16. Electronic Properties of Amorphous Silicon Dioxide

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Joint Services Electronics Program (Contract DAAG29-80-C-0104)

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The objective of this program is to study the electronic properties of amorphous SiO_2 (a-SiO_2) using pulsed laser excitation. There is a great deal of evidence that many of the optical and transport properties of this technologically important material are dominated by defects. Electron spin resonance experiments have identified a number of radiation-induced defects and certain types of defects present in unirradiated bulk a-SiO_2 and films of a-SiO_2 thermally grown on Si. Our work over the past several years has identified a number of photoluminescence (PL) bands which probably originate at intrinsic defects. The PL may be a more sensitive probe of the defects than other techniques.

One major goal of our current research is to determine which of the several PL bands we observe arises at the same, and which at different, PL centers. To do this we are carrying out time-resolved PL measurements at a variety of temperatures for a-SiO_2 prepared in a number of different ways. The time-resolved spectroscopy allows us to unambiguously identify PL bands by their different decay rates. The temperature dependence of the PL decay is important because it can provide information about whether two different PL bands can originate at the same defect. The excitation-energy dependence of the intensity of the various PL bands will also help to differentiate among PL centers.

The preparation of the glass, however, is the most direct probe of which bands arise at different centers. Neutron irradiation, for example, increases the intensity of some PL bands but not others. During the past year we discovered that our molecular flourine laser causes photo-induced optical absorption (PA) in a-SiO_2 and simultaneously enhances some of the PL bands. This may provide another means of correlating the various bands. We are also preparing to measure the time dependence of PA. Such measurements have proved very important in the study of the narrower band-gap chalcogenide glasses.

We have also begun studies on thermally grown oxide films. We have made a preliminary observation of PL from a 1 μm thick film of a-SiO_2 grown on single crystal Si at Lincoln Laboratory

Transient photoconductivity experiments on a-SiO_2 using the same films as well as bulk samples are beginning. Theoretical work on the interpretation of such photoconductivity experiments has led to interesting predictions for the experiments.

Publications

Kastner, M.A., "Dielectric Relaxation and Delayed-Collection Field Experiments in Amorphous Semiconductors," Solid State Comm. 45, 191 (1983).