profile

SIMS, R. G. Wilson, F. A. Stevie, and C. W. Magee, Wiley, New York (1989)

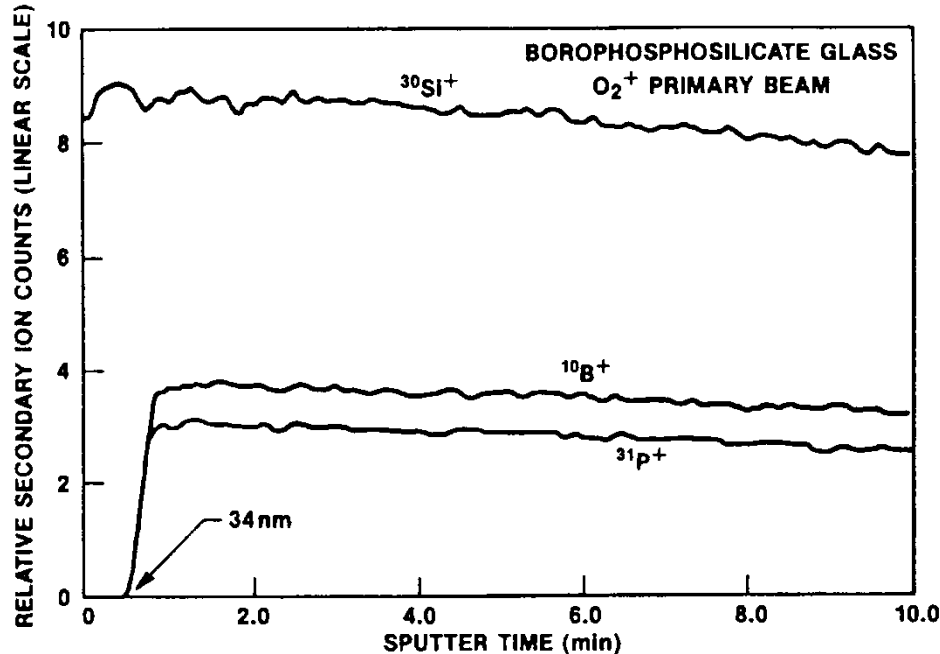
Surface Equilibration Region

O_2^+ normal incidence on Si substrate



Reduce pre-equilibrium region by reduction of primary energy

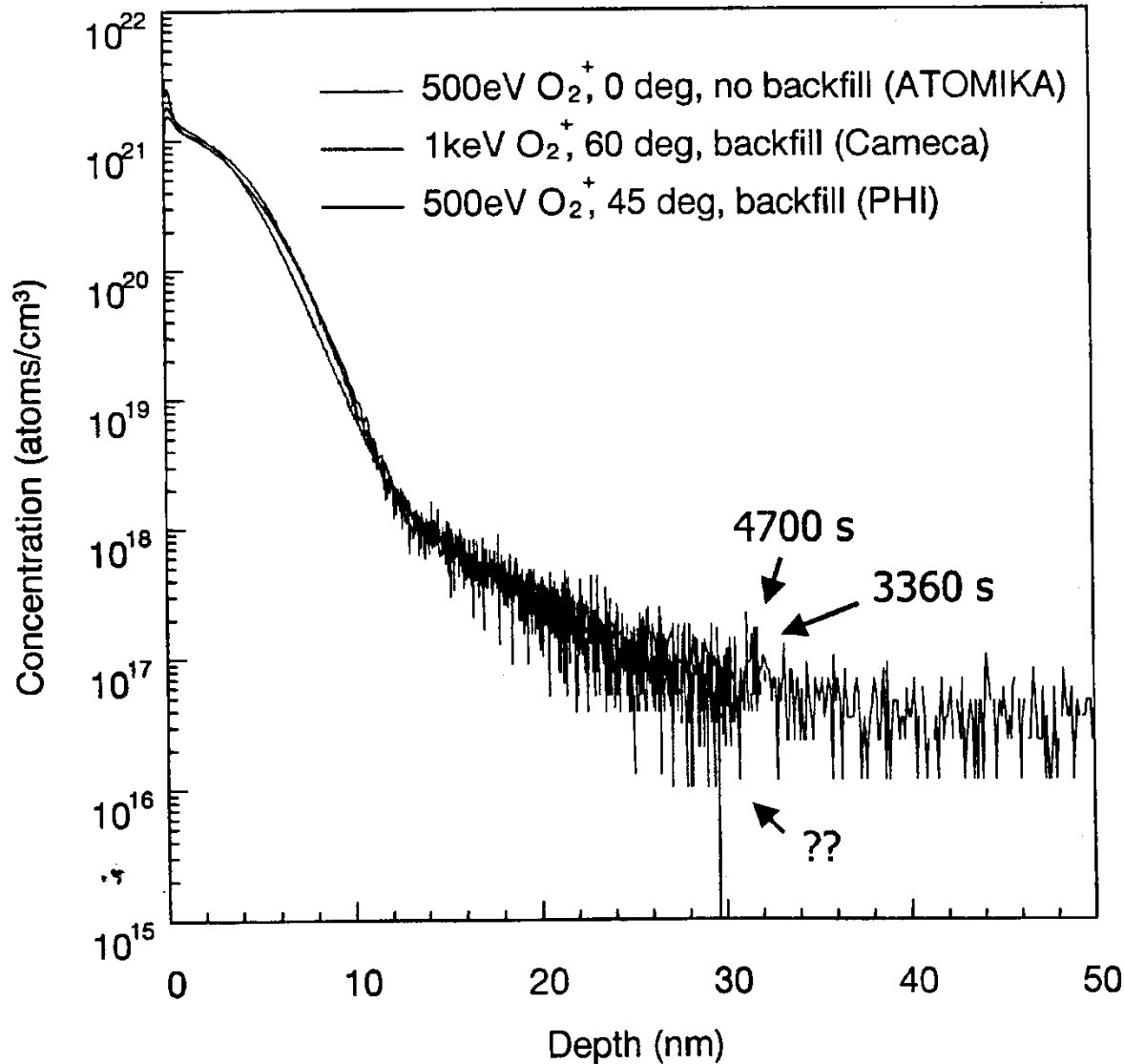
No Equilibrium Region Sample



- Depth profile of $SiO_2/BPSG$
- No equilibrium region because oxygen concentration constant starting at surface

SIMS, R. G. Wilson, F. A. Stevie, and C. W. Magee, Wiley, New York (1989)

