

# **Secondary Ion Mass Spectrometry (SIMS)**

**Presented by Jared Belinsky**



# Outline

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- Background
- Applications
- Ion Production
- Ion Sputtering
- Selected Instrumentation Examples
- Profiles and Outputs
- Factors Affecting Depth Profiling
- Conclusions

# Background

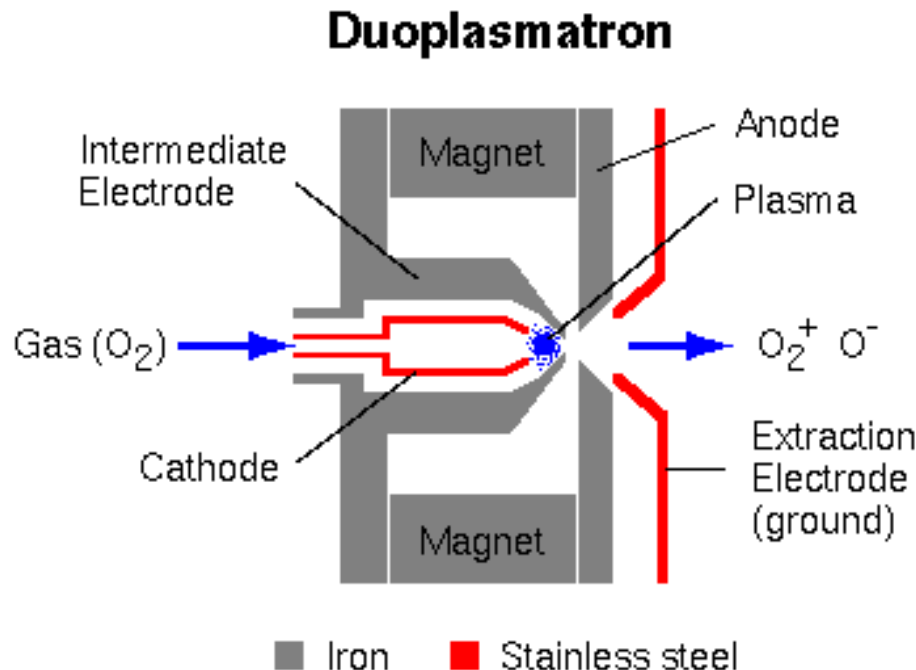
- Beam of incident ions used to erode the surface of a sample
  - Secondary ions released into the vacuum can be captured for analysis
- Analysis identifies chemical compositions within the sample
  - Concentrations
  - Depth profiling

# Applications

SIMS applications in process development and manufacturing

Material	Bulk dopant concentrations
Patterning	Photoresist particulate identification
Implantation	N- and P-type dopant concentrations
Contamination	Dopant species cross contamination

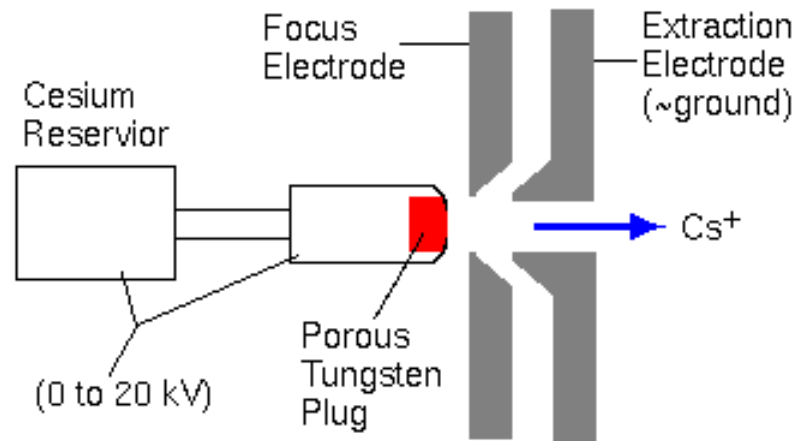
# O, Ar, or other gaseous elements Ion Production



