HAR Microfluidic Polymer Chip for Algae Dewatering

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Abstract

Algae are a promising candidate for large-scale production of biofuels, an important source of renewable energy [1]. A significant portion (20-40%) of the cost in the traditional processing comes from concentrating (dewatering) the algae from the dilute concentrations at which they are cultured to levels necessary for economic oil extraction. A continuous flow microfluidic dewatering chip has been suggested using an innovative, patented lateral displacement array (LDA) design. The array consists of a channel filled with specifically arranged and densely packed vertical posts (Fig.1) whose arrangement is such that particles above a certain critical diameter flowing through the channel are displaced to one side of the channel and if the pattern is mirrored on the other side (Fig. 1a) then they will be displaced to the enter from both sides and are thus concentrated in the center [2-5]. The spacing between posts is larger than the critical separation size, so these arrays can be run continuously without getting clogged.

In a joint effort funded thru an SBIR Phase I grant from DoE partners from Phycal, Princeton and LSU-CAMD were evaluating LIGA based fabrication techniques to build these arrays with moderate cost, high precision and tight tolerances in polymer materials. The paper will briefly discuss the requirements for an LDA device for dewatering algae with about 10µm particle size and introduce the mirror symmetry design in which the concentrated algae are collected in the center of the chip.

The main focus is on the fabrication efforts currently underway and comparing two LIGA based approaches – molding of chips and direct lithography using x-ray lithography. X-ray mask was fabricated by spin coating of SU-8 50 negative resist onto a graphite substrate (Ohio Carbon Inc.), patterning with UV lithography, and subsequent electroplating of Ni (~3µm) and Au (~30 µm). Fig. 2 shows the x-ray mask with both optimized LDA arrangements with minimum connection ports and test LDAs for systematic design/performance studies of the patterned arrays. For mold insert fabrication the x-ray mask was copied into ~ 120 µm thick PMMA bonded on Si substrate (substrate provided by KIT, Karlsruhe, Fig. 3) at the CAMD XRLM1 beamline and shipped to applied microSWISS and transferred into a robust Ni mold insert (Fig. 4) with thickness greater than 5 mm. The silicon on the front side is removed by standard 30% KOH bath at temperate of 60 to 80°C. Then it is machined to make its size conformable to the embossing machine fixtures and is followed by polishing to make it flat at the front end (within +/- 5µm). This mold insert was replicated into PC (Fig. 5) and initial tests show that the current height of ~100µm is too high for successful replication of this design and needs to be reduced further by polishing.

In order to achieving taller heights with the opportunity to increase the volume flow rate in one DA ship an alternative approach – direct lithography of LDA pattern in thick negative resist – is underway. In the presentation we will discuss details of our fabrication efforts and present latest results for both molded and lithographically patterned LDAs. In addition methods to cover the chips and initial results from fluidic experiments will be discussed, and other possible applications for LDA devices are discussed [6,7].

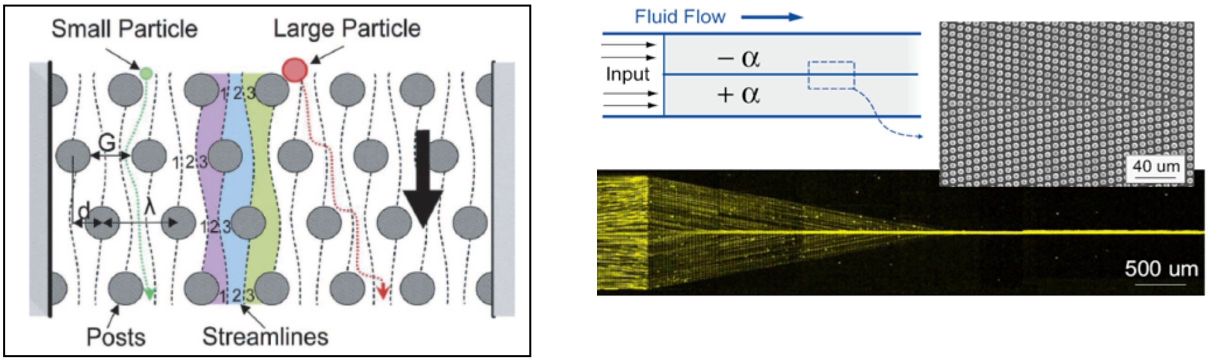

Fig 1: Schematic illustrating the 'bumping' of particles towards the center of an LDA device and actually picture illustrating the operation (courtesy: SBIR proposal, Phycal).

