

Microphase Separation Depending on Different Parameters for Nanopatterned Devices

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We report a comparative study on microphase separation of a serial of block copolymers (BCPs) depending on some parameters such as solvent, annealing time. Toluene-Chlorobenzene mixtures show the best phase separation in comparison with other pristine or mixture of solvents. The results were optimized for large area studies.

Keywords: Block Copolymers, Microphase separation, Nanopatterned devices

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1. INTRODUCTION

There has been much recent effort toward developing new concepts for preparing regular structures with length scales approaching the molecular level, and the self-assembly of polymeric macromolecules is emerging as a powerful tool for the fabrication of nanoporous media, membranes, lithographic templates, and scaffolds for the assemblies of electronic, magnetic, and optical materials [1-2]. Therefore the fabrication of large-area periodic nanoscale structures with self-organizing systems is very interesting because of its simplicity, high degree of controllability, and low cost. Since self-assembled structure is less than 100 nm long, these materials are interesting for magnetic, electronic, and optoelectronic applications. Block copolymers, which, in thin films, microphase-separate into densely packed, periodic, cylindrical or spherical structures, can be used for patterning or templating various materials. Many high-density nanostructures, such as posts or holes in semiconductor and magnetic materials, have been achieved through etching, electroplating, or chemical reactions with block copolymer lithographic templates [3].

In this study, since the reports on a comparative study of different parameters on microphase separation is rarely available, we investigated the influence of solvent and temperature on microphase separation of a serial of BCPs.

2. EXPERIMENTAL

2.1 Chemicals

A number of block copolymer and random copolymer samples with different molecular weights (M_w) and narrow molecular weight distribution

(M_w/M_n) were used in this experiment. Block copolymers were purchased from Polymer Source Inc. And random copolymers were synthesized with atom transfer radical polymerisation method.

2.2 Sample Preparation

Silicon wafer substrates were cleaned by immersion in a piranha solution (7:3 (v/v) of %98 H₂SO₄:%30 H₂O₂ at 90 °C for 60 minutes and then were immediately rinsed with deionised water two times. The silicon pieces were blown dry with nitrogen. Then the solution of BCPs in different solvents or solvent mixtures were spin casted at 1200 rpm on cleaned silicon surfaces.

3. RESULTS AND DISCUSSIONS

As mentioned in section 1, we prepared some BCP films on Silicon surfaces to determine the best route for facile microphase separation. Fig. 1 shows AFM phase image of BCP films. All films were annealed at 170 °C for solvent study of solvent comparison. It is clear from figure, the most obvious and regular microphase separations were obtained with ratio of 1/3 by volume of the toluene / chlorobenzene solvent mixture. Pristine toluene also show extremely good phase separation but worse than chlorobenzene mixtures. But we have to notice that the distance between the blocks was smaller in comparison with toluene / chlorobenzene mixture (Figure 2). No phase separation is observed with THF. It is most probably the fast evaporation of THF during thermal annealing.

Figure 2 also shows high magnification of BCP films casted from toluene and toluene-chlorobenzene mixtures.

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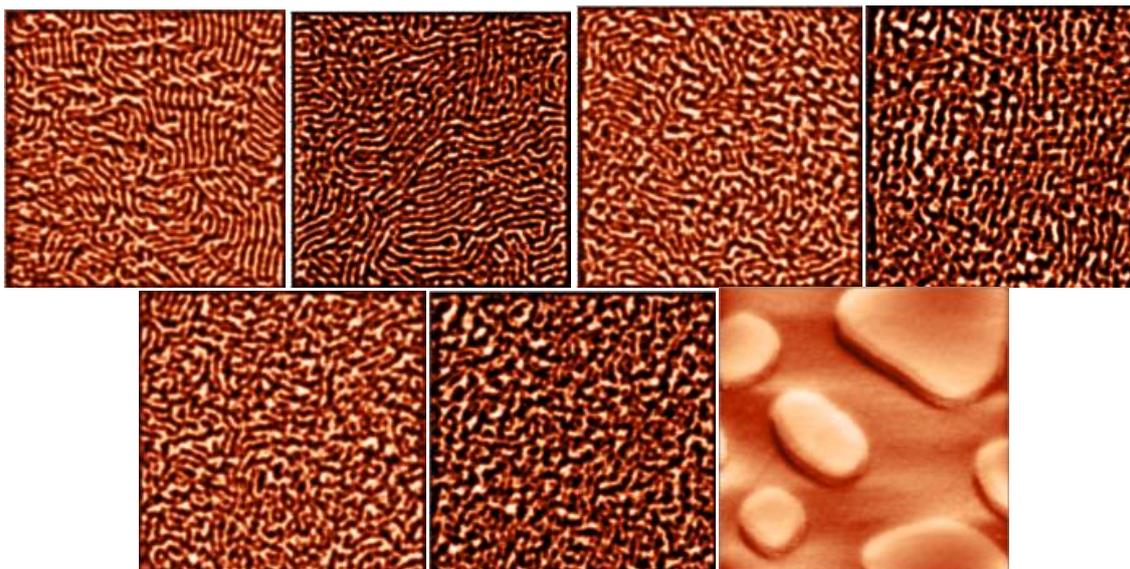


Fig. 1 – a-g. AFM images of phase separation of different solvent mixtures.

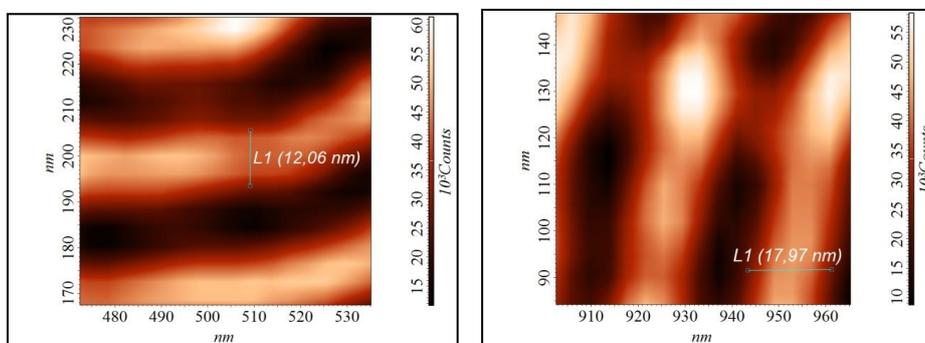


Fig. 2 – a-b. AFM images of BCP films casted from toluene and toluene-chlorobenzene mixtures

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