Selective doping effect of silver nanoparticles on the anisotropic light scattering of uniaxially-drawn sequenced copolyimide

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Fluorinated Polyimides (FPIs) are noticeable materials for optical devices because of their high thermal stability and high transparency in UV-Vis-NIR region. In addition, precipitation of metal nanoparticles in FPIs can change their optical properties, such as absorption, refractive indices, and birefringence [1,2]. In this study, silver nanoparticles were precipitated during thermal curing of sequenced copolyimide (coPI) films (Figure 1) with uniaxial drawing. PMDA/TFDB homopolyimide (homoPI) films exhibit large birefringence with increasing draw ratio \((R)\) [3], whereas PMDA/DTDA homoPI films exhibit little birefringence. As a result, uniaxially drawn PMDA-TFDB/DTDA sequenced coPI films show anisotropic light scattering. Figure 2 shows polarized transmittance spectra of uniaxially drawn silver doped and undoped coPI films \((R=1.5)\). In case of an undoped coPI film, the transmittance parallel to the drawing direction \((T_{\parallel})\) is slightly higher than that perpendicular to the drawing direction \((T_{\perp})\) in Vis-NIR region (dichroic ratio; \(D=1.51\) at 856 nm). In contrast, a silver-doped sequenced coPI film shows much enhanced optical anisotropy \((D=3.47\) at 856 nm). Figure 3 shows a cross-sectional transmittance electron micrograph (TEM) along the drawing direction of silver-doped sequenced coPI film. Silver nanoparticles are selectively precipitated in the PMDA/DTDA domain, which was confirmed by energy dispersive spectroscopy (EDS). Since the wavelength dispersion of light scattering for phase separated materials is strongly affected by relative refractive indices, the enhancement of the anisotropy in light scattering should be caused by the changes in the average refractive index of PMDA/DTDA domain.

![Figure 1. Structure of sequenced copolyimide PMDA-TFDB/DTDA (70/30).](image1)

![Figure 2. Polarized transmittance spectra of silver-doped (—) and undoped (---) sequenced copolyimide.](image2)

![Figure 3. TEM image along the drawing direction of silver-doped sequenced copolyimide.](image3)