Quantitative evolution of vacancy-type defects in high-energy ion implanted Si: Au labeling, microbeam x-ray diffuse scattering and the ***vacancy implanter***

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In the past decades ion implantation has been a ubiquitous tool for modifying properties of solids effected by introducing controlled amounts of impurities. Concurrently, the study of radiation damage has been actively pursued due to its role in processes like impurity diffusion, precipitation or phase formation, strengthening mechanisms, etc. In mainstream Si research, the role of interstitial defects on dopant diffusion is fairly well understood. As opposed to this, there is a relatively poor understanding of vacancy-type defects, mainly due to the inadequacy of present techniques to profile and especially count vacancy defects. Recently two important steps have been taken in the direction of understanding vacancy-type defects. The first is the demonstration that high-energy ion implantation can be used as a ***vacancy implanter*** to introduce controlled concentrations of vacancies (V) in Si that are separated from the interstitials (I). The vacancy implanter relies on spatial separation of the Frenkel pairs due to the average forward momentum of the recoils. The second is the development of the ***Au labeling*** technique, which can be used to accurately profile and count vacancies. In this work we have used the vacancy implanter in conjunction with Au labeling to study the evolution of excess vacancy defects created by high-energy Si^+ implantation in Si(100) as a function of annealing time and temperature. The evolution of vacancy defects generated by implantation of dopant species and Ge ions has been studied as well. In addition, we have characterized the depth dependence of V and I defects by cross-section x-ray microbeam diffuse scattering measurements. These measurements provide separate size distributions and concentrations for V and I defect clusters as a function of implantation depth. The x-ray results will be compared with the results of Au labeling to provide a quantitative and comprehensive picture of the vacancy clusters.

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