Defect Engineering for Optimization of Ion Beam Processing of Si.

O. W. Holland
Oak Ridge National Laboratory, Oak Ridge, Tenn. 37831-6048

Ion-beam modification and synthesis can be used in applications as diverse as selected-area doping of silicon to the formation of stoichiometric layers—as in the case of SIMOX (separation by implantation of oxygen) processing for forming a silicon-on-insulator (SOI) material. Buried-oxide layers in Si ranging in thickness from below 0.1 μm to ~0.5 μm can be formed by high-dose oxygen implantation. In addition, new applications are always emerging. One of the most exciting involves the use of hydrogen implantation as a cutting tool to precisely control the separation of thin layers from bulk crystals. This technique, when combined with wafer bonding, has been used to form heterostructures from many different materials. In principle, all process variations can be achieved simply by appropriately adjusting the ion energy and fluence. However, in practice, unique problems inevitably arise with each process variation. For example, the quality of the buried $Si:SiO_2$ heterostructure formed by SIMOX processing depends upon the thickness of the buried oxide (BOX) (i.e., the oxygen dose). The standard (~0.5 μm BOX) process suffers due to a high density of defects in the superficial Si layer, while a thin-BOX process often results in discontinuities in the BOX below a thickness of 0.1 μm. Techniques for overcoming material problems will be discussed for a wide range of ion beam applications. These techniques involve a defect-engineering approach for manipulation of the residual defects and the defect-induced microstructure to achieve the desired material property. A variety of characterization tools were used to monitor the implantation process. However, a focus will be given to Rutherford backscattering/channeling spectrometry and the unique techniques developed for specific material problems.

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