NON-DESTRUCTIVE THERMA-PROBE MEASUREMENTS ON ANNEALED USJ SAMPLES

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The scaling of CMOS devices involves several process adjustments [1]. One of the main challenges is the formation, control and monitoring of Ultra Shallow Junctions (USJ).

A basic p-channel USJ formation requires a low energy boron implant (typically less than 1keV) followed by a rapid thermal spike anneal (RTP). Additional defect engineering [2] may be required to inhibit detrimental effects such as transient [3], boron [4] and oxygen enhanced diffusion [5].

The increased value of production wafers, and the process associated failures in Ion Implanter [6] and RTP performance [7] provides the justification for a non-destructive in-line USJ metrology tool.

This paper introduces the patented Therma-Probe™ (TP) metrology tool [8, 9] for the control and monitoring of annealed ultra shallow junctions. We examine the tool performance and characterization with annealed USJ wafers that have had various boron implants and RTP processes. The implant species were B(11) and BF_2(49) with ion doses from 1E14 to 1E15 atoms cm^{-2}, and energies from 200 to 1000eV. The ultra shallow junctions were formed with rapid thermal spike anneals with temperatures ranging from 950°C to 1100°C.

The Therma-wave signal on the annealed USJ samples was found to linearly vary with junction depth. The linear response of the Therma-wave signal was compared to Secondary Ion Mass Spectroscopy (SIMS) data with a correlation of better than 0.98. Long term repeatability for the USJ application was measured to be less than 0.3% (1 sigma) with typical values around 0.16%. The ion energy resolution for the Therma-Probe technique for USJ samples was found to be 1 to 10eV, and the depth resolution was typically 0.4 to 1.8 angstroms over the sample range investigated.

Figure 1 displays a 137 data point contour map of TP measurements performed on an 8" annealed USJ blanket silicon test wafer. The distribution of contours provide fast feedback for the optimization of the anneal uniformity. Additional data can also be obtained from the TP measurements to indicate complete and incomplete damage annealing from the anneal process.

Figure 2 demonstrates the utilization of the metrology tool in a USJ application. The pre-anneal measurement along with the RTP anneal recipe selects the calibration curve to allow the meaningful control of the USJ process.

The Therma-Probe USJ application is shown to provide a linear signal response to USJ samples, and exhibits an excellent correlation to SIMS. This provides the semiconductor process engineer a clean, non-destructive in-line measurement to expedite USJ wafers with the assurance that the product will yield from this process step.

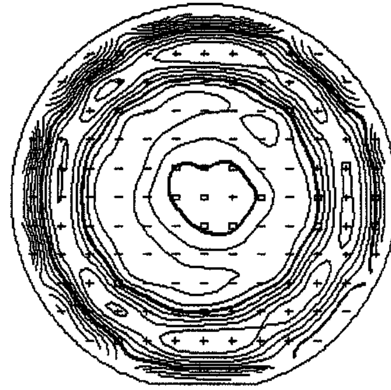

Figure 1: TP measurements on an annealed USJ blanket silicon test wafer, characterizing the RTP process.

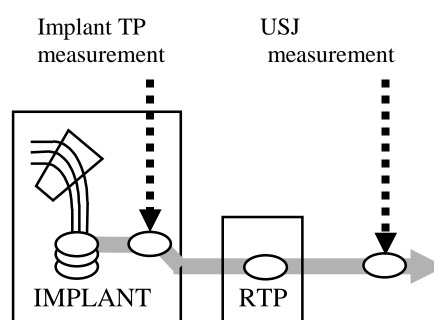

Figure 2: USJ Metrology on Product wafers. The TP ion implant measurement and the RTP recipe set the calibration curve for the USJ TP measurement.

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