XVII. ELECTRONIC PROPERTIES OF INTRINSIC DEFECTS IN AMORPHOUS SILICON DIOXIDE

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Defects in amorphous (a-) SiO_2 are thought to result in deleterious optical and electronic effects. They may be responsible for limiting the transmission of optical fibers; they may be the origin of surface states at Si-SiO_2 interfaces which trap charge carriers; they probably cause potential fluctuations which scatter mobile carriers moving near the Si-SiO_2 interfaces. Both of the latter effects seriously limit the performance of MOS devices.

Many techniques have been employed to study the defects in a-SiO_2, and a great deal is known about them. However, the electronic structure and properties of the intrinsic defects are not yet well established. On the other hand, much progress has been made in developing detailed models for intrinsic defects in narrower band-gap chalcogenide glasses (e.g., Se, As_2S_3, As_xTe_y, etc.). The models have been successful in explaining Fermi-level pinning in the diamagnetic ground state and a wide variety of excited-state properties. The model of Kastner, Adler, and Fritzsche strongly emphasizes that the nature of the defects is a result of the special chemical bonding in materials containing two-fold-coordinated group VI elements. Therefore, it was proposed that defects similar to those in sulfides, selenides, and tellurides would be present in oxide glasses as well.

The most valuable probe of defects in semiconducting glasses has been photoluminescence (PL). The large PL Stokes shift and linewidth provided evidence for the strong electron-photon coupling necessary to explain the effective attraction between electrons (Anderson's effective negative correlation energy). We therefore

undertook a program solely under JSEP funding to study PL in a-SiO_2.

The program has been very successful. After completing construction of a vacuum ultraviolet spectrometer, which includes the capability of cooling samples to low temperature in very high vacuum, we made the first observation of intrinsic defect PL in a-SiO_2. We found that both the radiative and nonradiative mechanisms were very similar to those in narrower band-gap glasses. Our observations of the temperature dependence of the PL intensity were particularly valuable for they suggested a mechanism for the nonradiative process which appears to dominate in all the glasses.

Since time-dependent spectroscopy has led to deeper insight into the radiative recombination mechanism in a-As_2S_3, it was important to develop the capability of carrying out such experiments on a-SiO_2. During the past year, we added to our optical system a pulsed F_2 laser which emits 10-nsec pulses with $\sim$1 MW peak power. This high power has enabled us to begin the time-resolved measurements. It has also allowed us to observe PL bands which we were not able to detect with the H_2 discharge lamp. The new laser has made possible a range of interesting experiments which we are now beginning to explore.