Fabrication of photonic crystals via pattern photo-polymerization in the mixture of photo-reactive monomer and liquid crystal

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Recently fabrication of photonic crystals has attracted immense attention due to a number of applications in telecommunication. A multi-wave interference device was developed in our lab to fabricate photonic crystals, which allowed two or four laser beams to interference at certain angle on the mixture of photo-reactive monomer and liquid crystal. The sample syrup was composed of hydroxyethyl metacrylate (HEMA)/ E7 and Pentaerythritol tetraacrylate/nematic liquid crystal (E7) respectively. Polarized optical microscopy, atomic force microscopy were utilized to characterize the emerged morphology. 2-D light scattering equipment was used to mimic evolution of diffraction patterns during structure formation.

Phase diagrams of HEMA/E7 and tetracrylate/E7 were established via cloud point measurement. Theoretical phase diagrams of HEMA/E7 and tetraacrylate/E7 were calculated based on the Flory-Huggins model for isotropic mixing and Maier-Saupe theory for nematic ordering. Photo-polymerization reaction kinetics of HEMA/E7 and tetraacrylate/E7 systems were also studied using photo differential scanning calorimetry and real-time Fourier transform infrared spectroscopy. Both reaction kinetic constants were found to be a function of conversion.

On the basis of thermodynamics and reaction kinetics studies, modeling and simulation of photonic crystal formation was carried out to gain an in-depth understanding of the nature of this second-scale process. The photo-polymerization patterning was simulated in the framework of time dependent Ginzburg-Landau equations (Model C) with a conserved concentration order parameter and a non-conserved orientation order parameter, coupled with the pattern photo-polymerization kinetic equations. It turned out that the simulated results were in good agreement with fabricated patterns.

Supported by NSF DMR 02-09272, AFOSR/WPAF, Ohio board of Regents Research Challenge Grant.