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Overview of results from the WODEAN collaboration

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QUANTITATIVE EFFECTS OF NEUTRON IRRADIATION
ON SILICON RADIATION DETECTORS

-Overview of results from the WODEAN* collaboration-

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Silicon detectors for the Large Hadron Collider must tolerate lifetime fluences of up to 1016 cm-2 high-energy hadrons. However, current understanding of the defects created by the damage is poor. Here, we present the results of a multi-technique experimental study of detector grade silicon, irradiated with 1011 to 1016 cm-2 1-MeV equivalent reactor neutrons. We suggest to separate the damage into two classes. The most probable damage events involve a very small number of atomic displacements, while the majority of the damage occurs when a knocked-out atom creates up to hundreds of defects in a disordered region. The small damage events produce mobile single vacancies and self-interstitials that undergo reactions similar to those well-known from electron damage. Isolated divacancies are generated, and, in almost equal numbers, di-interstitials (I2) which are captured by oxygen (O). The I2O complex is thermally unstable above room temperature, affecting the damage production rates. Comparison of infrared absorption and DLTS suggests that the I2O centre produces the two DLTS levels, 'E4 and E5'at Ec–0.37 eV and Ec–0.45 eV, which act as traps in detector material. In contrast, the disordered regions evolve mainly by restructuring within themselves, especially, as seen by DLTS, photoluminescence and photoconductivity data, on annealing near 200 oC. They pin the Fermi level in the region of the disordered structures, so that DLTS measurements of the concentrations of defects near the disordered regions are unreliable. For example, only about one third of the VO centres near the disordered regions can be detected by DLTS: Fermi-energy pinning occurs over a volume that is considerably larger than the physical size of the disordered region. This work establishes a quantitative understanding of the defect species and their concentrations for the small damage events, and identifies the major problems in understanding the evolution of defects in the disordered regions.

- WODEAN: "WOrkshop on DEfect Analysis"Subgroup of the CERN-RD50 Collaboration; http://sesam.desy.de/WODEAN/

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