SIMS MEASUREMENT of OXYGEN in FZ-SILICON

Adam Barcz [1, 2], Marcin Zielinski [1],
Elisabeth Nossarzewska[3], Gunnar Lindström[4]

[1]Institute of Physics, Polish Academy of Sciences
[2] Institute of Electronics Technology, Warsaw, Poland
[3] Institute of Electronic Materials Technology, Warsaw
[4] Institute of Experimental Physics, University of Hamburg, Germany

In order to detect O at levels relevant to diffusion into FZ Si, it was necessary to employ $Si^{18}O_2$ as a source; [Mikkelsen, 1986]

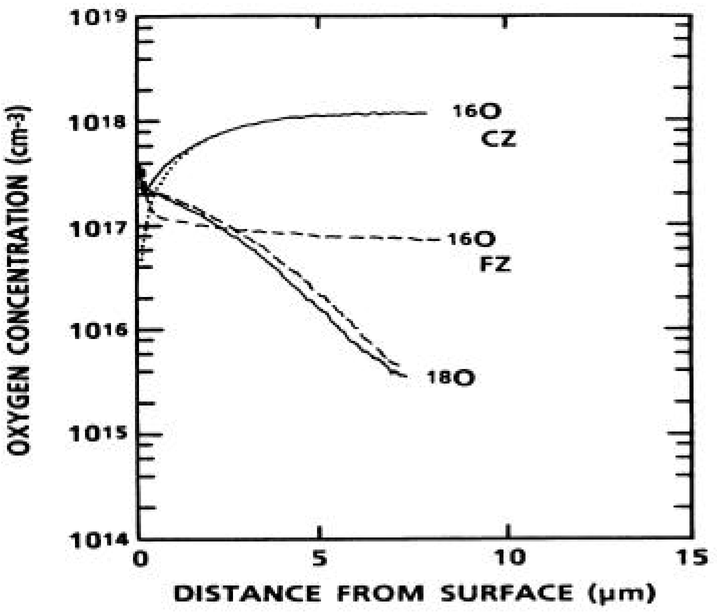

Fig. 1. SIMS profiles of CZ and FZ crystals in-diffused under 1 atm $H_2{}^{18}O$ oxidations at 1000C for 30 min. Dotted curve is the expected ^{16}O out-diffusion profile for the CZ crystal.

Our first results in ROSE using 16O; note decreasing concentration at surface

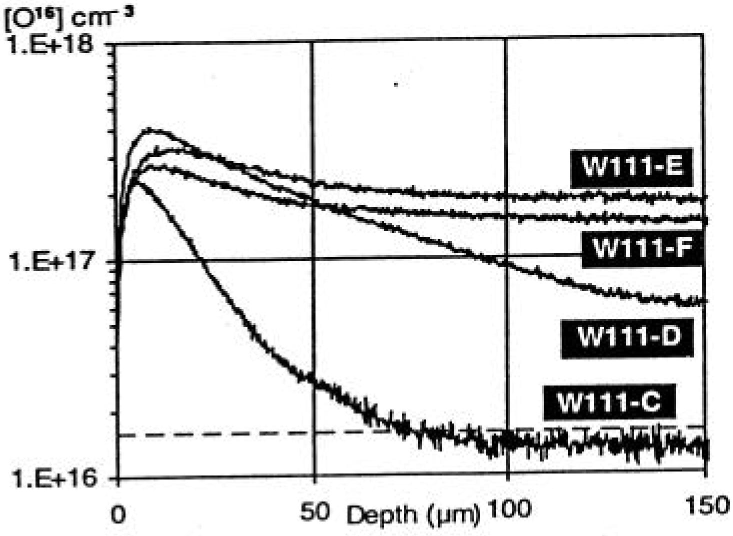

Fig. 2. Oxygen concentrations obtained with different processing times.

