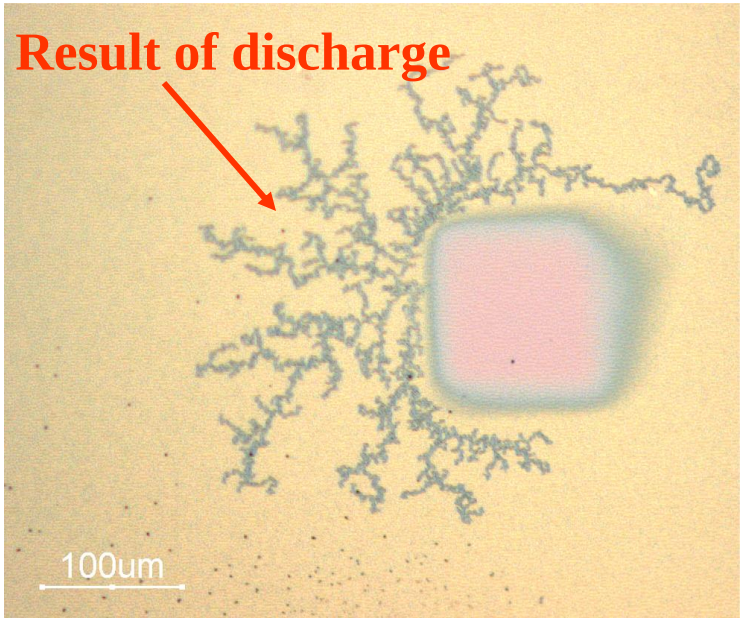
Insulators

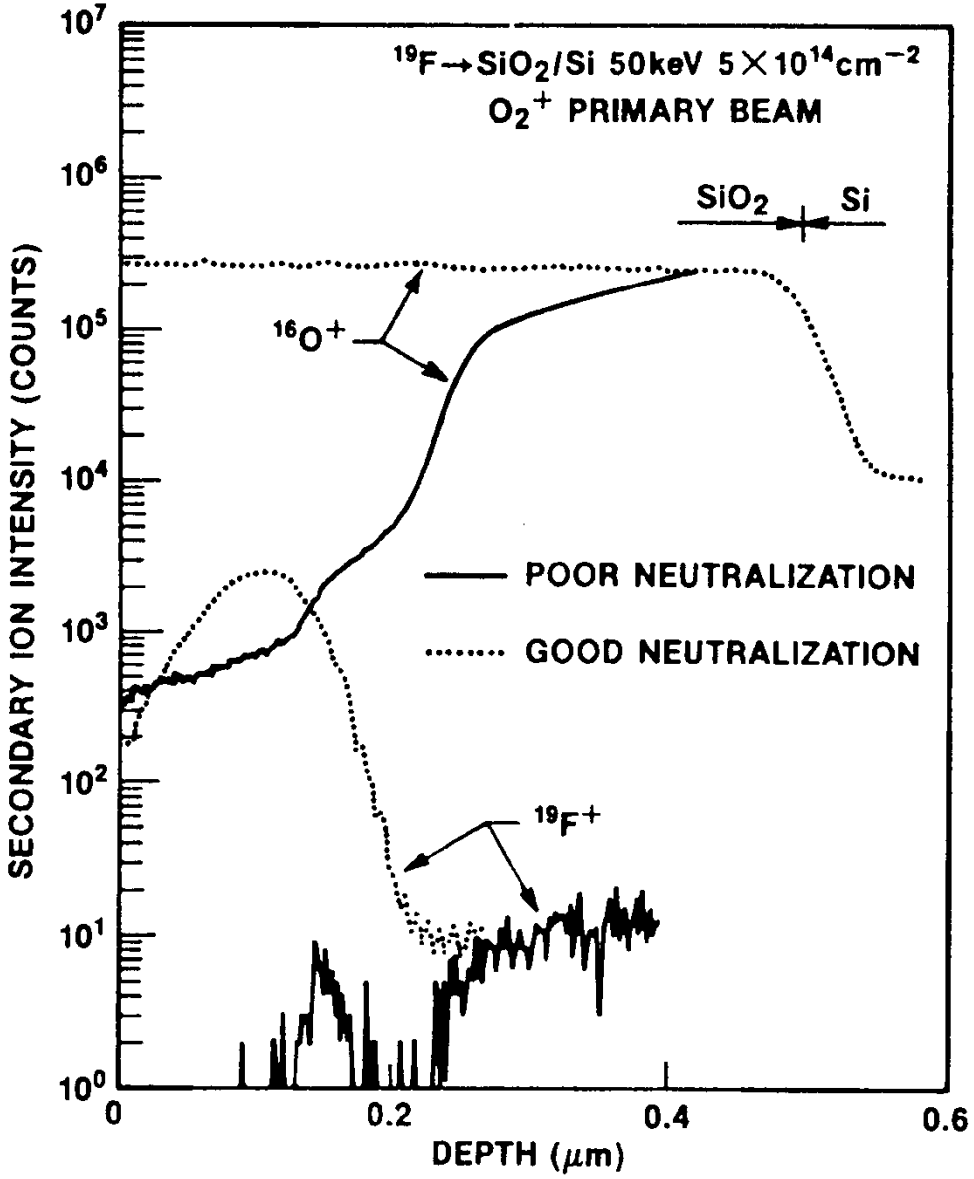
• Charged particle beam on insulating surface causes charge buildup that can affect extraction of secondary ions

• Charge can accumulate to the extent that discharges occur in the sample chamber



Cs^+ bombardment of SiO_2 layer on Si

Insulators



Depth profiles of F implanted into 500 nm SiO_2/Si with and without neutralizing electron beam

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

Charge Neutralization Methods

- Conductive layer or grid
  - Simple, but contaminates and may sputter unevenly
  - Does not work for many analyses