- Gas is converted into a plasma by a low pressure arc between the anode and filament
- Extraction electrode draws charged atoms from the plasma

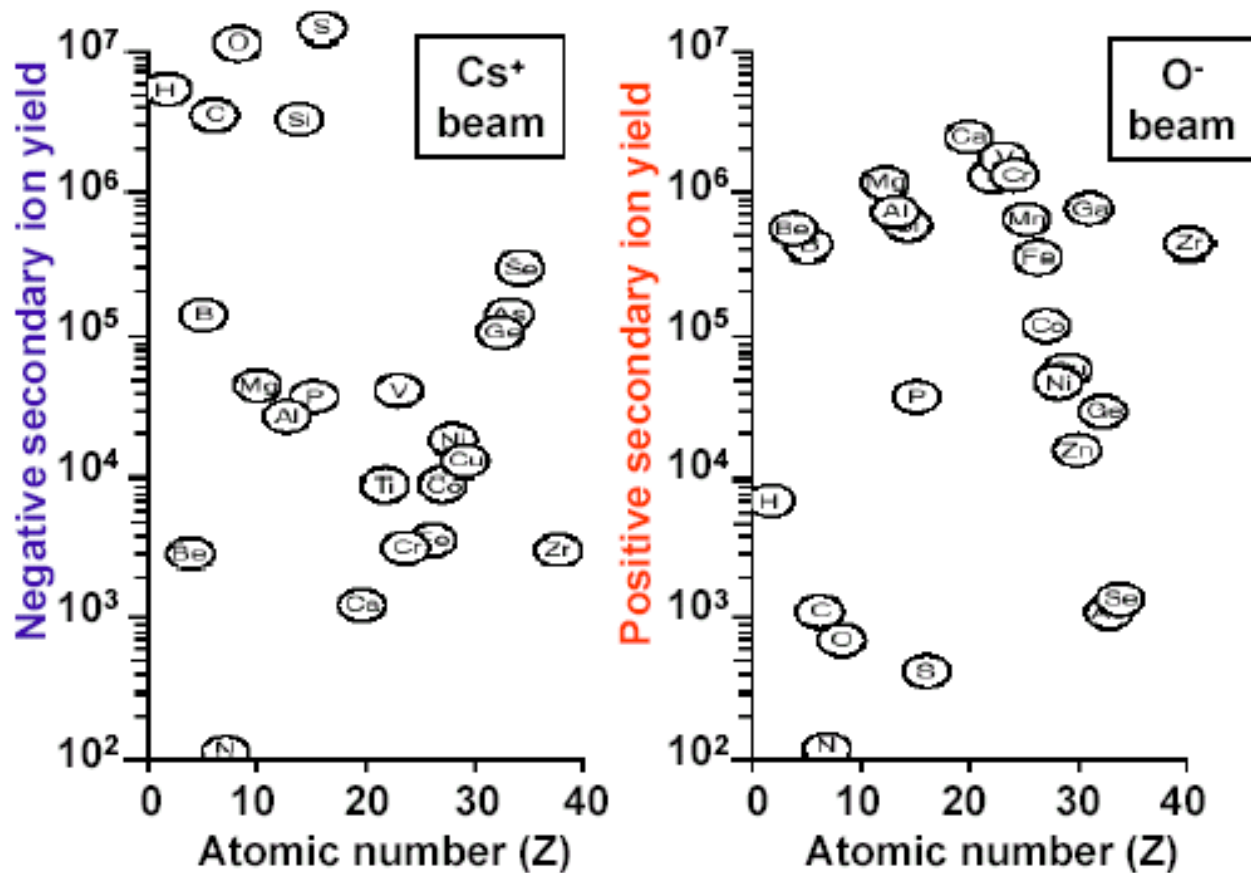
