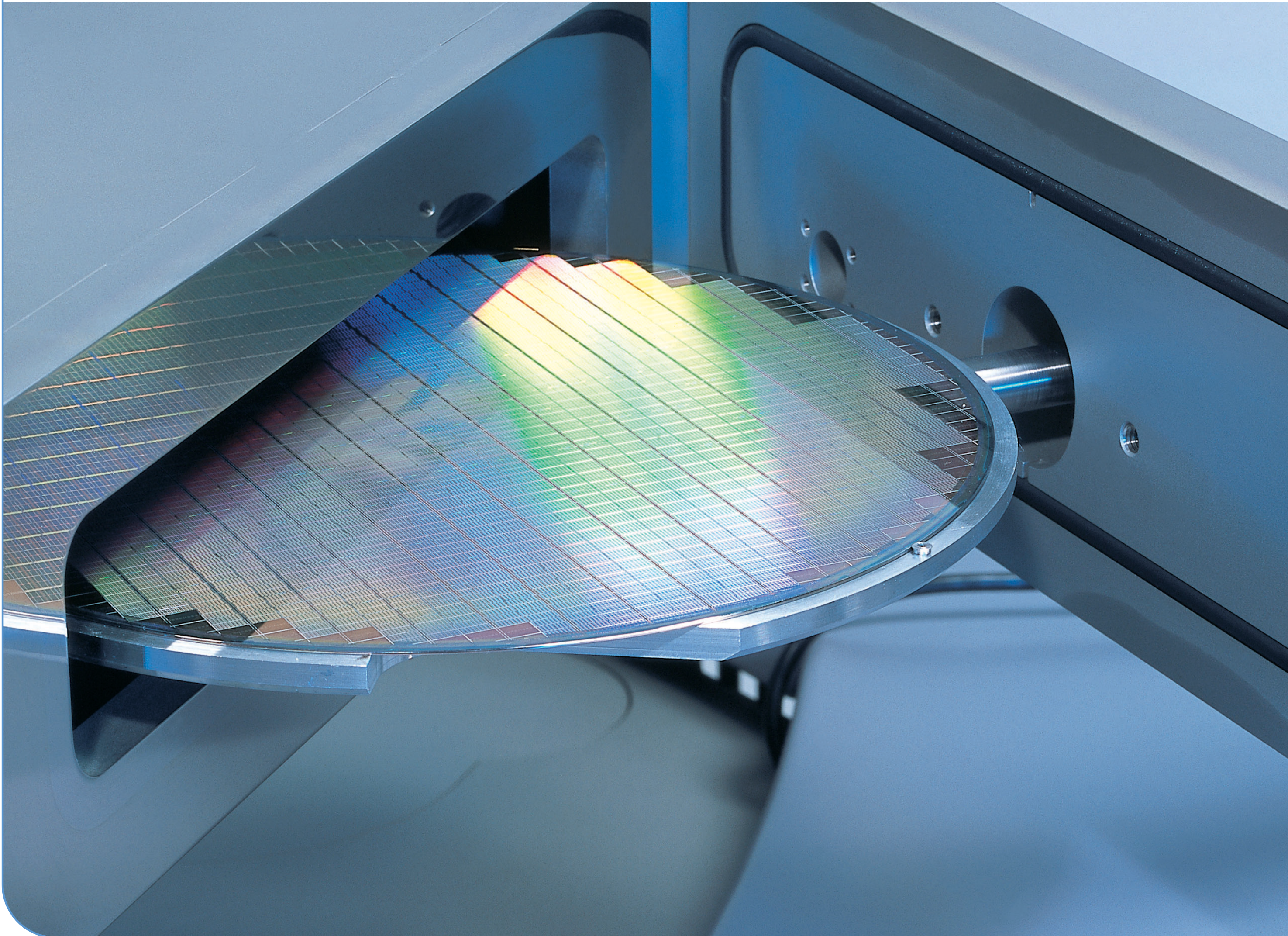


Boron Ultra-Shallow Depth Profiling

Increasingly, the semiconductor industry is making use of low energy ion implants for shallow junction formation. These implants, which are often made at between a few hundred to a few thousand electron volts, require an analysis capability that will allow depth resolutions < 1 nm to be obtained. A significant fraction of the implanted dose is located within the top few nm. In order to ensure an accurate dose measurement, sputtering conditions must be chosen such that the transient width is well below 1 nm and that sample roughening is minimised.

