



Electron beam patterning of polymerizable ionic liquid films for application in photonics.

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Planar photonic components can be fabricated with high resolution by electron beam patterning of polymer thin films on solid substrates such as silicon and glass. However, polymer films are normally formed by spin-coating lithographic resists containing not only polymers but also volatile solvents, which is a serious environmental and health issue. Therefore, we investigate a new type of material for planar structure fabrication (i.e., room-temperature ionic liquids (RTILs) with a polymerizable allyl group) that is electron-beam-curable, solvent-free, and thus potentially interesting for processing materials with weak resistance to solvents. We fabricate planar polymer microstructures by electron beam patterning of RTIL thin films in vacuum, which is possible because of the negligible volatility of ionic liquids. Three different polymerizable ionic liquids {i.e., [Allmim][Cl] (1-allyl-3-methylimidazolium chloride), [Allmim][NTf₂] (1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide), and [Allmmim][NTf₂] (1-allyl-2,3-dimethylimidazolium bis(trifluoromethylsulfonyl)imide)} are compared in terms of the quality of the fabricated microstructures. We demonstrate that the shape of the more viscous RTIL with the Cl[−] anion is less distorted during electron-beam-activated polymerization than the shape of the less viscous RTILs with a large NTf₂[−] anion. Furthermore, the surface tension of the NTf₂-based ionic liquid decreases significantly with temperature as compared to that of the Cl-based ionic liquid. Thus, we suggest that the thermocapillary effect, that is, the Marangoni flow caused by a temperature gradient, might be responsible for the differences in the shape of the RTIL-derived microstructures. Also, we analyze the chemistry of the electron-beam-activated polymerization of RTIL by the use of Fourier-transform infrared spectroscopy (FTIR) and conclude that because of the disappearance of C=C bonds the free radical polymerization is a probable reaction mechanism. Finally, we show that polymerized microstructures are potentially attractive as planar photonic components because of good optical properties such as a high refractive index.

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