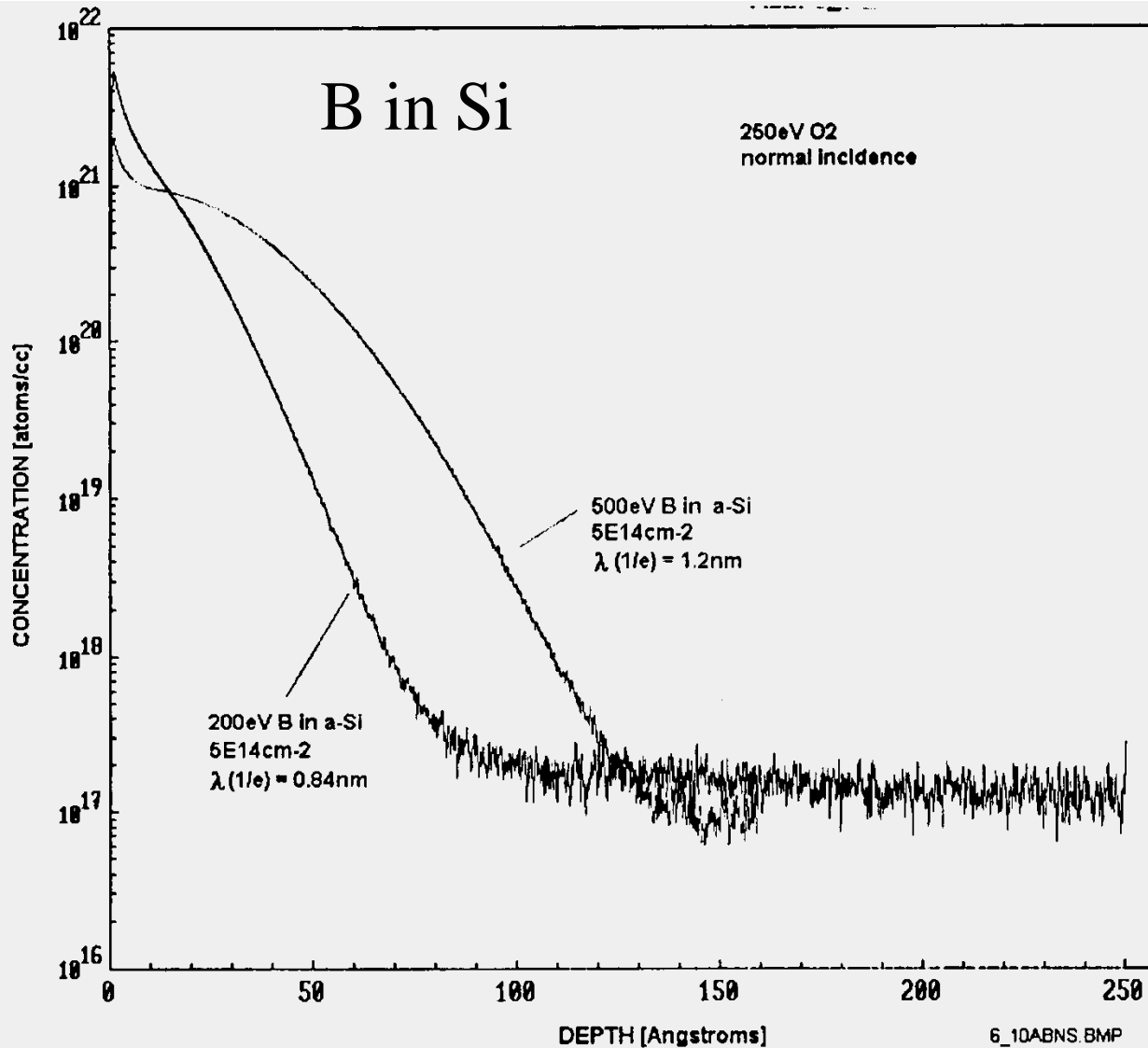
Ultra Shallow Analysis



Si substrate

