Selective doping of silver nanoparticles and its effect on anisotropic light scattering of uniaxially drawn sequenced copolyimide

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Fluorinated Polyimides (FPDs) are noticeable materials for optical devices because of their high thermal stability and high transparency in the UV-Vis-NIR region. In addition, precipitation of metal nanoparticles in FPDs can be used to control their optical properties, such as absorption, refractive indices, and birefringence [1,2]. In this study, silver nanoparticles were precipitated in sequenced copolyimide (coPI) films during thermal curing (Figure 1) with uniaxial drawing. PMDA/TFDB polyimide (PI) films exhibit large birefringence with increasing the draw ratio ($R$)[3], whereas PMDA/DTDA PI films exhibit little birefringence. On the other hand, uniaxially drawn PMDA-TFDB/DTDA sequenced copolyimide (coPI) films show significant 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 ($T_\perp$) (dichroic ratio; $D=1.85$ at 856 nm). In contrast, a silver-doped sequenced coPI film shows much enhanced optical anisotropy ($D=4.93$ at 856 nm). Figure 3 shows a cross-sectional TEM micrograph of silver-doped sequenced coPI film. Silver nanoparticles are selectively precipitated in the PMDA/DTDA domain, which can be confirmed by energy dispersive spectroscopy (EDS). Since the wavelength dispersion of light scattering in phase-separated materials is strongly affected by the difference in refractive indices, the enhancement optical anisotropy should be caused by the changes in average refractive index of PMDA/DTDA domain originated from the selective precipitation of silver nanoparticles.