Analysis of Photoconductive Mechanism of Polyimide Films Containing Diphenylbenzidine Structure via Applied Voltage Dependence of Photocurrent

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Polyimide (PI) is one of the super-engineered plastics exhibiting high thermal, chemical stability, and mechanical strength. Recently, PIs containing triphenylamine (TPA) structure were found to exhibit electric conductivity under photo-irradiation, so called photoconductivity. We have reported that the essential factors for photoconductivity of various PIs containing diphenylbenzidine structure are charge transfer transition ability (CT interaction) between the diamine and dianhydride moieties, molecular chain orientation and denser aggregation structures. Photoconductivity of the PIs is understood as a phenomenon in which a radical ion pair is generated by photoexcitation, separated by applying an external electric field, and become charge carrier of electric current. However, details of the transport mechanism and the relaxation mechanism of the generated carriers are still unknown. In this study, we discussed the conductive mechanism of the PIs on the basis of an increasing and relaxing behavior of time dependent photo-current spectra during and after light irradiation respectively.

A schematic drawing of measurement setup and the chemical structures of targets PIs are shown in Fig. 1. Out-of-plane photocurrent was measured by applying positive voltage on the ITO electrode under visible or UV light irradiation. The time-dependence of the current value during and after light irradiation were fitted by an exponential formula, $j(t)=j_0+Ae^{-t/\tau_1}+Be^{-t/\tau_2}$ to evaluate short relaxation time τ_1, τ_1' and long relaxation time τ_2, τ_2' (Fig. 2). The long relaxation times evaluated over 10 s indicated that the relaxation occurred slowly in the PIs due to many deep traps caused by twisted conformation of the main-chains. It takes long time to fill traps with photo-generated carriers, and reduction of traps can increase photocurrent response; however, this charge accumulation property is very useful for applications of optical memories using field effect transistor.

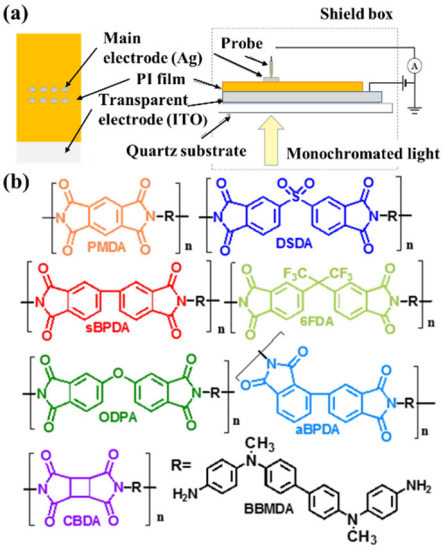

Figure 1 (a) Configuration of photocurrent measurement (b) Chemical structures of target PIs

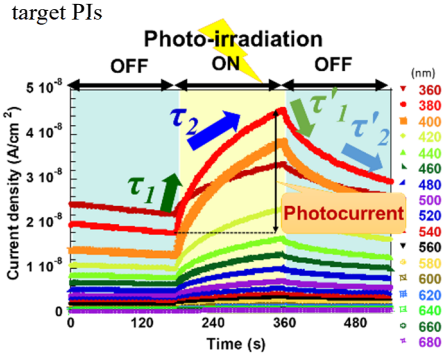

Figure 2 Temporal change of the current value and relaxation time τ