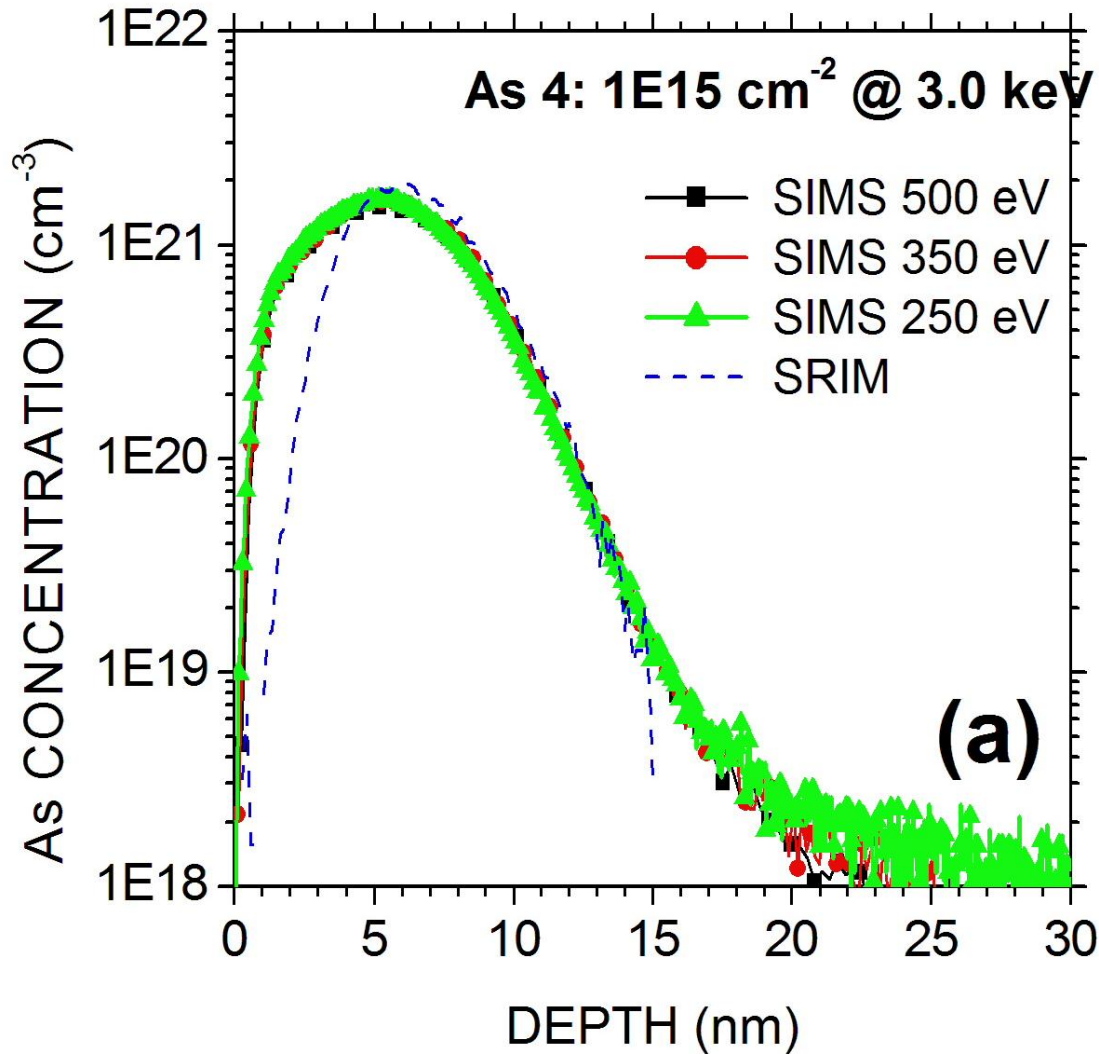
Backfill is also called oxygen leak or flood