# Cs Ion Production

## Cesium Surface Ionization Source

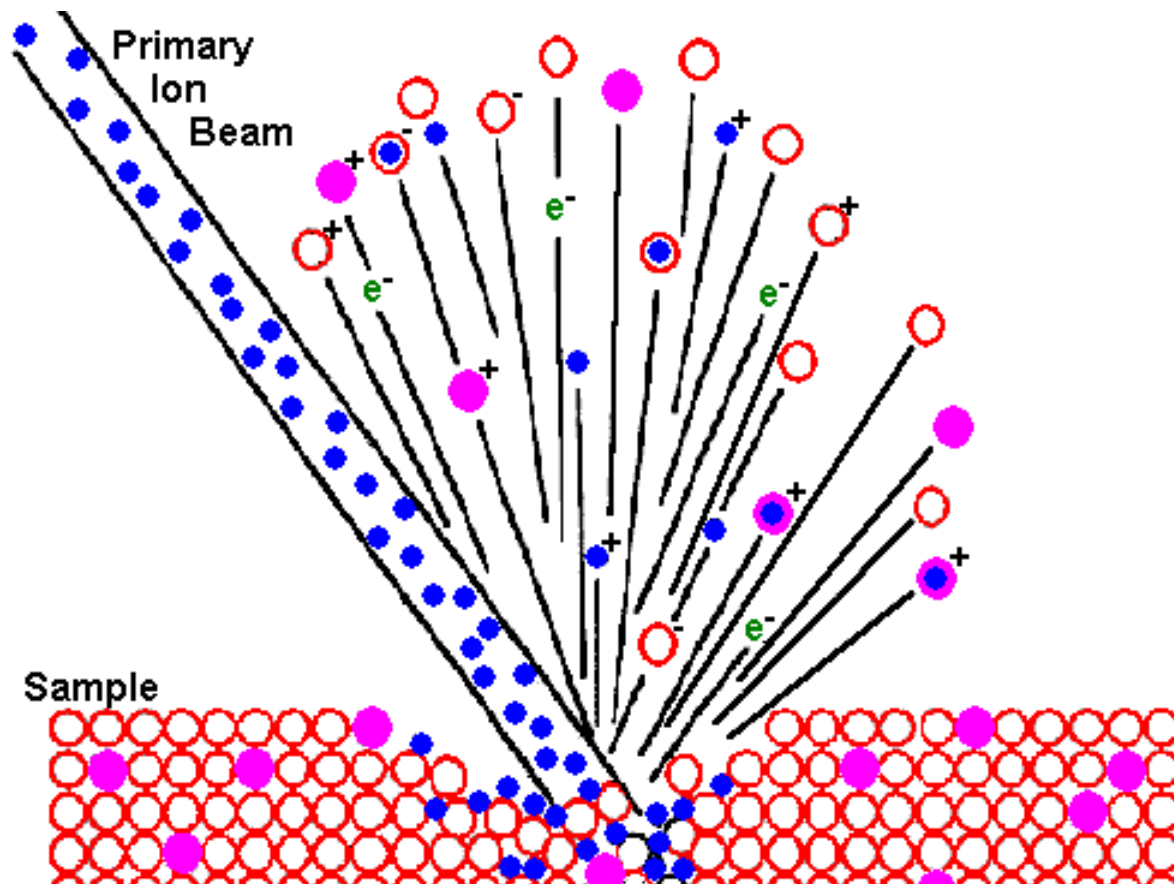


- Cs must be heated to produce a vapor thus a different method of ion production is needed.

