Activation and thermal stability of ultra-shallow B+-implants in Ge

The activation and thermal stability of ultra-shallow B+ implants in crystalline (c-Ge) and preamorphized Ge (PA-Ge) following rapid thermal annealing was investigated using micro Hall effect and ion beam analysis techniques. The residual implanted dose of ultra-shallow B+ implants in Ge was characterized using elastic recoil detection and was determined to correlate well with simulations with a dose loss of 23.2%, 21.4%, and 17.6% due to ion backscattering for 2, 4, and 6 keV implants in Ge, respectively. The electrical activation of ultra-shallow B+ implants at 2, 4, and 6 keV to fluences ranging from 5.0 × 10^{13} to 5.0 × 10^{15} cm^{-2} was studied using micro Hall effect measurements after annealing at 400-600 °C for 60 s. For both c-Ge and PA-Ge, a large fraction of the implanted dose is rendered inactive due to the formation of a presumable B-Ge cluster. The B lattice location in samples annealed at 400 °C for 60 s was characterized by channeling analysis with a 650 keV H+ beam by utilizing the 11B(p, α)2α nuclear reaction and confirmed the large fraction of off-lattice B for both c-Ge and PA-Ge. Within the investigated annealing range, no significant change in activation was observed. An increase in the fraction of activated dopant was observed with increasing energy which suggests that the surface proximity and the local point defect environment has a strong impact on B activation in Ge. The results suggest the presence of an inactive B-Ge cluster for ultra-shallow implants in both c-Ge and PA-Ge that remains stable upon annealing for temperatures up to 600 °C.

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