

418a Suspended Polymer Nanofiber Arrays of Long Range Order Fabricated by Manual Brush-on

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We recently demonstrated that a single bead of liquid polymer (suspended in a volatile solvent) applied to the edge of a microscope cover slip when dragged (by hand) over a textured surface will self-assemble into parallel oriented fibers of micron and even nanoscale dimensions in S. A. Harfenist *et al.*, Nano Lett **4**, 1931 (2004). Fibers as small as 30 nm that are suspended in air between pillars have been produced this way. The potential applications appear to be in more rapidly constructing experimental micro and nano- mechanical, optical and fluidic devices. The self-assembly of the fibers appears to be driven by capillary forces and surface wetting that breaks up the brushed on polymer film into parallel oriented fibers. If the rates of solvent evaporation and capillary thinning are appropriately balanced then the fibers can solidify to a stable diameter without breaking. A theory that supports our phenomenological observations was recently reported by A. Tripathi *et al.*, Rheol. Acta **39**, 321 (2000). Our previous results are extended by the report of long range order and uniformity of a brushed on fiber polymer network (see SEM images). Here the textured surface is an array of pillars that were produced by saw cuts into a glass substrate. The liquid polymer is 50,000 MW (poly) vinyl acetate (PVAC) in acetone. The applicator (i.e. the edge of the microscope cover slip) which has been coated with the liquid polymer is dragged once over the array surface in about 1 second (~12 mm/S.) The fibers form in the direction of the applicator motion. Strong wetting to the pillars is seen with a small amount of solidified polymer remaining between the pillars. The uniformity of the fiber array is reflected in that most pillars are connected by a single fiber on the order of ~ 2 microns diameter. We believe that surface tension driven capillary thinning drove large amounts of polymer from the bridge area to the pillars. Thus the crude manual application followed by the capillary and wetting forces caused much smaller fibers (on the order of 50X smaller than the drops on the pillars) to assemble into fibers of similar size and shapes. In order to further quantify the forces involved in fiber formation we recently began a nano-rheology effort that includes AFM force-distance measurements of liquid polymers (in non-volatile solvents), complementary macroscale measurements of extensional viscosity and capillary thinning rates, and observations of capillary thinning inside a variable pressure SEM (with low melting temperature polymers.) The AFM measurements of mineral oils and polymers in non-volatile solvents show that reproducible measurements are possible of capillary breakup. This is shown in the force-distance curves for mineral oil. This measurement was performed 10 times and the capillary breakup event showed a step that measured between 1,110 and 1,140 nN. Similar results in the 5 to 100 nN levels have been observed with comparable reproducibility for several polymers in non-volatile solvents. Further control will be possible by using a cylindrical rather than conically shaped AFM tip, which we are developing. If we can understand the signature it may be possible to use this information in reliable manual drawing of individual fibers in a force-feedback to the hand (referred to as a “haptic”) AFM.

