"Trillions of quantum dots, Fingerprints, Nanolithography with diblock copolymers and Annealing of striped phases"

Paul Chaikin
Princeton University
Department of Physics
Jadwin Hall, P.O. Box 708
NJ 08544 Princeton
U.S.A.

We have been using diblock copolymers as a new way to make ultradense patterns which cover wide areas on a variety of inorganic substrates. The feature sizes are determined by the length of the polymers and can range from ~5 to 50 nm. The diblock copolymers form lamellar, cylindrical (hexagonal cross-section), and spherical (BCC) phases in bulk. We use monolayer films to make templates to transfer these patterns to metals, semiconductors etc. For example we cover a three inch wafer with ~ 3 trillion posts, holes, etc. spaced by ~ 25nm, to make quantum dots (for semiconductor lasers), metal particles and other structures. In trying to understand how the polymer patterns order we have used atomic force microscopy (AFM) to image the cylindrical phase which lies flat on a substrate. The patterns look like fingerprints and Benard rolls and the coarsening (annealing) law we observe is t^(1/4) as in previous studies of these striped phases. This law remained unexplained for decades. However, we made time lapse AFM movies which show that the annealing dynamics is governed by the attraction of disclination PAIRS, quadrupoles, rather than simple +/- annihilation. This directly provides an explanation for the alignment of the striped patterns as a function of time. Thus these systems, while aimed at technological and fundamental electronic applications are also ideal materials for studying the dynamics of ordering. Recently we have also studied the thermodynamics and kinetics of the monolayer hexatic phase and used shear strain to macroscopically align the cylindrical and hexagonal patterns.