- O^- primary beam
  - Charge balance on bulk insulators
  - Requires grid or coating and is current density limited

- Electron bombardment
  - Works well for quadrupole and thin films on magnetic sector
  - Bulk insulators can be difficult on magnetic sector,
  - Some materials degrade with electron impact
  - Pulsed beam successful on TOF

Insulator Analysis Parameters

Magnetic Sector

CAMECA IMS-6f, normal incidence, (O_2^+, pos secondaries)

9 keV, 40 µA electrons into 1400 µm diameter circle

Power = current x voltage

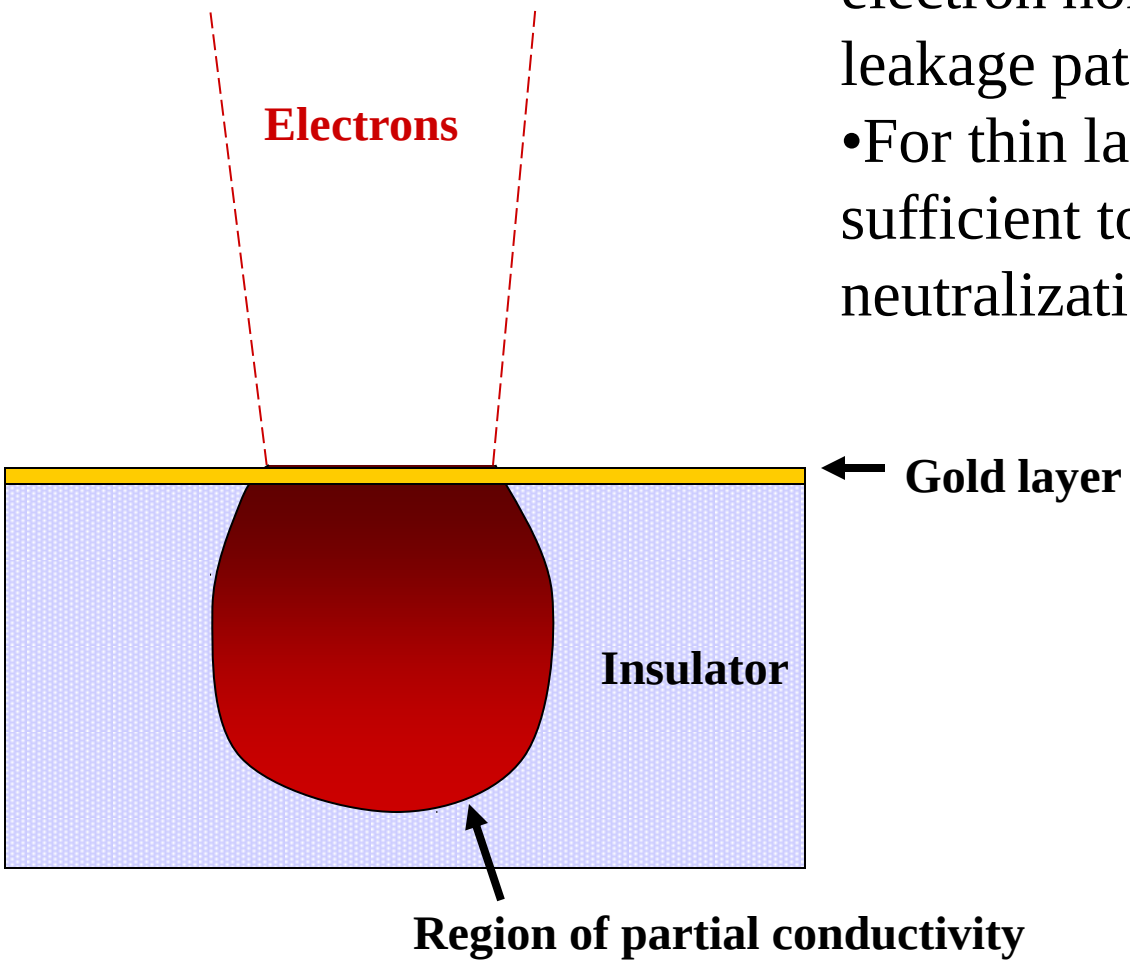