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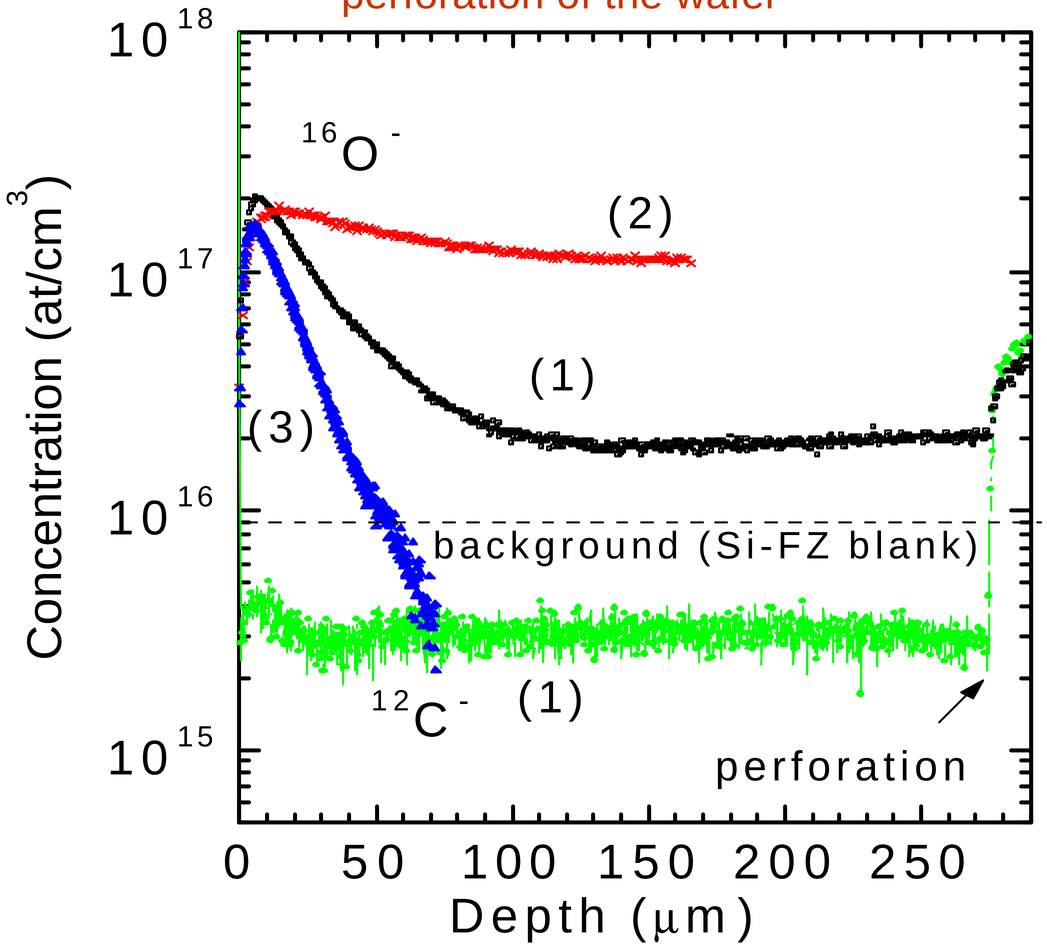
To check correctness of the profiles, one analysis was done until perforation of the wafer



Oxygen depth profiles for FZ-Si wafers annealed at 1150 °C for: (1) – 16 hrs, (2) – 72 hrs, (3) – 6 hrs.

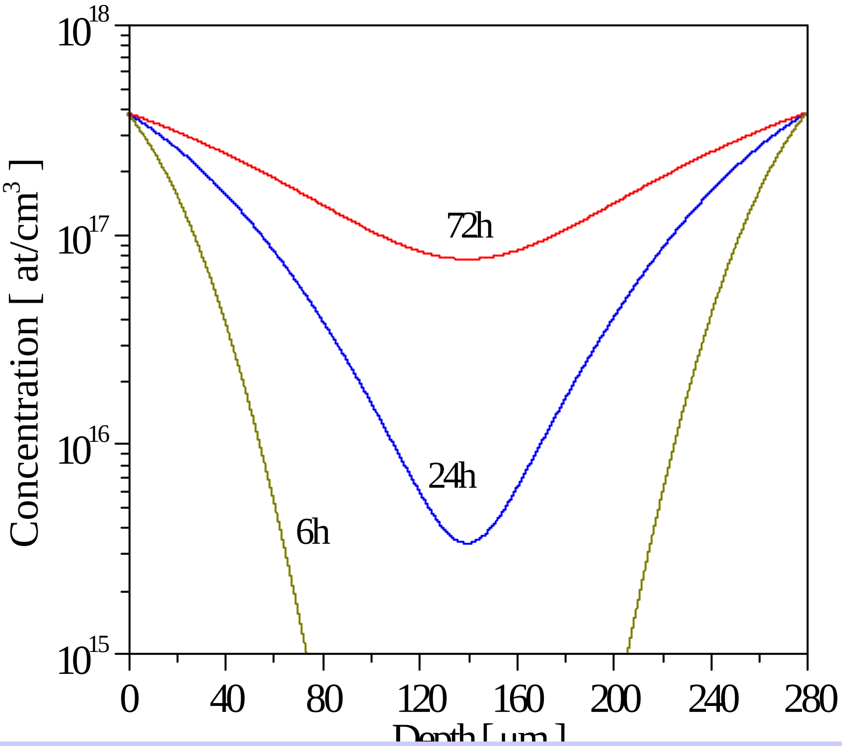
immediate observations :