Ultra Shallow Analysis



250 eV O₂⁺ primary beam at normal incidence

Multi Technique As Ultra Shallow Analyses

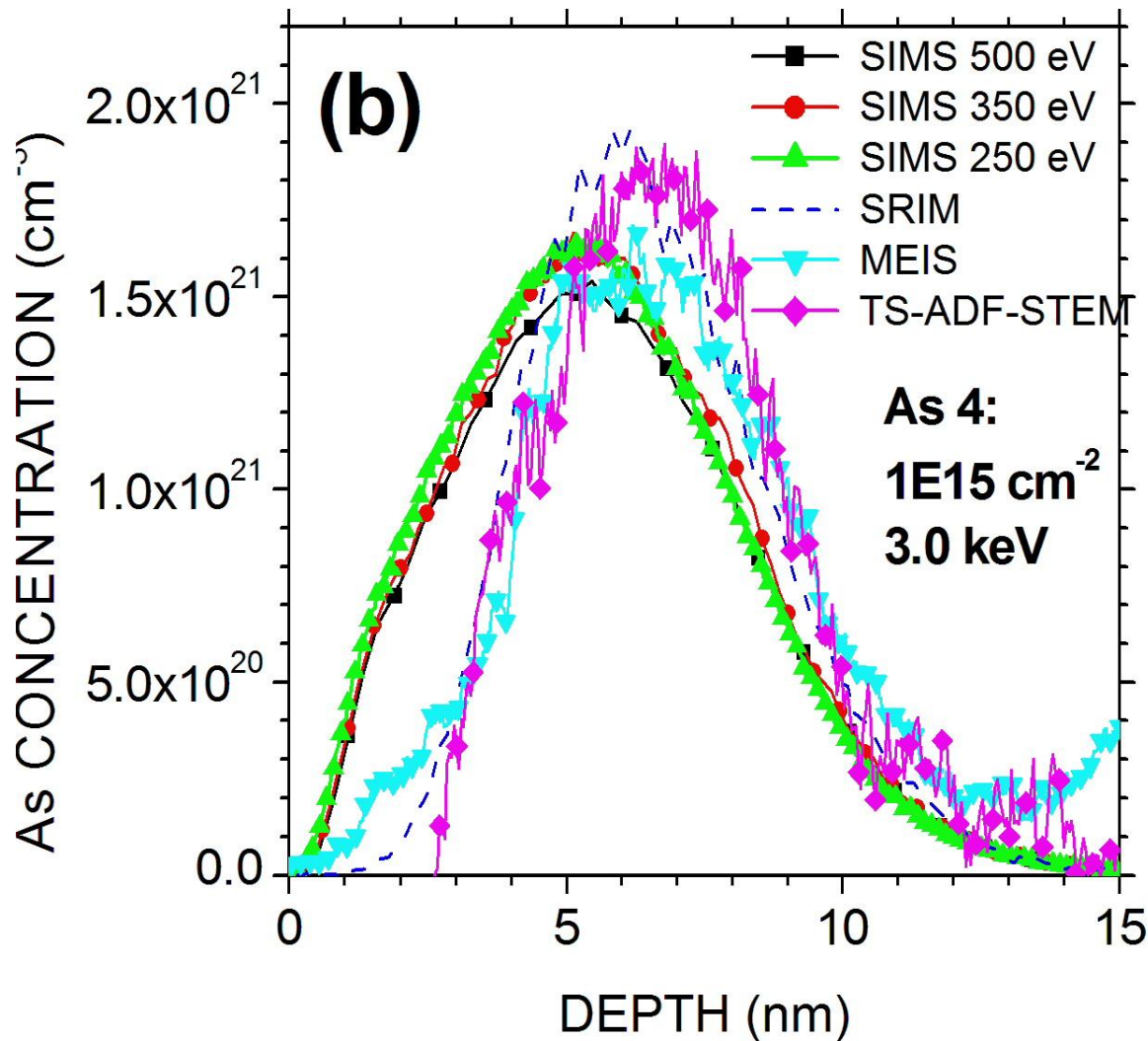


As 3keV

CAMECA Wf/Sc-Ultra
Cs⁺ beam

SIMS and
