Three-dimensional microfabrication with conjugated polymers

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Introduction

In the last few years, two-photon polymerization (2PP) has been used to fabricate complex three-dimensional micro- and submicron structures, with potential applications in photonic crystals, optical devices, and 3D micromechanical actuators. However, the application of this technology has been hindered because the properties of majority of the microstructures reported so far cannot be changed externally. We therefore looked for new resin formulations containing active components, that can still be polymerized by two-photon absorption. To this end, we prepared a variety of blends in a guest/host scheme using an acrylate resin and the conjugated polymer poly[2-methoxy-5-(2'-ethylhexyloxy)-1,4-phenylene vinylene] (MEH-PPV), whose interesting optical and electrical properties have attracted considerable attention.

Two-photon polymerization

The nonlinear nature of the two-photon absorption process confines polymerization to the focal volume of the ultrashort laser, allowing fabrication of microstructures by moving the focal point three-dimensionally through the resin.

We induced two-photon absorption polymerization using a Ti:sapphire laser oscillator that produces 130-fs pulses at 800 nm. To fabricate structures we used an average laser power of 10 mW, measured after the 0.65-NA objective that focuses the laser beam into the resin. The resin sample was positioned in the z-direction using a motorized stage, and the laser beam was scanned in the x-y-direction with a set of galvanic mirrors. After fabrication, the un polymerized resin was washed away with ethanol and dried at room temperature.

Lutrin TPO-L (ethyl-2,4,6-trimethylbenzoylphenylphosphinate) was used as the polymerization photoinitiator.

Microstructure

This figure shows the scanning electron micrographs of a three-dimensional microstructure fabricated using acrylate resin containing conjugated polymer MEH-PPV. The microstructure shows excellent integrity and good definition.

Absorption of MEH-PPV blend

This figure shows the UV-Vis absorption spectrum of polymeric blend containing MEH-PPV (0.4 %). For comparison, we also present the absorption spectrum of a pure MEH-PPV film.

Fluorescence

This figure shows the fluorescence spectra of thin films prepared with pure MEH-PPV and the polymeric blend with the acrylate resin. For excitation we used an Ar ion laser operating at 514 nm.

For all polymeric blends we observed a fluorescence peak around 600 nm, which is characteristic of the MEH-PPV emission. For comparison, we also present the fluorescence spectrum of a pure MEH-PPV film.

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