= 40 µA x 9 keV = 0.36 watts

Electron Current Density = current / area

= 40 µA / 0.016 cm^2

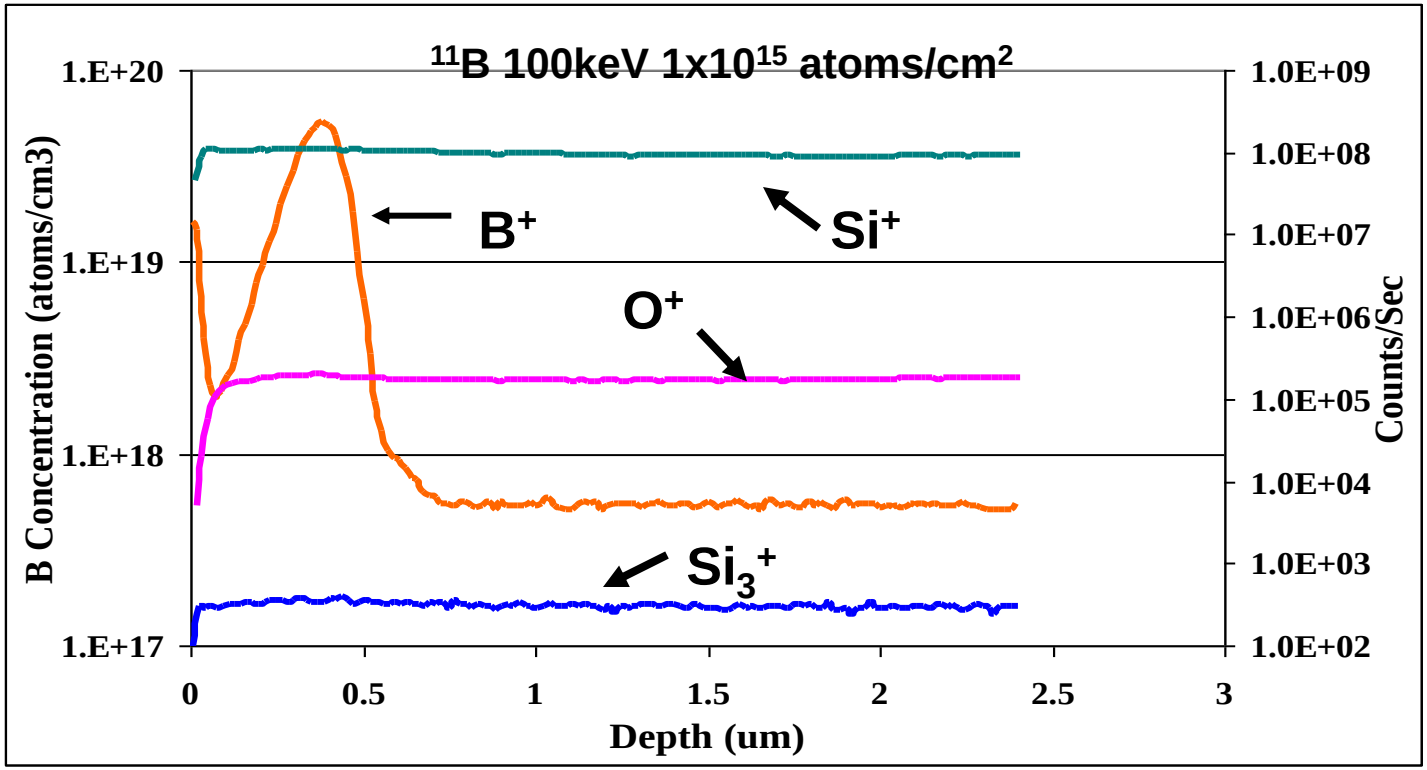
= 0.0025 A/cm^2

Electron Beam Induced Conductivity (EBIC)



- Electron bombardment creates electron hole pairs that can provide leakage path
- For thin layers, if electron energy sufficient to penetrate layer, good neutralization possible

Depth Profile of B Implanted Bulk SiO_2



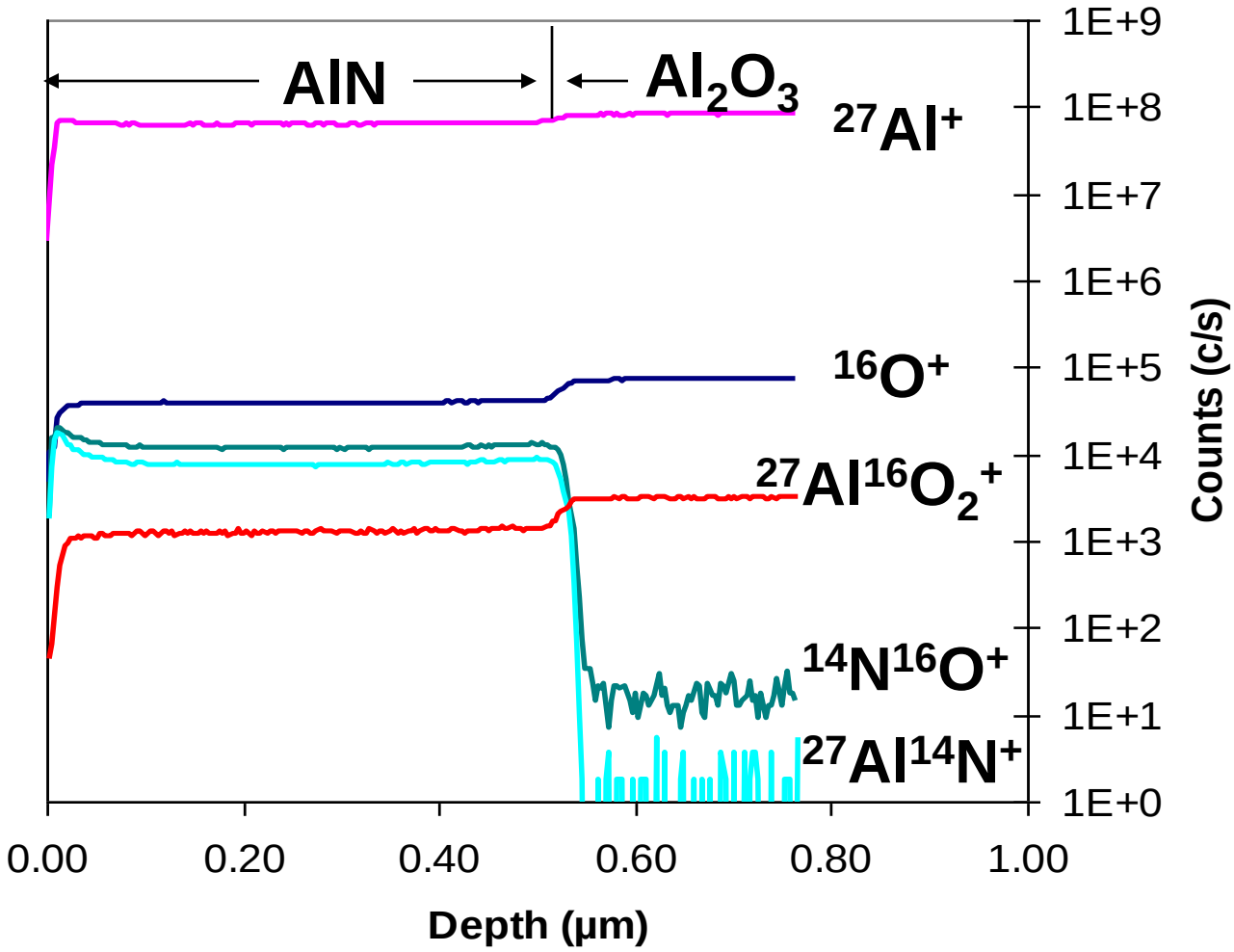
- O_2^+ 400 nA 230µm x 230µm raster
- 2.2 nm/s sputtering rate, higher rate possible