SRIM simulation

Multi Technique As Ultra Shallow Analyses



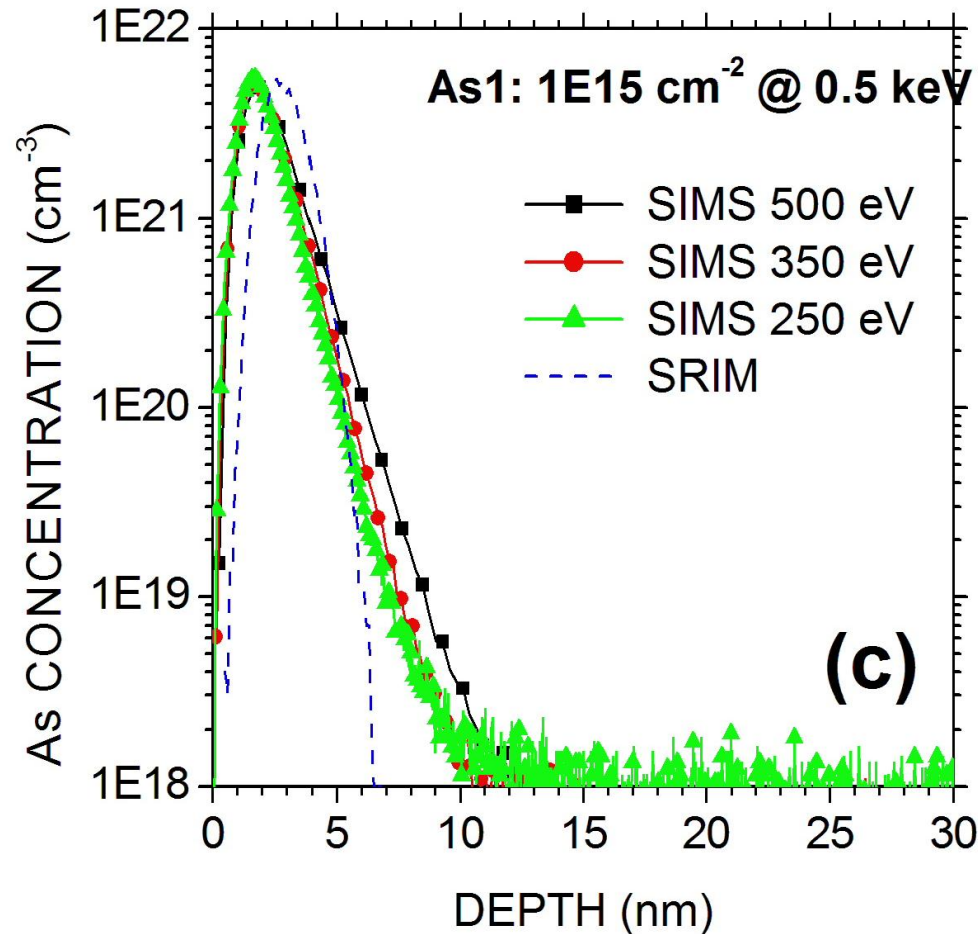
As 3keV

CAMECA Wf/Sc-Ultra
Cs⁺ beam

- MEIS and STEM agree with SRIM
- SIMS shows shift to surface