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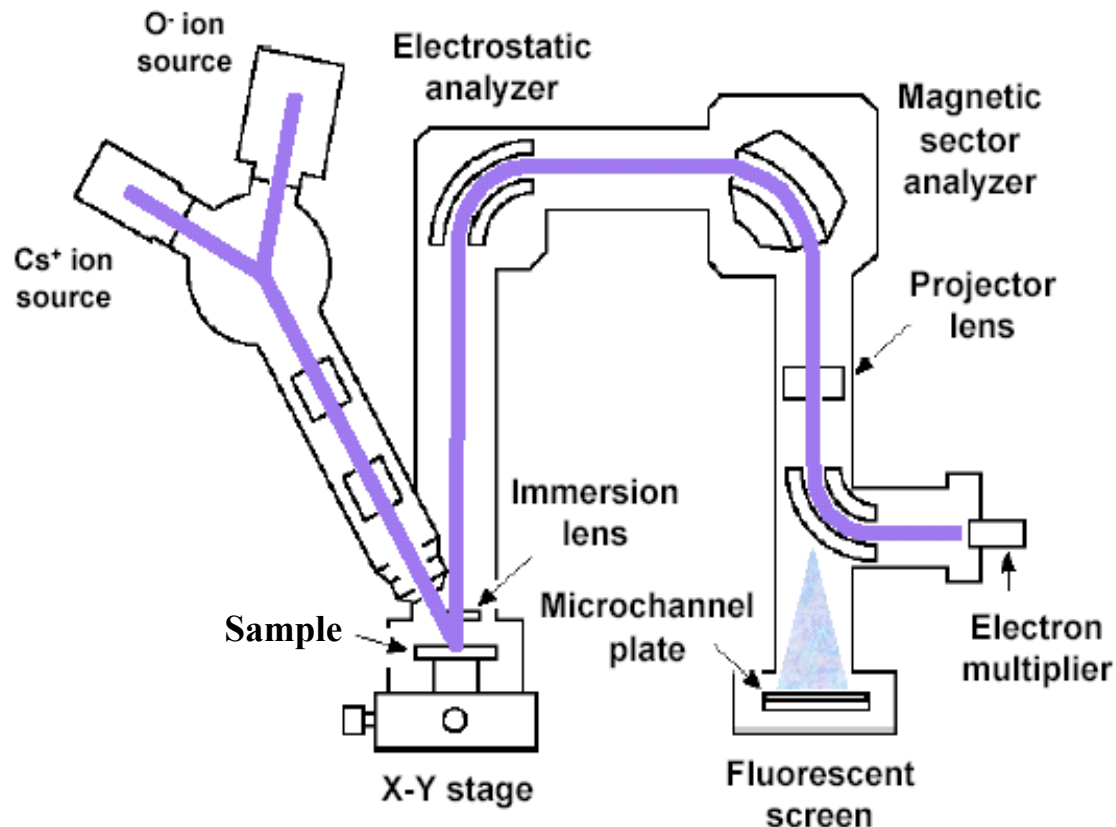


