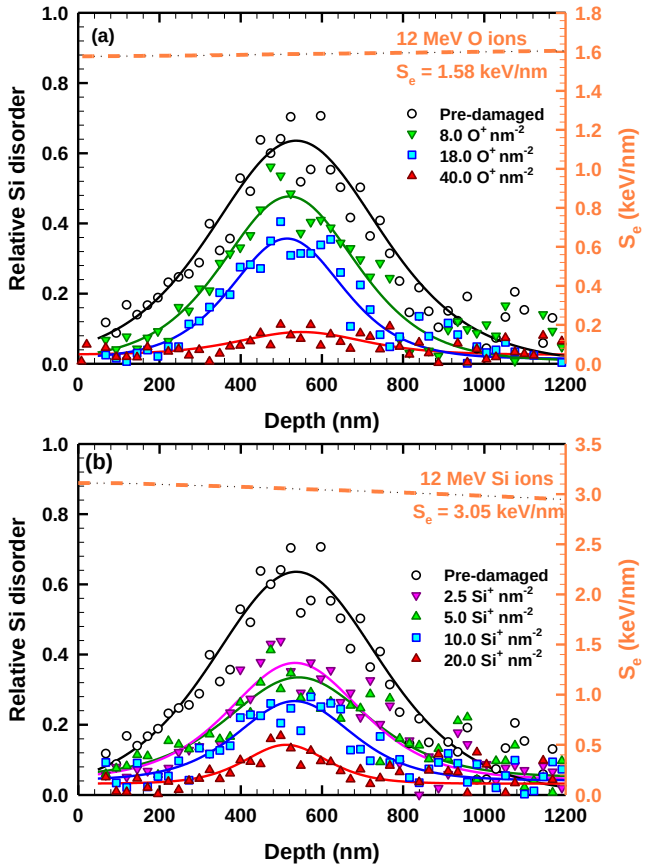
Ionization Induces Healing of Defects in Silicon



Relative Si disorder profiles for pre-damaged Si single crystals with a maximum initial disorder fraction $f_0 \sim 0.7$ and sequentially irradiated with: (a) 12 MeV O ions and (b) 12 MeV Si ions at the indicated ion fluences. Also superimposed are the SRIM-derived Se curves (orange dash-dot lines).

Scientific Achievement

Energy transferred to electrons in silicon (Si) by energetic ions via ionization can effectively heal pre-existing defects and restore structural order.

Significance and Impact

Selective annealing of pre-existing defect levels in Si at room temperature can be considered as an effective strategy to mediate the transient enhanced diffusion of dopants in Si. This approach is more desirable than the regular thermal annealing, which is not compatible with the processing requirements that fall below the typical thermal budget.

Research Details

- Defects were introduced into single-crystal Si by implantation with 2.0 MeV Au ions.
- Irradiation of these samples with intermediate-energy ions (12 MeV O and Si ions) having relative low electronic energy loss (1.5–3.0 keV/nm) healed pre-existing defects.
- Healing was validated by ion channeling, high resolution transmission electron microscopy and molecular dynamics simulations.
- Energy transfer of 1.5 keV/nm to electrons was sufficient to activate this process.

M.D. Mihai, D. Iancu, E. Zarkadoula, R.A. Florin, Y. Tong, Y. Zhang, W.J. Weber, and G. Velișa, "Athermal annealing of pre-existing defects in crystalline silicon" *Acta Materialia* 261 (2023) 119379. https://doi.org/10.1016/j.actamat.2023.119379

The ion irradiations and ion channeling measurements were performed using the the 3 MV Tandetron Cockcroft-Walton accelerator located at IFIN–HH, Magurele, Romania. The atomistic simulations were performed using the resources of the Compute and Data Environment for Science (CADES) at the Oak Ridge National Laboratory. TEM analysis was performed at Institute for Advanced Studies in Precision Materials, Yantai University.