Chapter 8
Soft Materials and Bioprinting

Soft Materials

A rapidly advancing area of MEMS is the fabrication of soft materials. These polymer-, paper-, and hydrogel-based devices have unique advantages as compared to traditional hard materials like silicon. They can be very low cost and fabricated without the need for expensive capital equipment by using molding techniques and bioprinting.

One common polymer material is polydimethylsiloxane (PDMS), also known as dimethicone, that belongs to a group of polymeric organosilicon compounds commonly referred to as silicones. PDMS is known for its excellent flow properties and is a hydrophobic viscoelastic material. It is also optically clear, inert, nontoxic, and nonflammable; thus, its applications range from contact lenses and medical devices to elastomers, and it is used in shampoos, food (as an antifoaming agent), caulking, lubricants, flexible electronics, and heat-resistant tiles.

PDMS is commonly used as a resin for soft lithography to make microfluidic devices. The process of soft lithography consists of creating an elastic stamp (using normal techniques of photolithography or electron-beam lithography) to transfer patterns of only a few nanometers in size onto glass, silicon, or polymer surfaces. The resolution, which depends on the mask, can be as small as six nanometers. It is possible to produce devices using this technique for optical telecommunications and biomedical research.

In biomedical MEMS applications, soft lithography is used extensively for microfluidic devices. Silicon wafers are etched to make channels, and PDMS is then poured over these wafers and left to harden. When removed, even the smallest of details are imprinted in the PDMS. Glass slides are used to cover the PDMS channels to create permanently sealed, waterproof channels. Researchers are using this technique to create lab-on-a-chip devices. PDMS is also being used to make synthetic gecko setae dry adhesive materials (Fig. 8.1).

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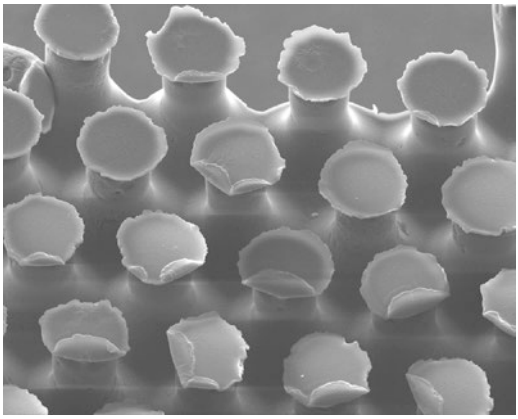

Fig. 8.1 Artificial gecko setae on SEM at 500X magnification

Bioprinting

Bioprinting is a form of 3D printing (also known as additive manufacturing) that utilizes hydrogels and other materials known as bioinks to create three-dimensional microscopic structures. Hydrogels are popular because they can be constructed with geometries that will hold cells or allow biological tissue to grow within them.

The advantage of using bioinks is their low cost. A desktop bioprinter can create a hydrogel scaffold for significantly less money than other MEMS processes, and the configuration of the geometry can be much more complex. Printing of bioinks is often combined with PDMS substrates to provide flexible, organic, and inorganic materials for use as sensors, tissue scaffolds, and chemical reactants.