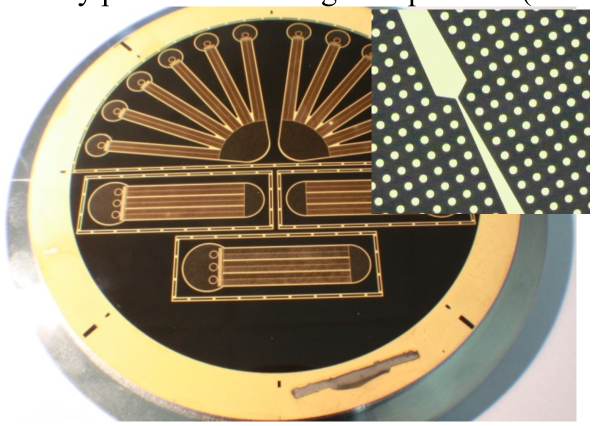
Fig. 2: Graphite x-ray mask with different LDA designs

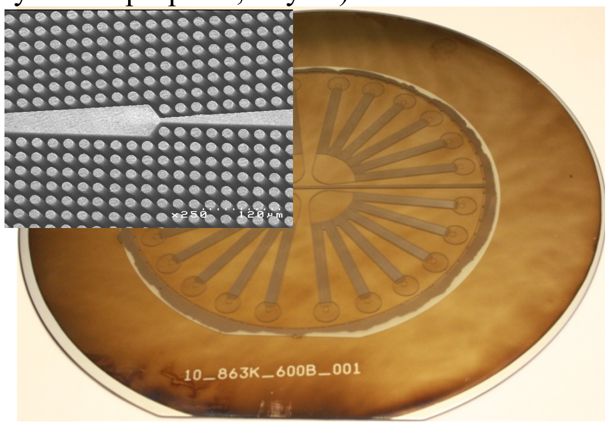

Fig. 3: 6" Si wafer with TiO_2 layer and glued PMMA resist after lithographic patterning.

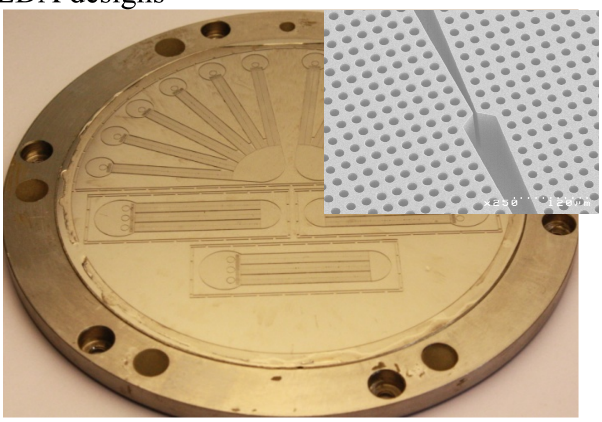
Fig. 4: Ni mold insert with ~100µm deep holes and ~15µm holes ready for molding.

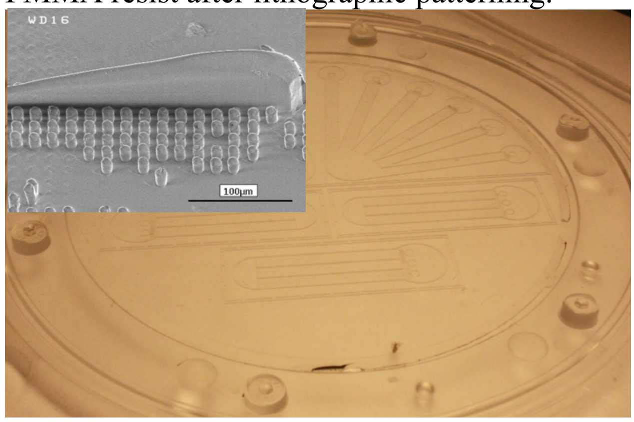
Fig. 5: Molded PC substrate showing that the tall posts are not replicated properly.

References

[1] More information on the Phycal homepage, http://www.phycal.com/site/.
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