Sharp-Tipped Hollow Metal Microneedles Fabricated by Sacrificial Micromolding

Authors: James J. Norman[1], Seong-O Choi[1], Avishek R. Aiyar[1], Samantha N. Andrews[2], Mark R. Prausnitz[1,2], and Mark G. Allen[1,3]
1 – School of Chemical and Biomolecular Engineering, Georgia Institute of Technology, Atlanta, GA
2 – Wallace H. Coulter Department of Biomedical Engineering, Georgia Institute of Technology, Atlanta, GA
3 – School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA

Abstract:
Hollow microneedles have been used for many drug delivery applications over the past decade including intradermal injection of insulin and influenza vaccines, and intrascleral injection of model compounds. Whereas hollow microneedles have been made by expensive silicon micromachining techniques, newer, inexpensive techniques such as plastic micromolding and length-limiting of stainless steel needles have made hollow microneedles a practical option in the marketplace. We sought to fabricate a hollow microneedle that combined advantages of these newer methods: the mechanical strength of metal and the compact, low profile of a micromolded device. In this abstract, we describe a sacrificial micromolding process capable of fabricating sharp-tipped hollow metal microneedles. The resulting needles were characterized *in vitro*.

The fabrication process starts with the creation of a brass microneedle master structure on a micro-lathe. A poly(dimethylsiloxane) (PDMS) mold of the master is made and used to create a poly(lactic acid) (PLA) replica of the master. A shallow 50x50 micron square cavity is ablated into one side of the microneedle using an excimer laser operating at 248 nm. A PDMS mold of the ablated master is made, and several poly(lactic acid)-poly(glycolic acid) (PLGA) replicas are made from that mold. The PLGA replicas are sputtered with a gold seed layer, and that layer is electroplated with nickel to a thickness of 20 microns. The PLGA is then dissolved in acetone to release the metal structure. The sputtering process does not coat the bottom of the square cavity with gold because of the cavity's high aspect ratio. Because no seed layer is present at the bottom of the cavity, no nickel is plated, and therefore, a hole is formed when the PLGA is dissolved. This technique can be used to fabricate single needles or arrays of multiple needles.

We used this method to fabricate 1.1 mm tall, single, conical microneedles. These devices were glued to plastic syringe adaptors to examine their fluid flow properties. We were able to deliver sulforhodamine dye to pig skin *in vitro* at rates of microliters per minute. *In vivo* sulforhodamine delivery experiments are underway.