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PATTERNING AND MECHANICAL ANALYSIS OF FIBER-BASED MATERIALS

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Abstract
The ability to define and control the topography of a surface has been studied extensively due to its importance in a wide variety of applications. The control of a non-planar topography would be very valuable since a number of structures that are pervasive in artificial applications (e.g. fibers, lenses) are curved interfaces. This potential of enabling applications that incorporate non-planar geometries was the motivation for this thesis. The first study of this thesis comprises the study of patterning the circumference of micrometer sized fibers. Specifically, a unique technique was described to pattern the fiber with a periodic array

of colloids. The effect of immobilizing fibers on different substrates and the parameters that govern a successful transfer of the colloidal array onto 7 mm diameter fibers were studied. Finally, replication of inverse submicrometer patterns onto the diameter of the fiber is completed with mild removal of the colloidal template.

The second component of the thesis is the patterning of fabric assemblies of fibers. Composites of soft elastomer resins and rigid fiber materials are explored for their complimentary properties. Specifically, the organization of the fiber structure was contrasted with other homogenous materials. These composites were shown to possesses rigid in-plane strength, yet remain flexible to bending deformation. Furthermore, the carbon fiber fabric composites demonstrate superior tensile strength and greater flexibility than common homogenous materials such as PET and crosslinked elastomers. Finally, the use of a liquid resin permits submicrometer patterns to form on the periphery of the fabric assembly.

The final component of the thesis is the use of the patterned fabric assemblies for adhesive applications. Carbon fiber-elastomer composites were patterned with submicrometer shear adhesion. The effects of the pattern size and orientation on the shear adhesion were studied. By varying the velocity of the sample testing, adhesion was observed to change for different patterned samples. We highlight the aspects of the fabric composite and the patterning that permits the features to alter the adhesion. Finally, we suggest how these results could be designed to improve the shear adhesion of reversible adhesives.