Use of electron beam adjacent to ion beam raster

Sample is Au coated

A. Pivovarov, F. A. Stevie, D. P. Griffis, SIMS XIV Proceedings Applied Surface Science 231-232, 786-790 (2004).

AlN / Al_2O_3

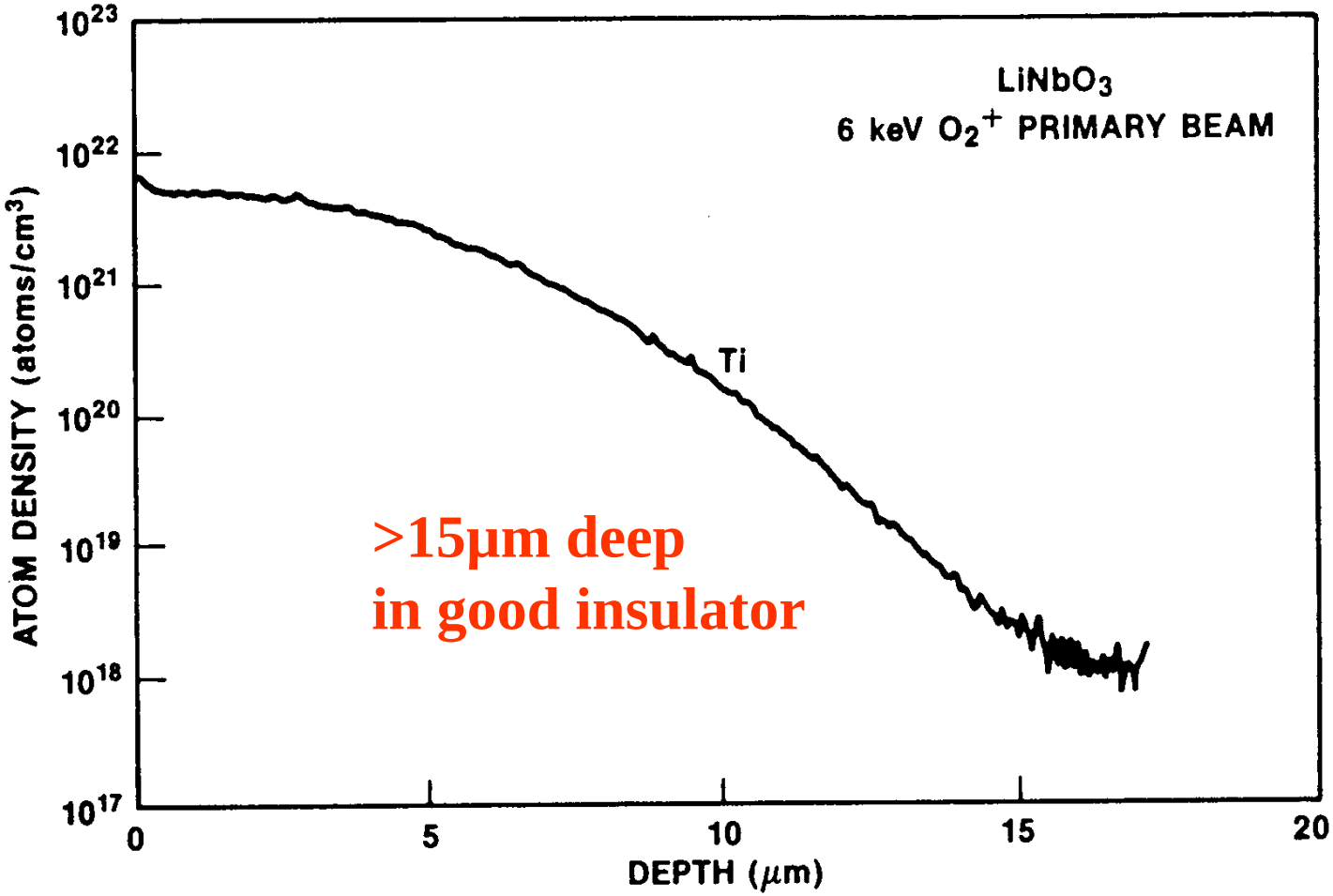


O_2^+ 100nA
180µm x 180µm
Mass Res 1200

Electrons adjacent to ion raster

Neutralization with electron beam adjacent to ion beam raster

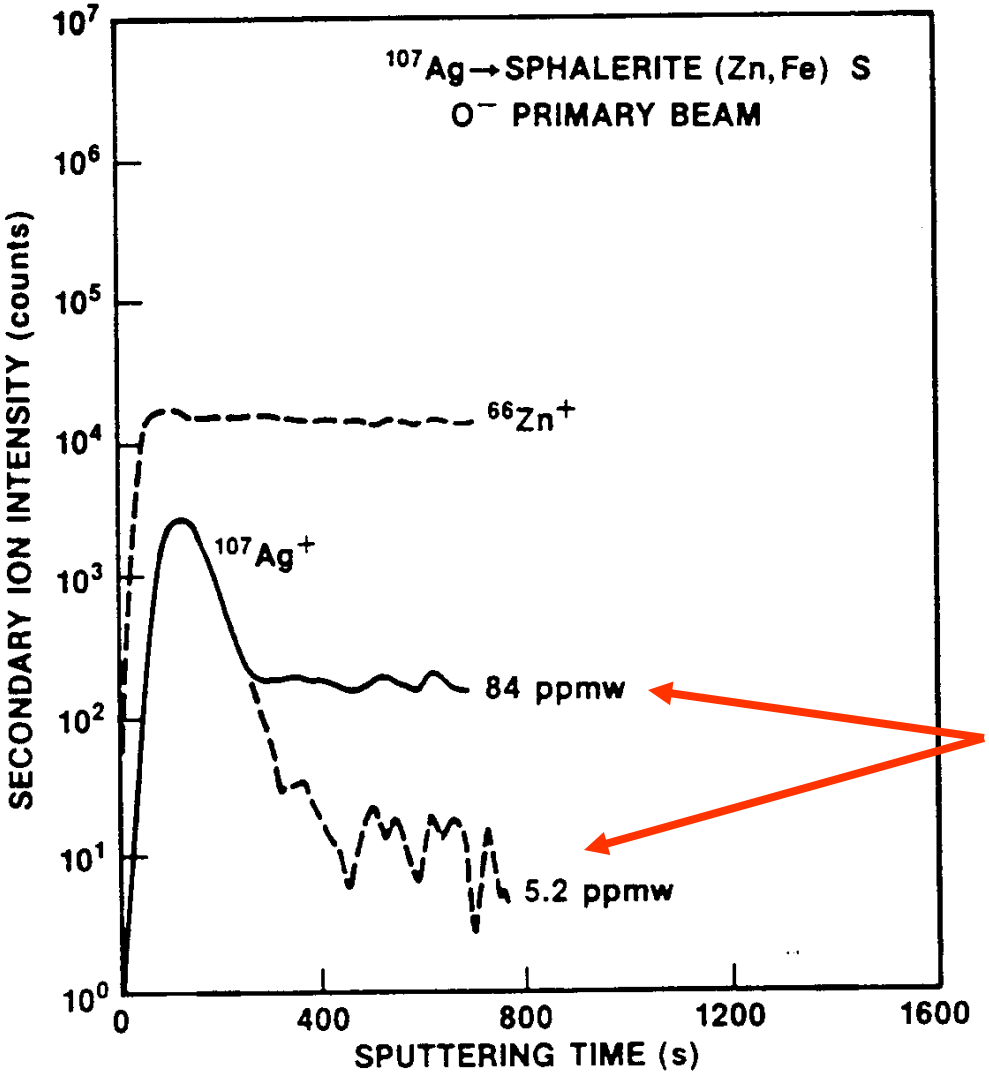
Bulk Insulator: Ti in $LiNbO_3$



Quadrupole analyzer

