

Photo-induced micro-patterning of polymer films

M. Wu¹, D. Elfstrom¹, A. Kuhne², E. Gu¹, A.R. Mackintosh²,
R.A. Pethrick², M.D. Dawson¹

1) Institute of Photonics, SUPA, Wolfson Centre, University of Strathclyde, 106 Rottenrow, Glasgow, G4 0NW, Scotland

2) Pure and Applied Chemistry Department, University of Strathclyde, 295 Cathedral street, Glasgow, G1 1XL, Scotland

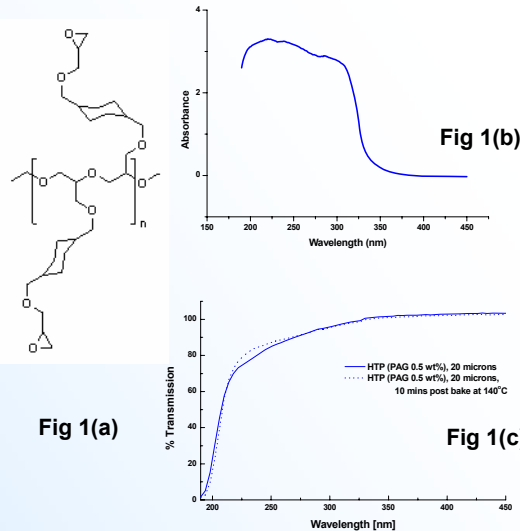


Abstract

A study of microstructure-patterning in photo-curable polymers utilizing some novel processing methods is shown. The key work is on polymeric structures formed by (1) electric fields, (2) aperture masks and (3) laser direct writing. The electrically induced structure formation shows much promise in patterning different kinds of polymers, as has been reported in ref 1 and 2. And the "bottom up" ultraviolet curing through aperture masks is a simple patterning technique used in shaping both ultraviolet (UV) transparent polymers (HTP) and blend polymers (light-emitting polymer and HTP). The laser direct writing which features in high resolution and PC control is also presented.

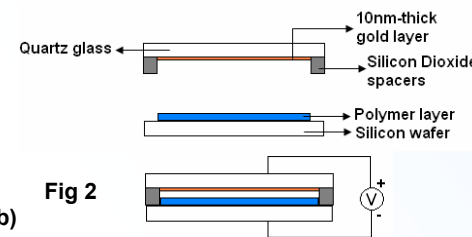
Photo-curable polymers

Photo-curable polymer used in the electrically induced formation. Fig 1(a) is the molecular unit of the polymer, Fig 1(b) is the absorption spectrum, Fig 1(c) is the transmission spectrum.



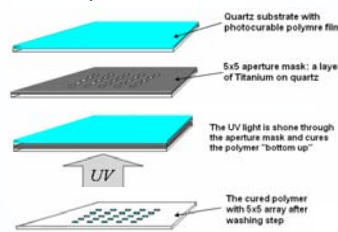
Electrically-induced experiment set-up

Electrically induced formation experiment set-up (Fig 2)



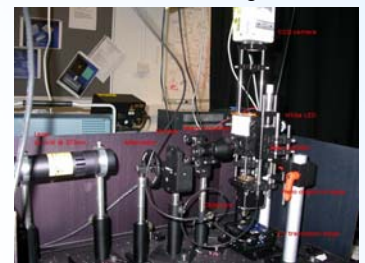
Bottom-up UV Curing and thermal reflow technique

Another patterning method is "bottom-up" UV curing through aperture mask. Fig 3 is the layout of the experiment



The laser direct-writing technique set-up

In direct laser writing, a focused laser beam is used to alter a light sensitive material. The pattern is either formed by beam scanning or sample scanning (ref 3). The setup consists of a diode laser giving a power of 16mW at 375nm (computer controllable), an attenuator, a mechanical shutter with a minimum opening time of 10ms (computer controllable), a beam expander to make sure the objective is not under filled, a beam splitter cube, a piezo objective positioning stage (computer controllable), a microscope objective, a X-Y translation stage (computer controllable). Also fitted to the setup are a white LED for illumination and a CCD camera for monitoring the writing.



Electrically induced formation

Fig 5(a) shows the pillars formed by the electric field strength. Fig 5(b) shows the replication of the pattern on the upper electrodes.

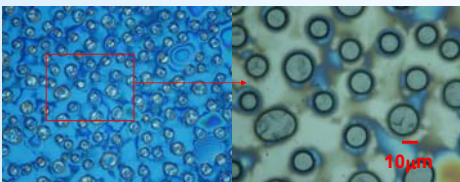


Fig 5(a)

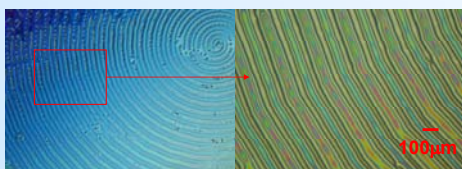


Fig 5(b)

"Bottom up" UV curing through aperture

Fig 6 shows the ultraviolet transparent polymer spots array formed by aperture curing. The UV wavelength is 368nm/5mW/cm², and the cure time is 4mins. Light-emitting polymer blended with the ultraviolet transparent polymer can be shaped through the aperture as well. Fig 7 shows different blend polymer patterned by the aperture curing under the same UV wavelength and the cure time is 2s.

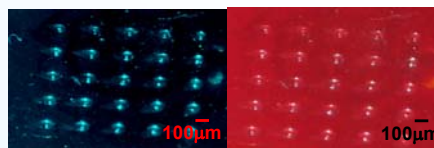


Fig 6

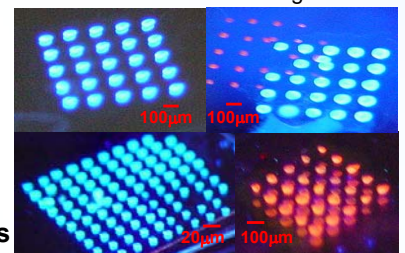


Fig 7

Hybrid µ-LED devices & polymer µ-structures fabricated by direct UV-laser writing

Fig 8 shows a line of NOA81 on top of a stripe µ-LED device. The smallest feature size achieved so far is ~3µm. Patterns written so far include lines (an AFM image of one NOA61 line is shown in Fig 9), dots, circles and Lissajous patterns (Fig 10).

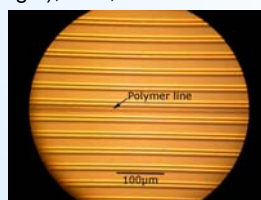


Fig 8

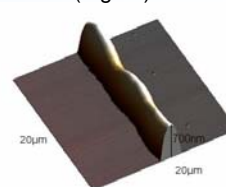


Fig 9

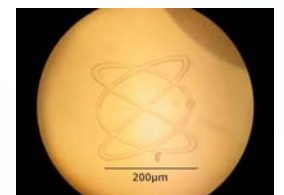


Fig 10

References:

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