

Making a Microfluidic Device to Mimic Flow Through Porous Medium

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Primary CNF Tools Used: CAD software L-Edit, hot press, CorSolutions Microfluidic Probe Station

Abstract:

With the rapid depletion of known oil reserves, detecting properties of the oil reservoirs and optimizing oil extraction is critical. By measuring the aqueous properties of the reservoirs, decisions can be made on which reservoirs to drill and the available quantity of oil to extract, with minimal environmental impact. Utilizing particles in testing can provide a variety of information about the reservoir. The objective of the proposed work is to characterize the behavior of particles at the oil-water interface in order to optimize their use as subsurface sensors. In order to complete the optimization, a microfluidic model for the environment needs to be developed. This past year's work involves making microfluidic devices to mimic water flowing through the subsurface and oil trapped in pores. The design and mold to make the mold was developed in the CNF first using photolithography to create a mold with negative photoresist which was used to make microfluidic channels out of polydimethylsiloxane and later using positive photoresist and etching to create a mold to make microfluidic channels out of polypropylene.

Summary of Research:

The work in the CNF has consisted of using micro-fabrication techniques to make a microfluidic device. Using the CAD software L-Edit to make patterns to transfer to a mask using the Heidelberg mask writer, in the past year, we have made two types of masks: one for positive photoresist and the other for negative photoresist. The first set of microfluidic devices used the negative photoresist (SU-8) to make a mold. The process of making a mold with photoresist (photolithography) consist of the steps; 1) Pour and spin photoresist onto a wafer (using CNF spinner), 2) Bake photoresist (using CNF hot plates), 3) Wait time, 4) Expose photoresist (using ABM contact aligner), 5) Second wait time, 6) Development of photoresist.

At the end of the process, we have a mold out of SU-8 on top of a wafer. In the Kirby research group's lab, we made microfluidic devices by pouring PDMS on top of the mold and baking, then attaching, the molded PDMS to a glass slide through plasma cleaning. Unfortunately for our application, we need the PDMS to be very

hydrophobic and PDMS was not hydrophobic enough for the experiments. Therefore, we switched to making devices out of a polypropylene — a much more hydrophobic material. To make molded polypropylene pieces we used hot embossing, which is done on the CNF hot press.

Because of the large pressure applied during embossing, we needed a stronger mold than SU-8, so we switched to making molds out of silicon. To make a mold out of silicon, a positive photoresist is spun instead of negative and after the photolithography process, the wafer is etched on the deep reactive ion etcher in the CNF. The mold is used in the CNF hot press to hot emboss the pattern onto polypropylene. Another piece of polypropylene is pressed to a thinner thickness using the using the hot press. Finally, the device is bonded together using the hot press. We also used the CorSolutions Microfluidic Probe Station as a connection method for tubes to the device, which allowed us to flow oil and particles into the device.

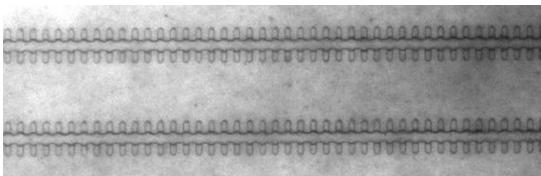


Figure 1: Oil-water contact line in polypropylene device.

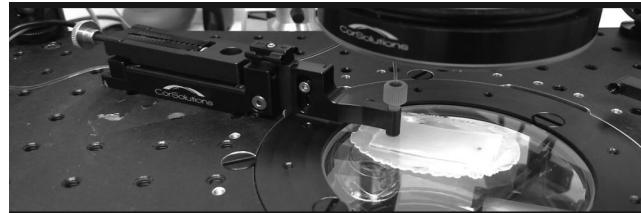


Figure 2: Device on CorSolution station.

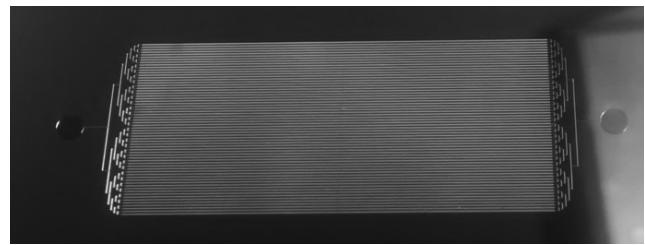


Figure 3: Etched silicon mold for hot pressing.