F. A. Stevie, V. V. S. Rana, A. S. Harrus, T. H. Briggs, and P. Skeath, J. Vac. Sci. Technol. A6, 2082 (1988)

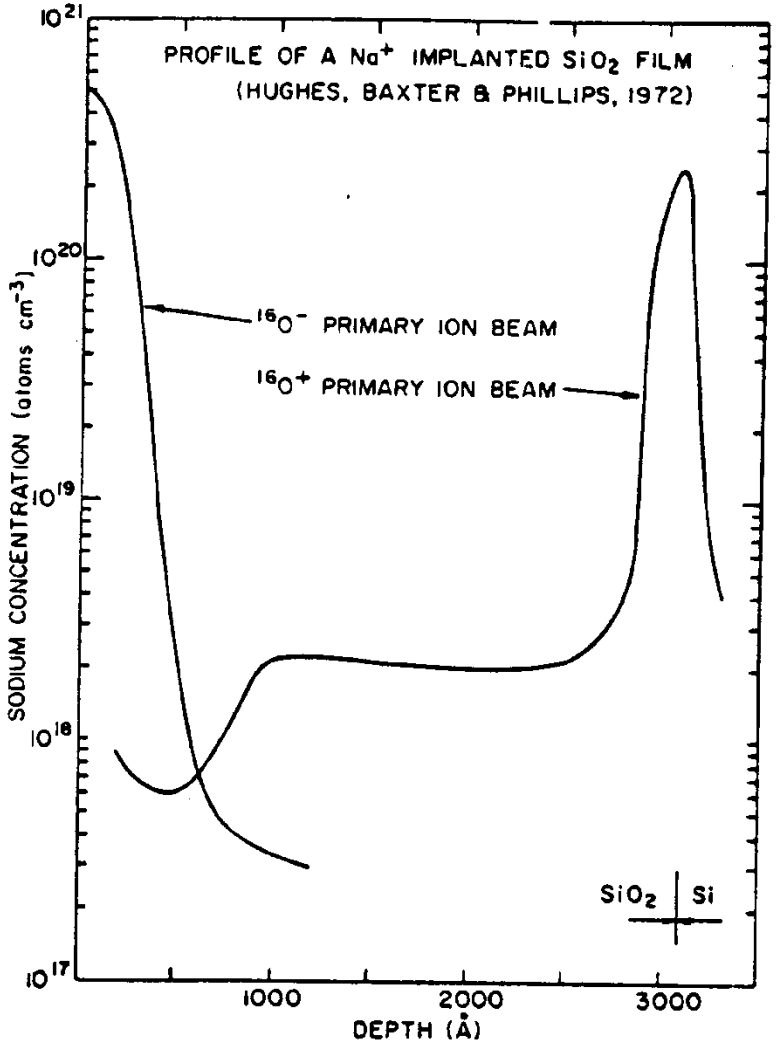
Bulk Insulator



Depth profiles of Ag
in two samples of Sphalerite

Different Ag bulk levels measured for the two samples

Insulators - Mobile Ion Species

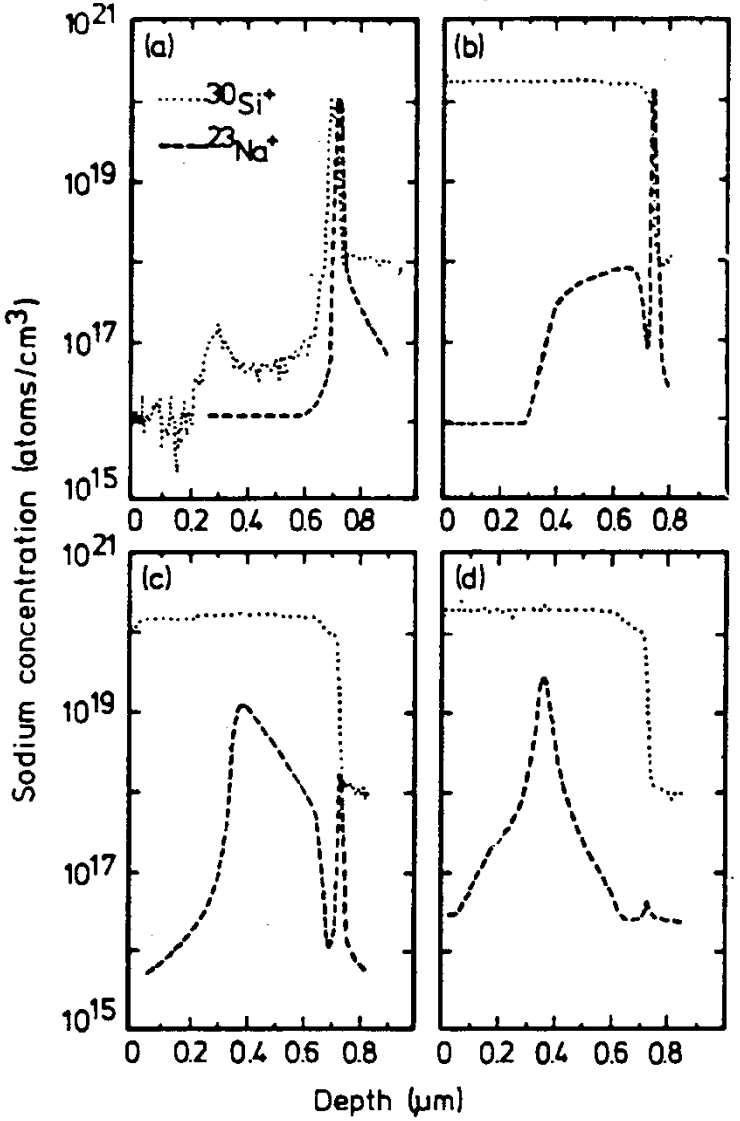


Depth profiles of Na implanted (20 keV, 1E15 atoms/cm^2) in SiO_2/Si using $^{16}O^-$ and $^{16}O^+$ primary beams

Migration of Na as result of ion beam sputtering of SiO_2 film

