 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 × 10¹³ to 5.0 × 10¹⁵ 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.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration, Experimental Surface and Nanomaterials Physics, Silicon Microtechnology, University of Florida, Capres A/S, Università di Catania, Sandia National Laboratories, Applied Materials Incorporated
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Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Journal of Applied Physics
Volume: 112
Issue number: 12
ISSN (Print): 0021-8979
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.03 SJR 0.739 SNIP 0.953
Web of Science (2017): Impact factor 2.176
Web of Science (2016): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.72 SJR 0.906 SNIP 0.977
Web of Science (2016): Impact factor 2.068
Web of Science (2015): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.57 SJR 0.821 SNIP 0.996
Web of Science (2015): Impact factor 2.101
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.04 SJR 1.039 SNIP 1.197
Web of Science (2014): Impact factor 2.183
Web of Science (2014): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2013): CiteScore 2.24 SJR 1.155 SNIP 1.286
Web of Science (2013): Impact factor 2.185
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1