Comment on "Optical Bias Control of Dispersive Relaxations in *a*-Si:H"

In *a*-Si:H, the rate of decay of the excited carrier density after pulsed excitation follows closely a power law, $dn(t)/dt \sim t^{-1-\alpha}$. In the multiple-trapping model of dispersive recombination, the dispersion parameter α is of central importance. Pfost, Vardeny, and Tauc[1] found that the effect of a continuous excitation (bias) during the decay in photoinduced-absorption (PA) experiments is to increase the value of α. At low temperature ($T = 10$ K), they found that $\Delta\alpha$ is proportional to the density of excess carriers induced by the bias, and they considered that this result was consistent with tunneling recombination theory.

Tunneling recombination rates in *a*-Si:H may be calculated by the methods of distance-pair kinetics[2]; the results do not agree at all with the data of Pfost, Vardeny, and Tauc.[1] Photoluminescence (PL) data show, however, that the theory of Ref. 2 is applicable to *a*-Si:H.

Detailed calculations for decay curves under bias are given by Duncan[3]; they predict that the power-law PL decay curve will be unchanged, until it is cut off sharply at a time of the order of milliseconds. Qualitatively, this occurs because the bias has two effects. It increases only slightly the carrier density ρ during the experiment; this has almost no effect on the decay curve. Secondly, it recycles, or turns over, the population at a rate $\tau^{-1} = G_{\text{bias}}/2\rho$; this provides an upper limit to the lifetime of any perturbation from steady state. Consequently, the decay curves are cut off exponentially at the time τ. PL decay curves show just this behavior (Fig. 1 and see Stoddart and Tauc[4] and Merk, Dunstan, and Czaja[5]), both at low temperature and at 120 K.

There are several possible reasons for this severe discrepancy with the results of Pfost, Vardeny, and Tauc.[1] Among others, it is possible that PA and PL do not measure the same set of carriers, or that PA does not measure directly the excess carrier density. In the former case, it would be hard to understand the results of infrared-stimulated PL[6]; also it would be necessary to consider to which of the two sets of carriers a theory such as the multiple-trapping model is to be applied. Data such as those in Ref. 6 suggest that in PA the powerful ir probe beam may perturb the system to such an extent as to account for the discrepancy between PA and PL data; at any temperature it could force the kinetics to be bimolecular (in the sense of Ref. 2).

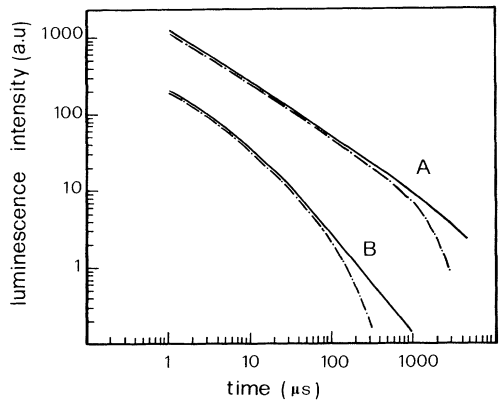

FIG. 1. Experimental PL decay curves with bias (broken curves) and without (solid curves) at 10 K (*A*) and 120 K (*B*). Excitation was provided by 1-μJ, 6-ns pulses at 2.1 eV and 25 Hz. The bias light was cw, at the same energy, and 100 mW cm^{-2}.

In conclusion, Pfost, Vardeny, and Tauc[1] have observed a power-law decay in PA under conditions where PL experiments and theory agree that a power law should not be observed. Further work in this area is clearly desirable; a comparison with light-induced ESR and photoconductivity data would be useful.

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