H. L. Hughes, R. D. Baxter, and B. Phillips
IEEE Trans. Nucl. Sci. NS-19, 256 (1972)

Insulators - Mobile Ion Species



^{23}Na 150keV 1.5x10^{14} ions/cm^2

(a) No charge neutralization
98% of Na pushed to SiO_2/Si interface

(b) 500eV electrons
89% of Na moved to interface

(c) 1keV electrons
1% of Na moved to interface

(d) 2keV electrons
0.06% of Na moved to interface

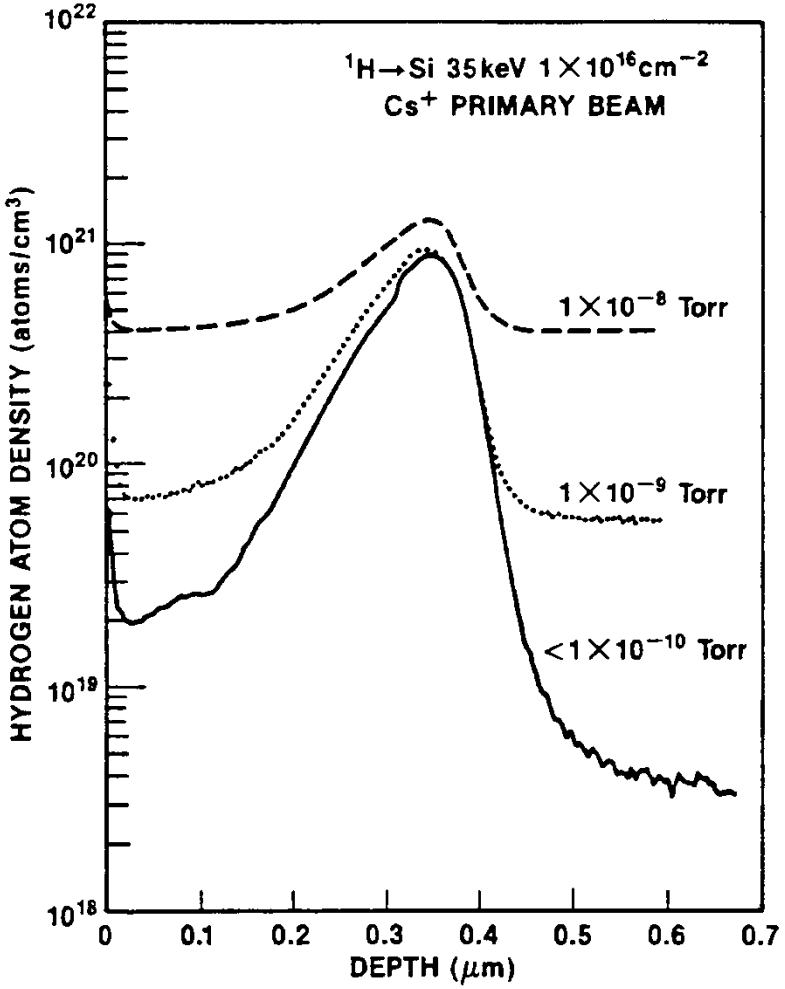
$^{30}Si^+$ higher in oxide because of matrix effect