# Ion Sputtering



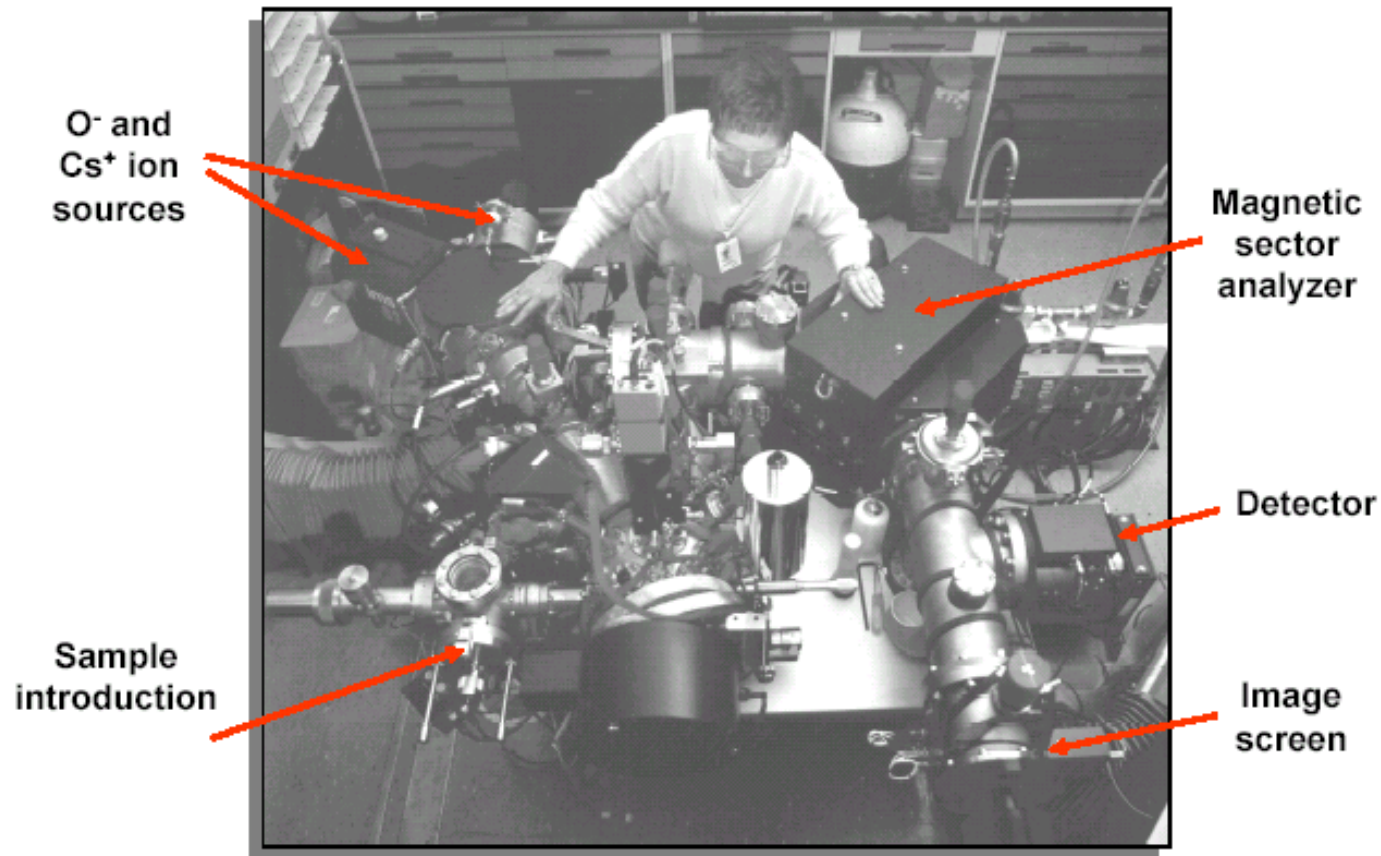


# Instrumentation: Ion Microscope

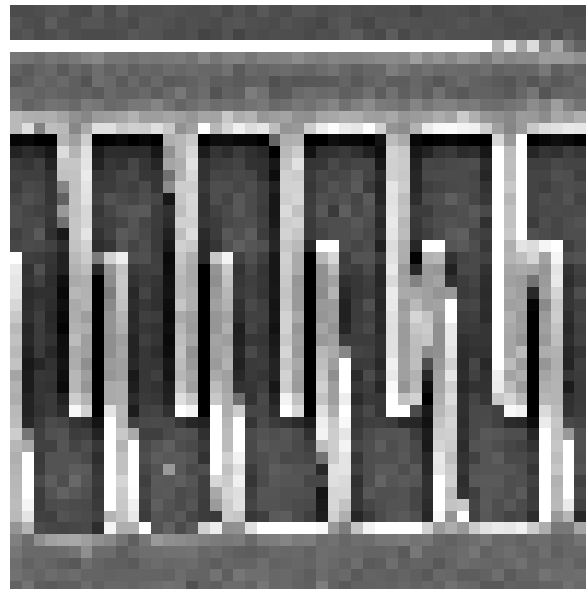


- Sorts Secondary Ions by  $m/q$  ratio
- Able to create enlarged images
- Requires Conductive Sample

