Electric-field-induced alignment of block copolymer/nanoparticle blends

Thin films of a phase separated, symmetric polystyrene-block-poly(2-vinyl-pyridine) copolymer exhibit upstanding lamellar morphology. The lamellar domains can be perfectly aligned parallel to an applied external electric field (figure 1a). Due to the movement of polymer domains within the electric field, hydrophobically capped gold nanoparticles, selectively incorporated into the polystyrene phase, are arranged in parallel lines. The particles influence the polymer alignment and promote the formation of defects (figure 1b).

We prove the selective particle incorporation into the polystyrene phase via transmission electron microscopy (TEM) imaging (figure 2a). The polystyrene phase appears dark due to selective staining with ruthenium tetroxide. Similar to the atomic force microscopy (AFM) results, TEM images confirm the assumption of a less oriented structure for electric field aligned polymer films with nanoparticles (figure 2b).

Upon incorporation of gold nanoparticles the threshold electric field strength, above which alignment proceeds, is substantially reduced as function of gold nanoparticle concentration (figure 3).

The electric-field-induced alignment of block copolymer/nanoparticle blends provides a technical approach for the fabrication of conductive 2D templates on nanometer length scales.

![Figure 1. AFM phase images of PS-b-P2VP block copolymer films without (a) and with (b) gold nanoparticles. a, b) After solvent vapour annealing for 90 min in a saturated solvent atmosphere with simultaneous application of an in-plane electric field, phase contrast 20°. The scale bar applies to all images. Reproduced by permission of John Wiley and Sons.](image)

![Figure 2. TEM images of PS-b-P2VP composite films. a) PS-b-P2VP/gold nanoparticle composite film after solvent vapor annealing; b) PS-b-P2VP/gold nanoparticle composite film after solvent vapor annealing in the presence of an electric field the electrode edge is visible in the lower part of the image). Reproduced by permission of John Wiley and Sons.](image)

![Figure 3. Threshold electric field strength for alignment of PS-b-P2VP/gold nanoparticle composite films as function of the nanoparticle fraction in the composite. Reproduced by permission of John Wiley and Sons.](image)