C. W. Magee and W. L. Harrington, Appl. Phys. Lett. 33, 193 (1978)

Residual Gas Species: H, C, N, O

- Residual gas species are present as background gases
- Detection limit compromised by re-deposition
- Need good vacuum
- Small analysis area
- Raster reduction method

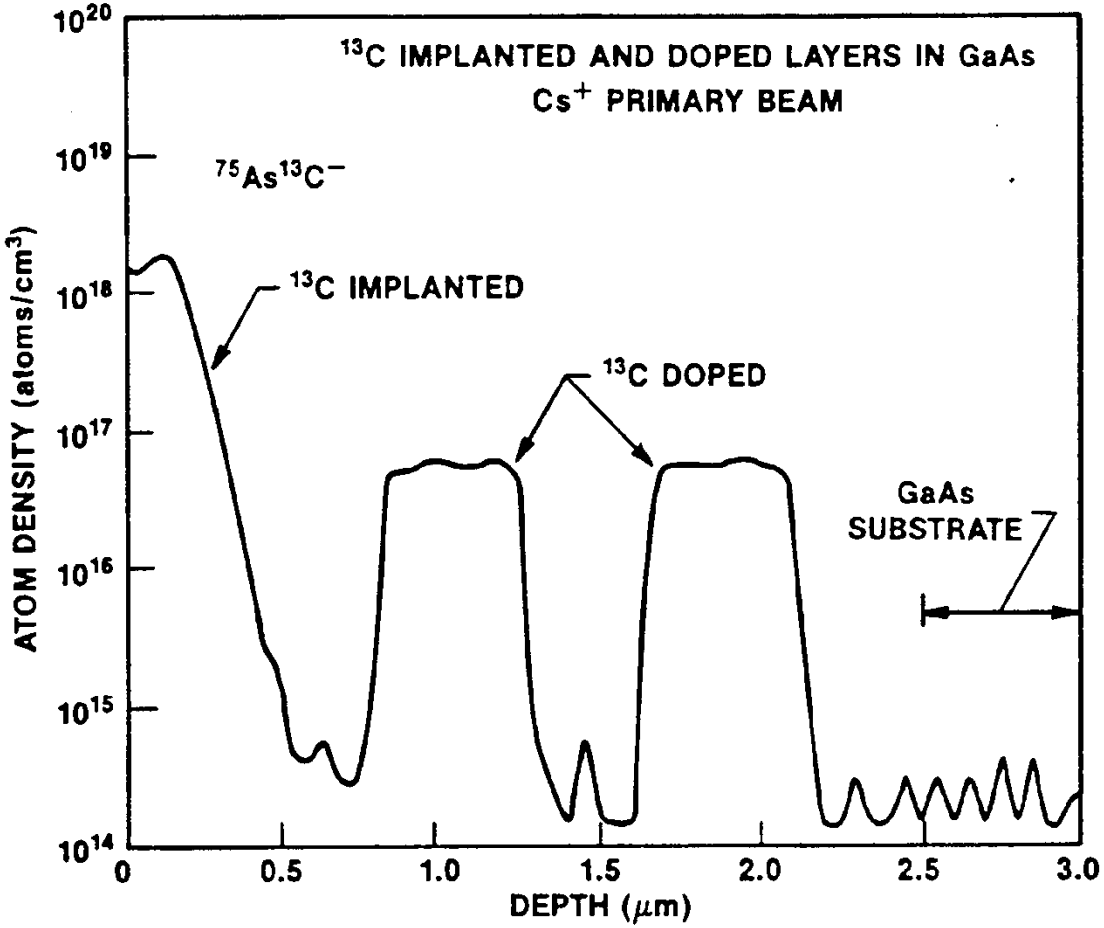
Residual Gas Species



The partial pressure of H_2O is related to H background level for H in Si analysis. The H profiles are normalized to $1x10^{16}$ atoms/cm^2. Note the gradual leading edge and sharp trailing edge, for a light element, such as H, caused by backscattering of H from the Si sample atoms.