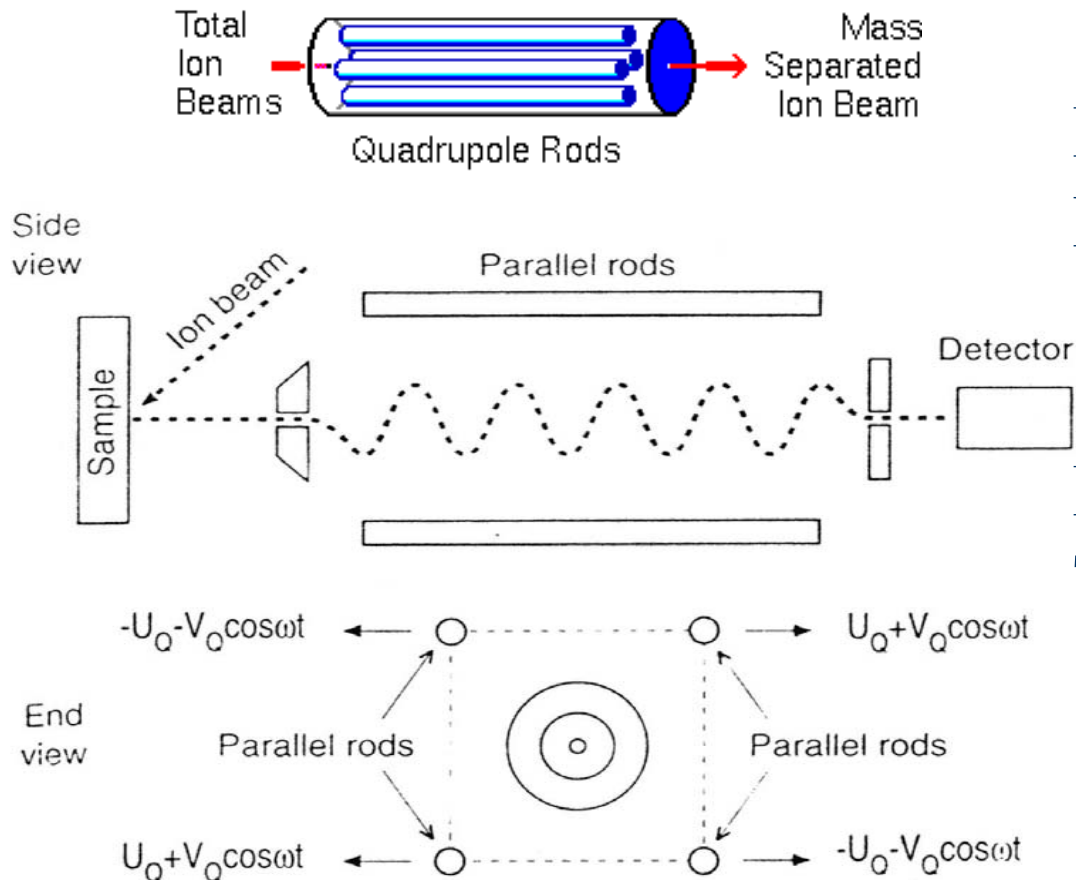
# Instrumentation: Ion Microscope



# Sample Ion Microscope Images



# Instrumentation: Quadrupole

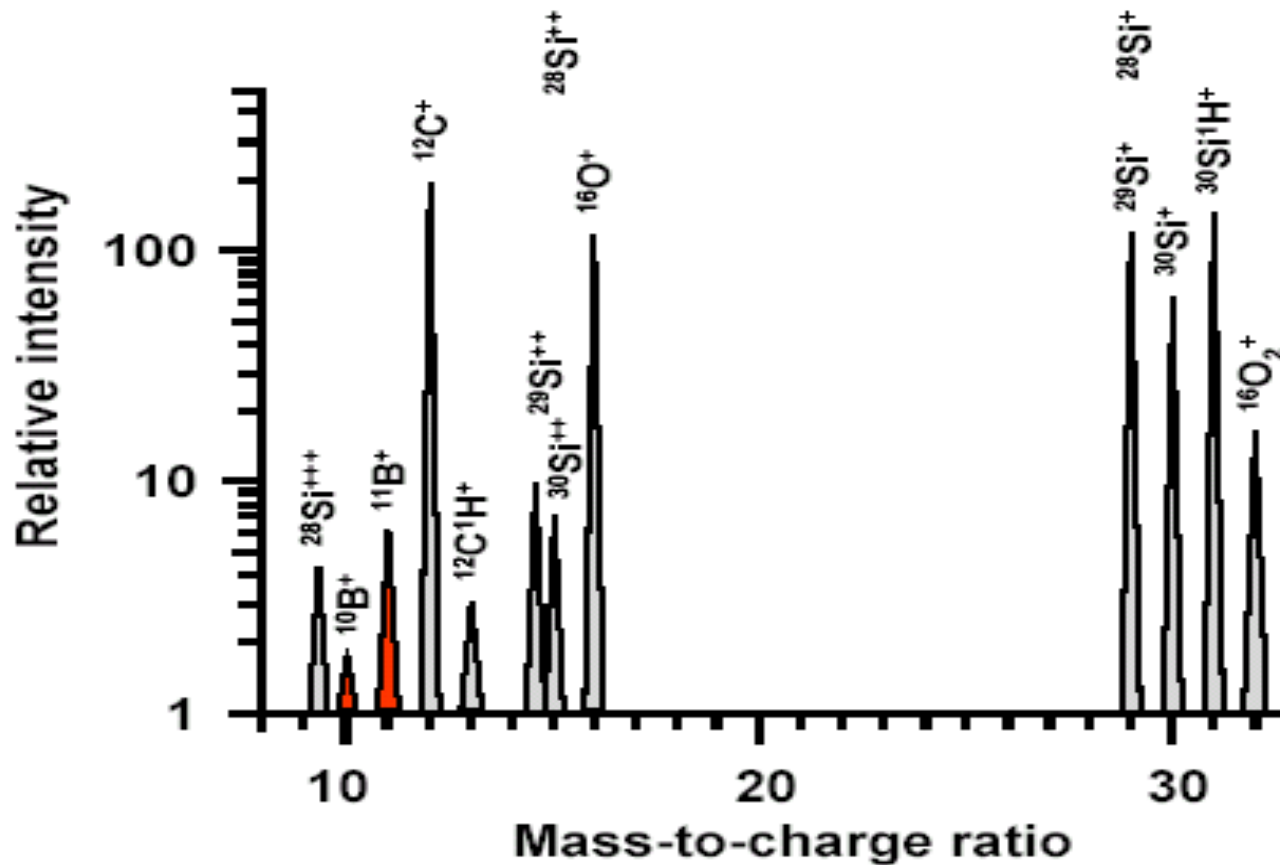


- Low Cost Relative to Ion Microscope

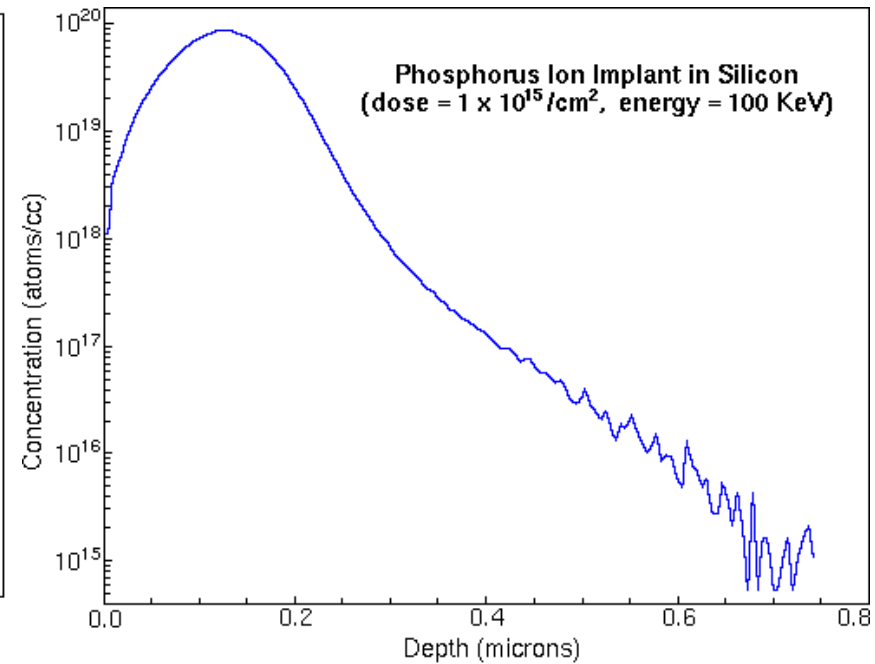
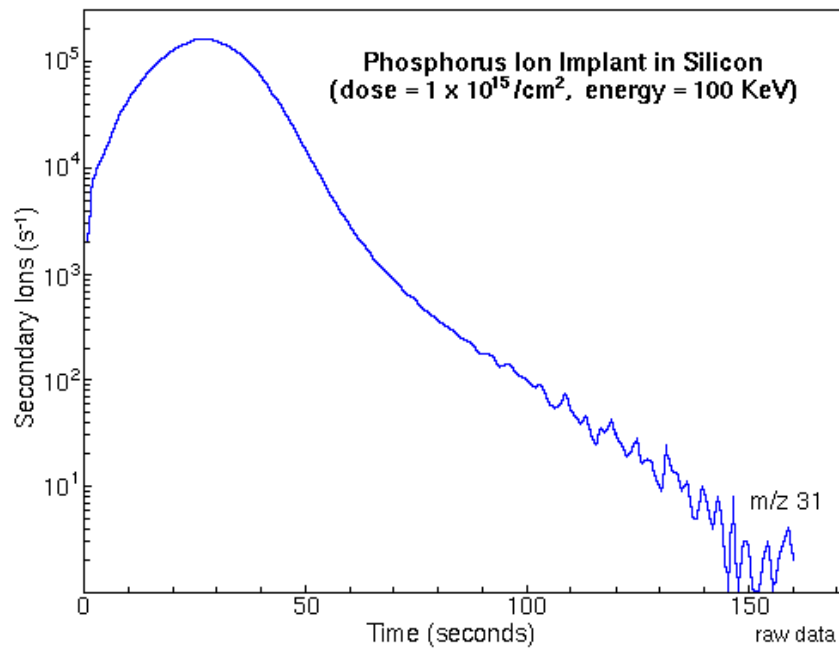
- Lower Mass Resolution Than Ion Microscope

- (Non)Conductive Samples

# SIMS Mass Spectrum



# Depth Profile



# Factors Affecting Depth Profiling

- Depth Measurements
  - Constancy of Erosion Rate
  - Primary Beam Induced Diffusion
  - Atomic Mixing
- Measurement of Elemental Concentration