i – the profile1 is not symmetrical with respect to the mid-thickness as it should be since diffusion proceeds from both sides of the (oxidized) 280μm thick wafer.

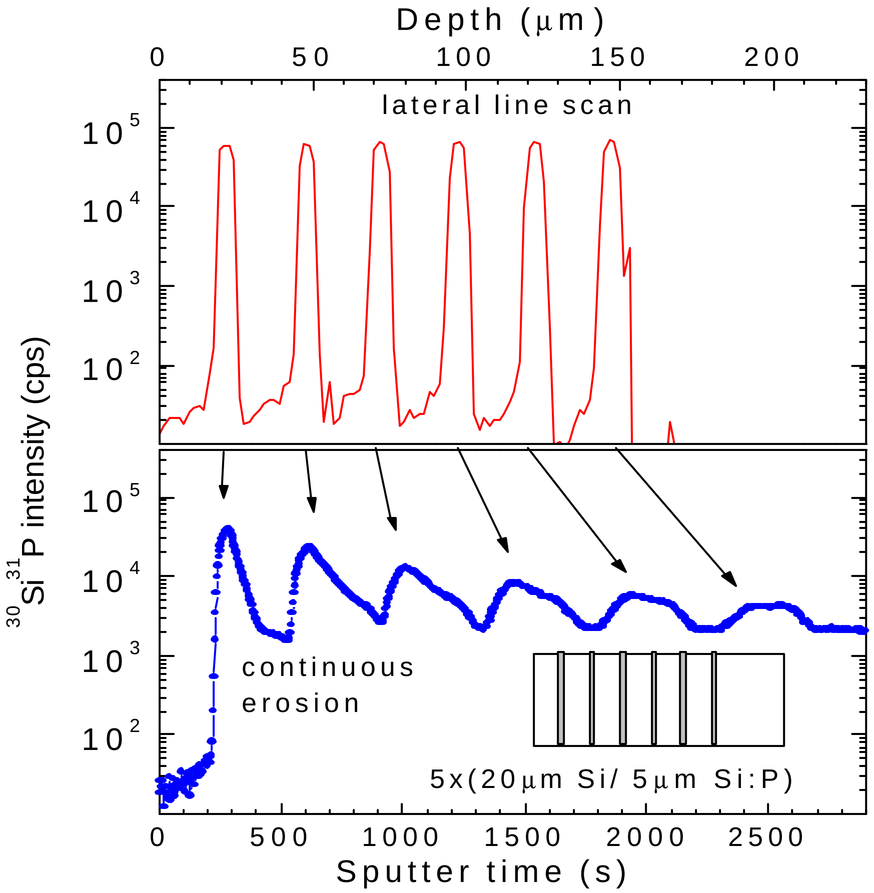
ii – the O signal levels off at $\sim 2*10^{16}$ i.e. well above the *bkg*: hence, direct background correction not feasible.

iii – the mean sputter rate differs markedly from that established at shallow depths from either stylus profilometry or the location of the implant maximum.

