RAPID THERMAL SOLID PHASE EPITAXY ANNEALING FOR USJ FORMATION

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Two of the key challenges according to the 2001 International Technology Roadmap for Semiconductors for the source/drain extension junction at the 65-70 nm node and beyond are to produce junctions between 10 and 19 nm with sheet resistance values between 760 to 830 ohm/sq. for low parasitic source/drain series resistance [1].

In contrast to fast spike anneals [2, 3] a simple approach for the formation of ultra-shallow junctions with boron consists of pre-amorphizing the substrate prior to dopant implantation and followed by a low-temperature (500-600°C, 10-30 min) solid phase epitaxial regrowth process in a standard furnace. The advantage of this technique is that boron changes over to the electrically-active substitutional site during the regrowth process while the dopant diffusion within the lattice is suppressed/minimized by the low temperature process. Numerous groups around the world are investigating low-temperature solid phase epitaxial regrowth in furnaces.

An alternative to spike anneals in rapid thermal annealing systems would be to run solid phase epitaxy processes in lamp-based systems with reasonable process times and in a tightly controlled ambient. This paper summarizes the latest results for low energy implants employing conventional beamline (B and BF_2) wafers (with Ge pre-amorphization) with varying energies and doses in the Mattson 3000 Plus RTP system. The as-implanted $^{49}BF_2^+$-profiles in Ge pre-amorphized samples are shown in Figure 1. The Rapid Thermal Solid Phase Epitaxial process at 650 °C for 60 s itself is rather short and with a high throughput compared to above mentioned furnace anneals.

Comparable spike anneal data with the same implant conditions are also presented. The data are analyzed and discussed with respect to the sheet resistance versus junction depth metrics (R_S/X_J) and compared to literature. These data as well as the uniformity results demonstrated on 200 mm wafers show the production-worthiness of the Rapid Thermal Solid Phase Epitaxy technology for the 65-70 nm technology nodes. This process also has the potential of extending Rapid Thermal Processing in conjunction with ion implantation beam line technology to the 65-70 nm technology node and perhaps beyond.

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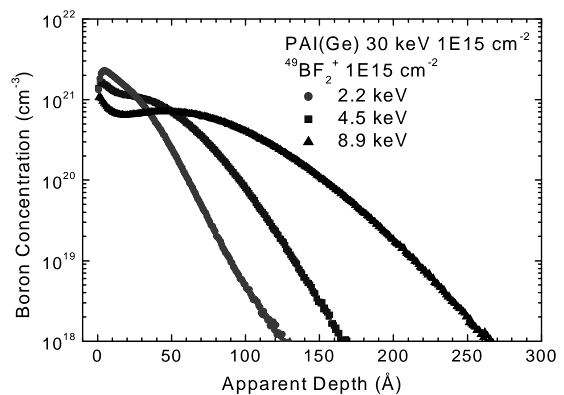

Figure 1: As-implanted $^{49}BF_2^+$-profiles in a Ge pre-amorphized Si substrate.