Multi Technique As Ultra Shallow Analyses

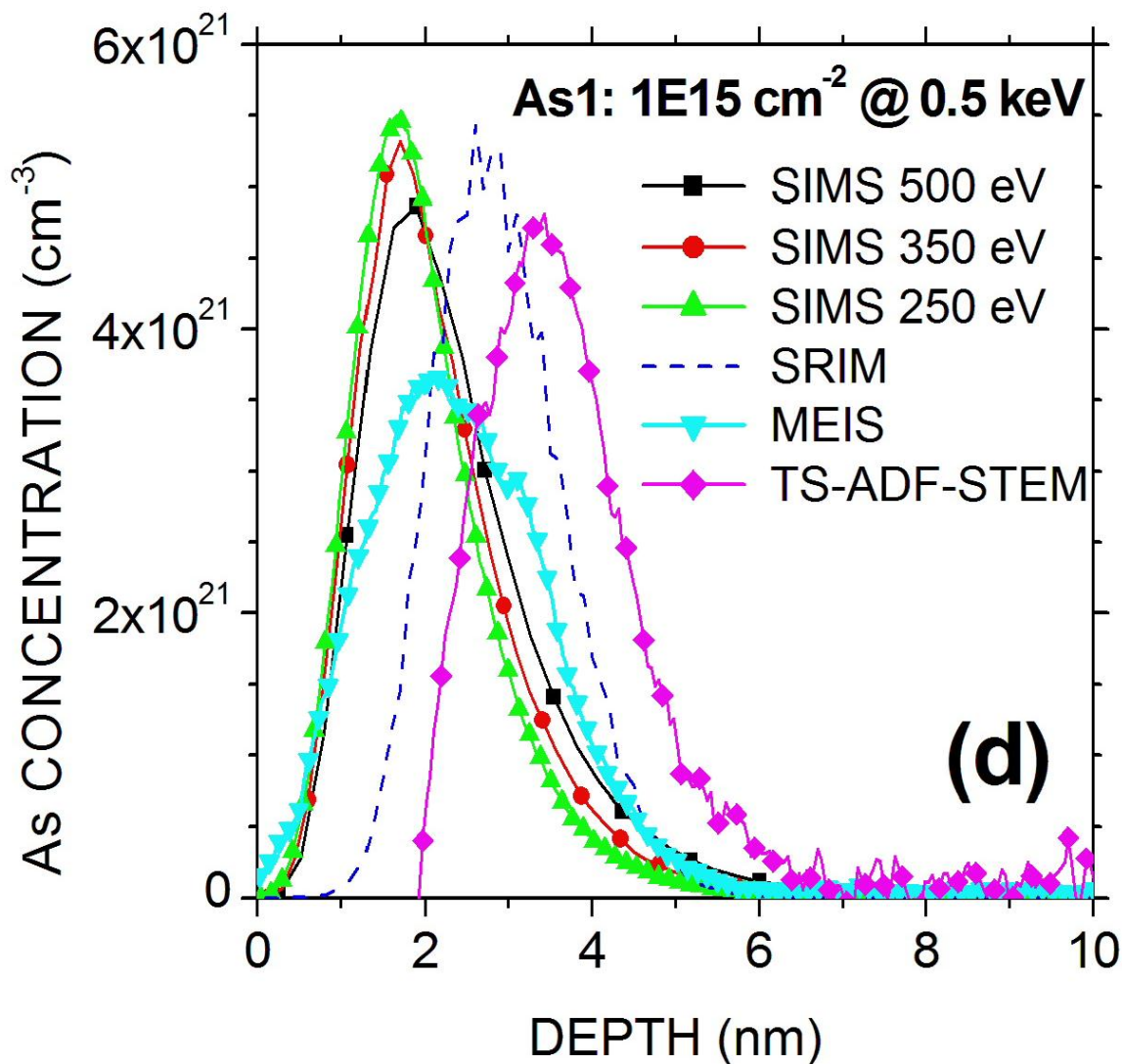
As 0.5keV



CAMECA Wf/Sc-Ultra
Cs⁺ beam

SIMS and
SRIM simulation

Multi Technique As Ultra Shallow Analyses

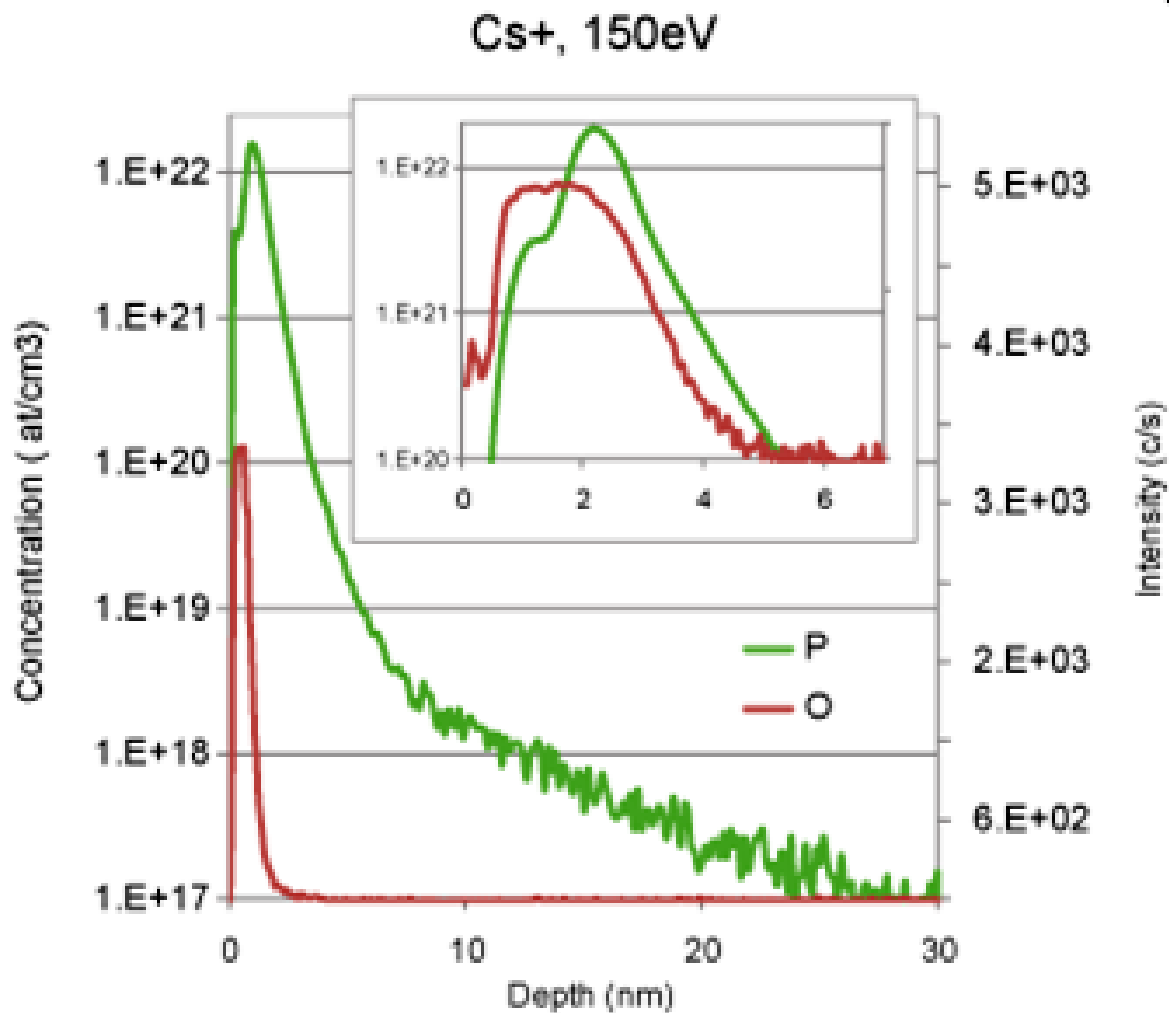


As 0.5keV

CAMECA Wf/Sc-Ultra
Cs⁺ beam

- MEIS and STEM agree with SRIM
- SIMS shows shift to surface

500eV P Implant in Si Analyzed with 150eV Cs⁺



CAMECA
Extremely low
impact energy
(EXLIE)