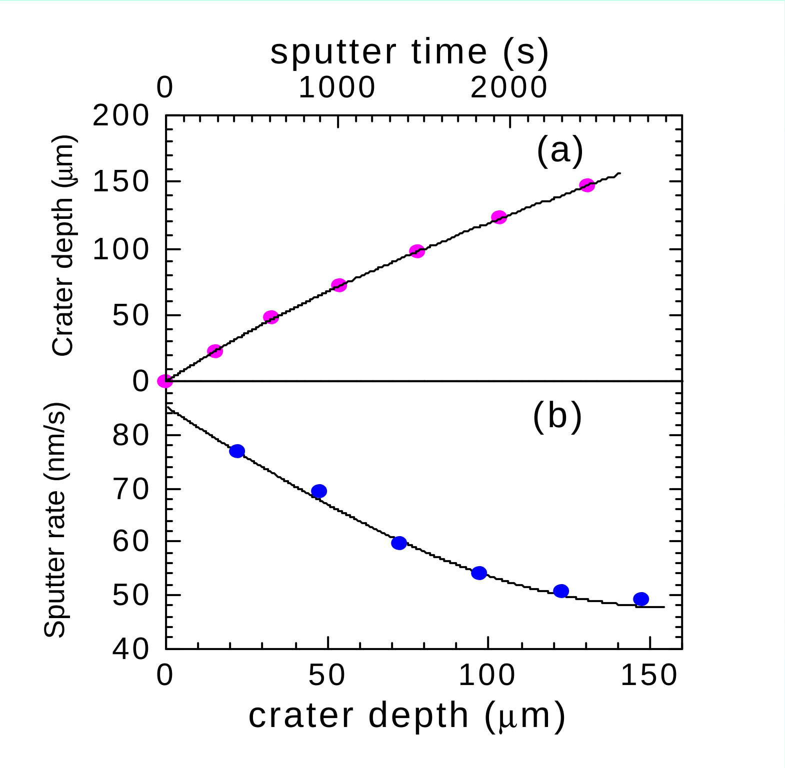
Calculated curves for diffusion into a slab



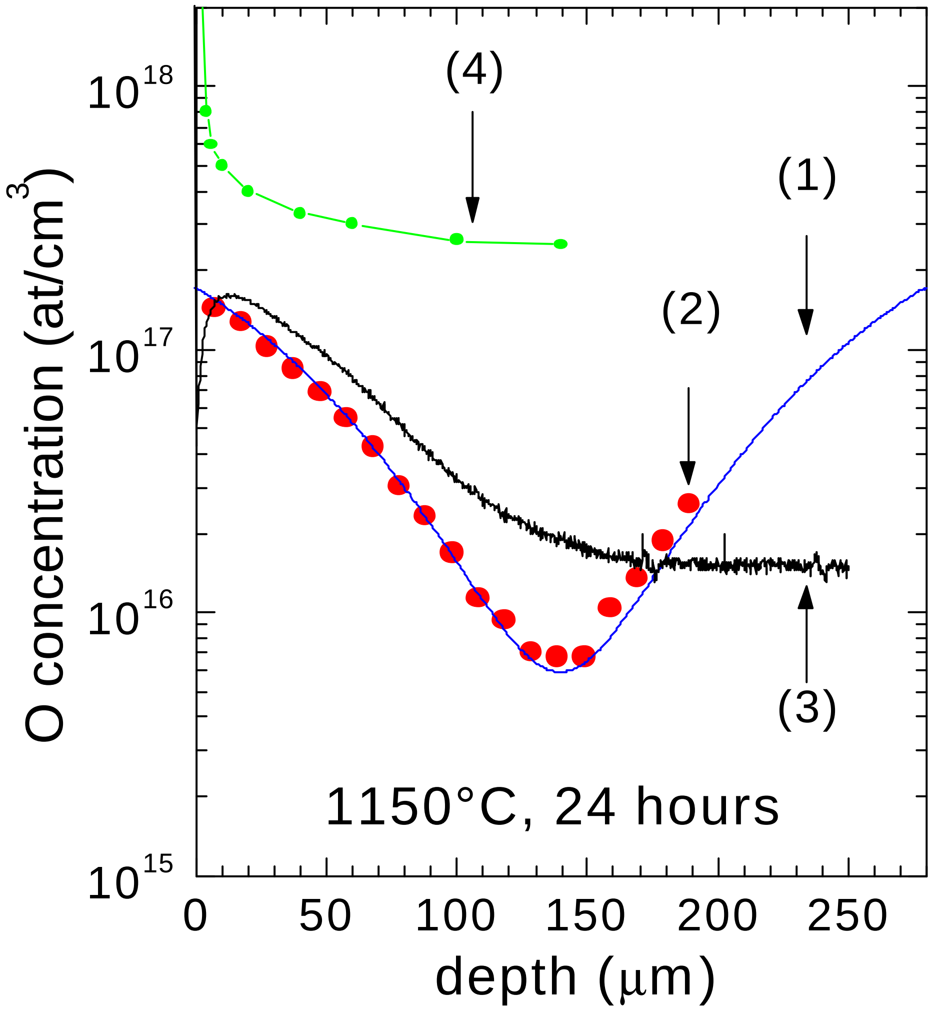
To verify the degree of reliability - a test epi-structure was manufactured for step-by-step measurement on beveled surface (top) or by standard profiling (bottom)