C. W. Magee, J. Vac. Sci. Technol. A1, 901 (1983)

Residual Gas Species



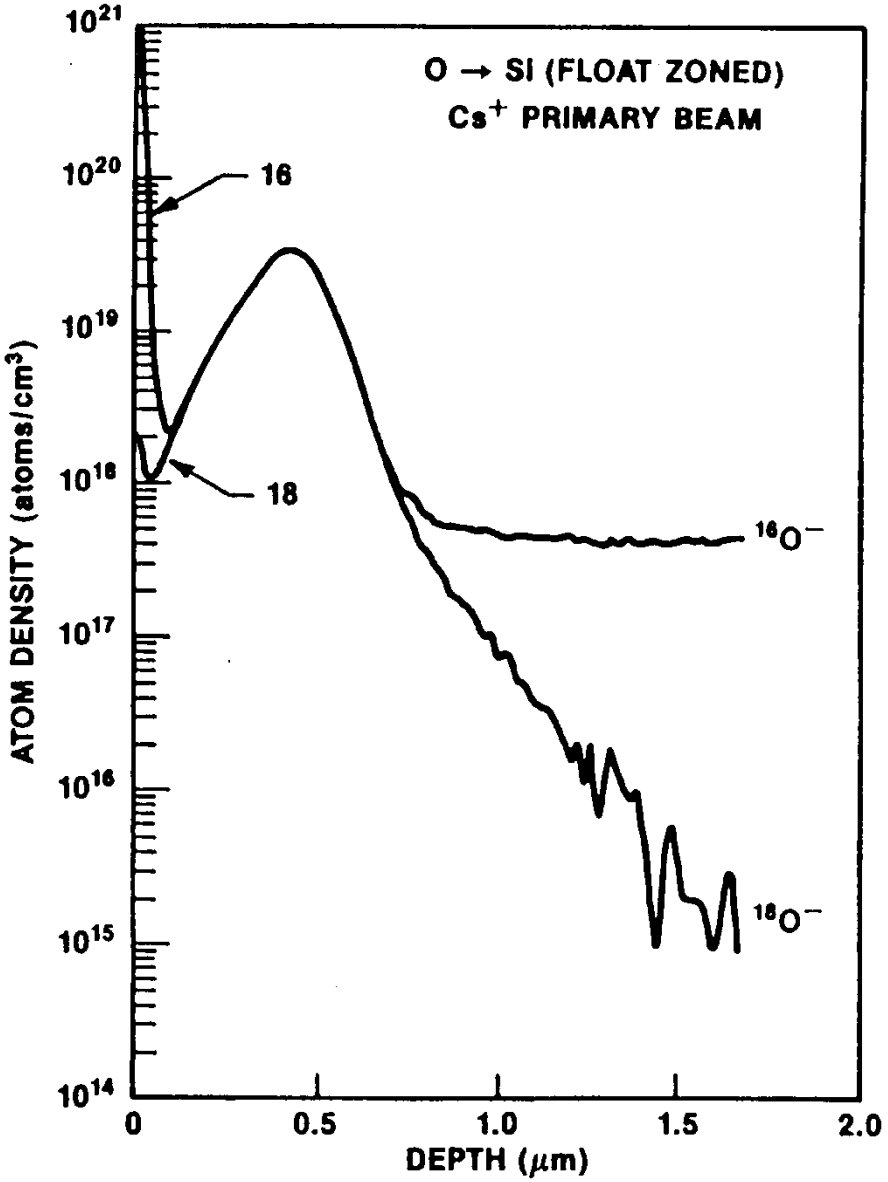
PHI-6300 Quadrupole

^{13}C implanted and analyzed

$^{75}As^{13}C$ monitored to obtain 2E14/cm^3 C detection limit which is better than for ^{12}C

R. M. Lum, J. K. Klingert, D. W. Kisker, S. M. Abys, and F. A. Stevie, 4th International Conf. on Metalorganic Vapor Phase Epitaxy Hakone, Japan (1988)

Residual Gas Species



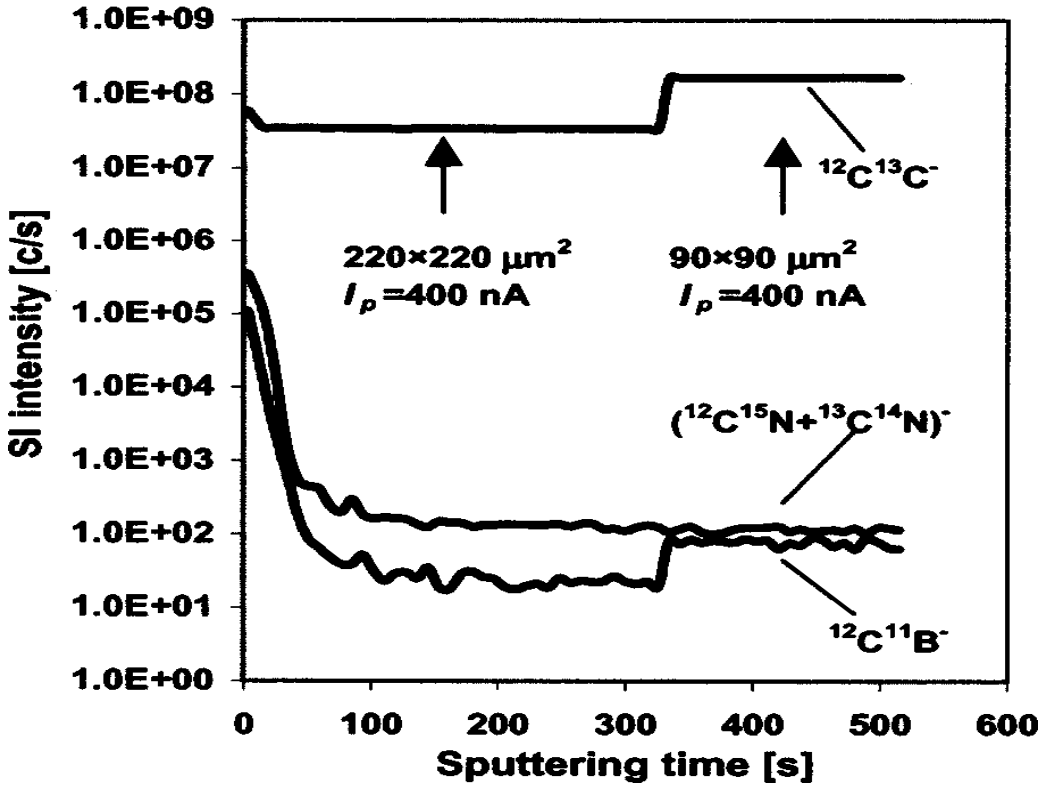
Improved detection limit for O in float zoned Si using ^{18}O as the implanted species

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

Raster Reduction

Start profile, after signals established, reduce raster by ~factor of 2

- Species in sample will increase by ~factor of 4
- Background species will stay at same count rate



A. L. Pivovarov, F. A. Stevie, D. P. Griffis, and G. M. Guryanov, J. Vac. Sci. Technol. A21, 1649-1654 (2003)