  - Mass Interference
  - Chemical Impurities in the Primary Beam
  - Re-deposition of Sputtered Materials

# Mass Interference

- Mass interferences occur whenever two ions have the same  $m/q$  ratio.

Atom	Molecular Interference
$^{31}\text{P}^+$	$(^{30}\text{SiH})^+$
$^{56}\text{Fe}^+$	$(^{28}\text{Si}^{28}\text{Si})^+$
$^{75}\text{As}^+$	$(^{29}\text{Si}^{30}\text{Si}^{16}\text{O})^+$
$^{74}\text{Ge}^+$	$(^{29}\text{Si}^{29}\text{Si}^{16}\text{O})^+$
$^{58}\text{Ni}^+$	$(^{29}\text{Si}^{29}\text{Si})^+$
$^{14}\text{N}^+$	$^{28}\text{Si}^{+2}$



# Conclusions

- SIMS can create depth profiles for a variety of different sample compositions.
- Ion sputtering does not occur without complications such as induced diffusion and varying constancy of erosion.
- Issues such as mass interference can create difficulties in creating spectrometry measurements

# References

Semiconductor Measurements & Instrumentation  
W.R. Runyan and T.J. Shaffner  
McGaw Hill 1998

Evans Analytical Group  
CEA online tutorial – Ron Flemming collection  
<http://www.cea.com/tutorial.htm>

<http://www.eas.asu.edu/~schroder/SIMS.pdf>

# Questions

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