iONTOF

Boron Ultra-Shallow Depth Profiling

Dual Beam Depth Profiling

Boron depth profiles with ultimate depth resolution are acquired in the dual beam interlaced mode. A beam of low energy oxygen ions is used for sample erosion, and a Liquid Metal Ion Gun is used in high current mode for the analysis of the eroded crater bottom. An excellent dynamic range is achieved by using the interlaced mode with high repetition rates. The unique extraction geometry of the TOF.SIMS 5 eliminates memory effects. A high level software is used to program the acquisition and evaluation of multiple depth profiles.

Accuracy of the Depth Scale

The change of the erosion rate in the transient regime causes errors in the depth scale and results in a surface shift of the profile. The accuracy of the depth scale has been tested using a sample with 15 Boron delta layers (Sematech Austin, Boron Round Robin 1999). The depth of the delta layers have been determined using the analytical conditions mentioned above. The results are in perfect agreement with the TEM data. Similar accuracy can be achieved for the measurement of the junction depth of shallow implants.

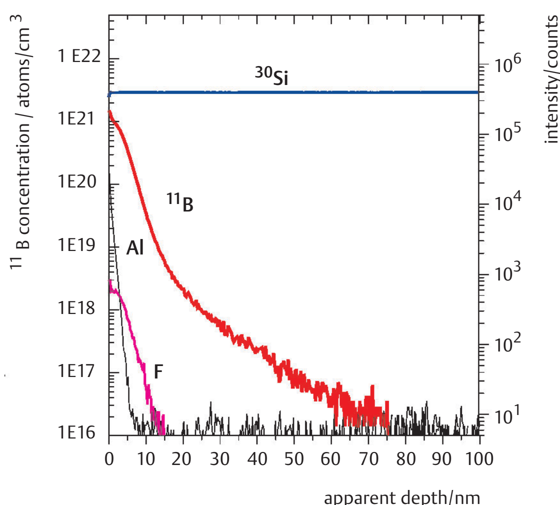
	TOF.SIMS 5	TEM
1st delta layer	4.10 nm	4.15 nm
5th delta layer	22.5 nm	22.5 nm

Boron Ultra Shallow Implant

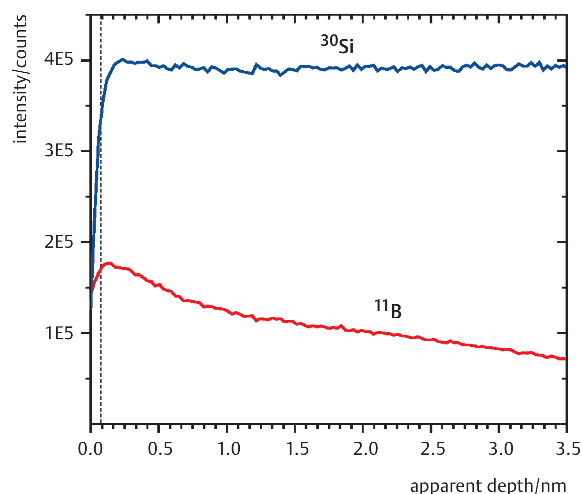
A 2.3 keV BF_2 implant has been analysed using 500 eV O_2 sputtering, oxygen flooding and 15 keV Ga analysis with a repetition rate of 50 kHz. Detection limits well below 10^{16} atoms/cm^3 and a dynamic range for B of more than 5 decades are achieved.
The parallel detection of all masses allows the measurement of the implanted F as well as metal surface contaminants, for example aluminium, at the same time. The excellent depth resolution is seen from the decay length of Al of only 0.68 nm. The implanted dose can be determined with a reproducibility better than 1 % SD.

Transient Width

In the very beginning of the profile, the oxygen concentration changes lead to a variation in the ion yields and sputter rate until steady state conditions are reached. Under the conditions used the width of the transient regime is only 0.1 - 0.2 nm.



Profile of a 2.3 keV BF_2 implant in Si obtained with 50 kHz repetition rate



Detail of the 2.3 keV BF_2 profile

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