The loss of depth resolution is evident, also the removal rate is not constant; a polynomial fit was derived to enable corrections



$$Y = -0.398 + 0.085 \cdot t - 1.71 \cdot t^2 + 3.408 \cdot t^3 - 2.632 \cdot t^4$$



Comparison of different results concerning deep O diffusion into FZ Si: (1) calculated, for D=2e-10, C_0=1.7e17, (2) line scan with ***bkg*** correction,; continuous profiling: (3) – this work, (4) - ref. [6]

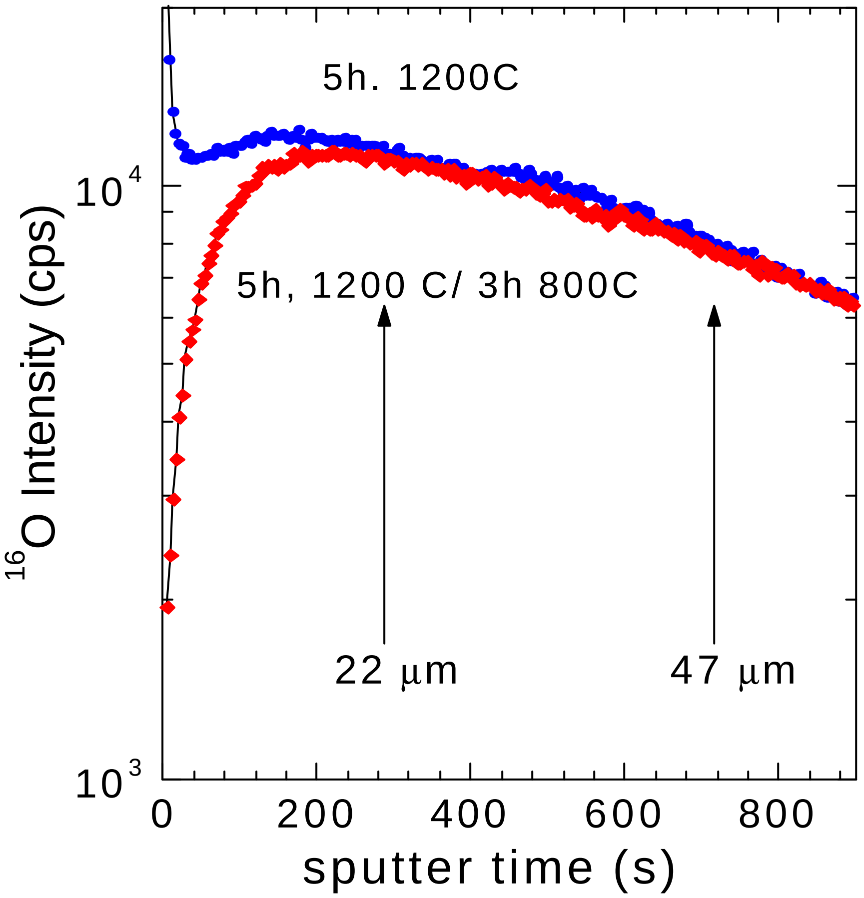


Figure showing the origin of the observed „depletion" at the surface: it takes place upon prolonged cooling and segregation back to the oxide

CONCLUSIONS

When a dynamic range of at least two orders of magnitude is required over a depth exceeding 50-70 µm, the beveling of the sample followed by line-scan analysis is necessary.

For shallower [O] distributions, a continuous analysis can be applied; however, the variation of the sputter rate with depth should be taken into account.

When investigating deep diffusion together with the process of oxygen segregation at the SiO_2 – Si interface, both methods are recommended.