Fabrication of large area polymer microfilters via vacuum assisted UV micro-molding

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FABRICATION OF LARGE AREA POLYMER MICROFILTERS VIA VACUUM ASSISTED UV MICRO-MOLDING

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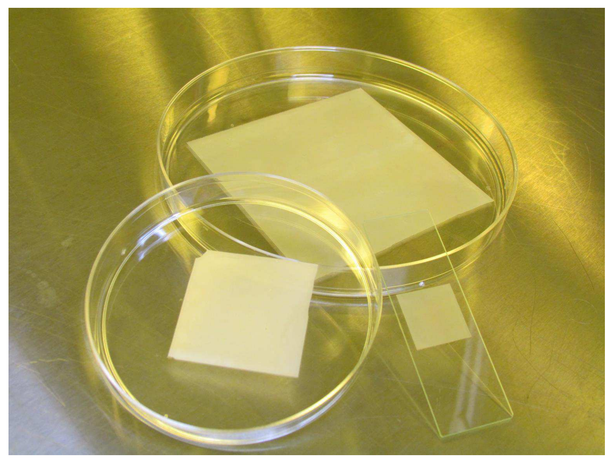
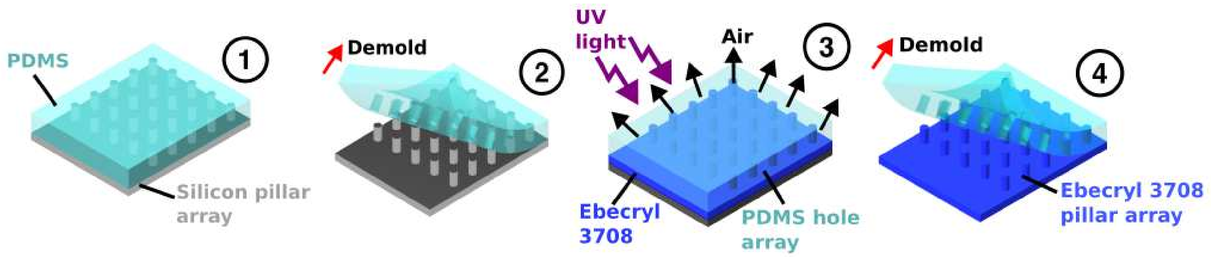
I Introduction

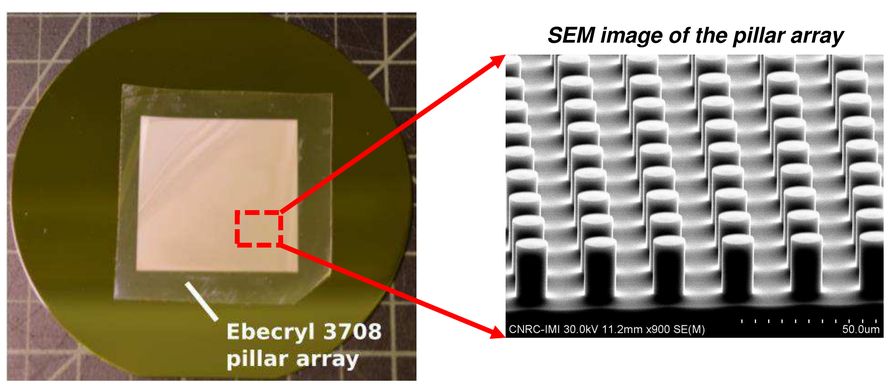
- Microfilters (MFs) with pore openings from ~1 – 100 µm can be used for microbead isolation, CTC capture, cell population enrichment, sample preparation and purification, among others.
- Many different MFs exist, but they suffer from drawbacks, notably:
  - Silicon[1] and parylene C[2] MFs can be made precisely, but fabrication is cumbersome. Also, Si is opaque and brittle, while parylene C is auto-fluorescent.
  - Polymer track-etched membranes[3] are available commercially, but porosity is limited to values < 30%, which limits filtration flow rate.
- Here, we introduce **(i)** a robust, low cost, and scalable fabrication process based on vacuum assisted micro-molding[4] and UV-curable polymers for making **(ii)** large area, high porosity, transparent MFs with pore sizes ranging from 3 – 50 µm.



1 Microfilter mold fabrication

- A silicon master mold is fabricated through standard photo-lithography techniques.
- The mold is replicated twice, first in PDMS, and then in a UV-curable epoxy (Ebecryl® 3708).

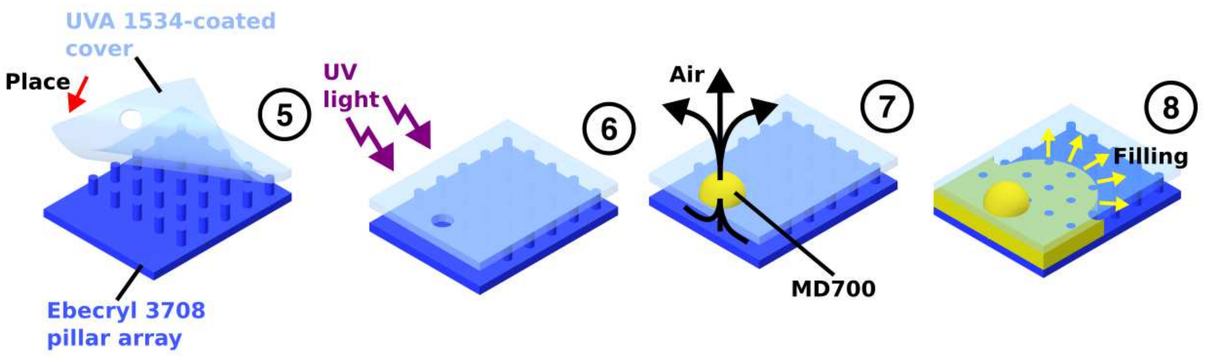




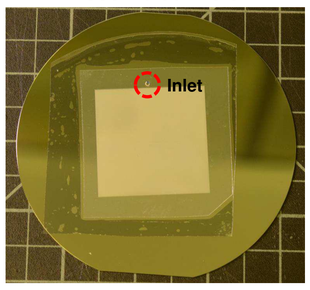
SEM image of the pillar array

2 Fluoropolymer filling

- The Ebecryl® 3708 mold is covered using a PET film coated with a different UV-curable resin (UVA 1534). A single opening will be used to fill in the pre-polymer.
- A droplet of a fluorinated methacrylate pre-polymer (Fluorolink MD 700), with a dynamic viscosity of 430 cP, is placed on the inlet.
- The pre-polymer fills the mold via vacuum assisted micro-molding.

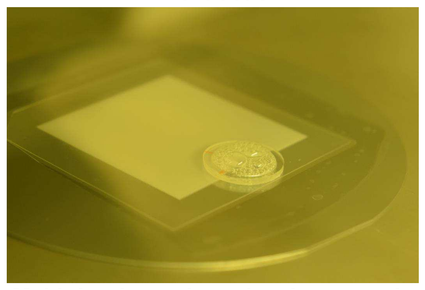


Assembled mold



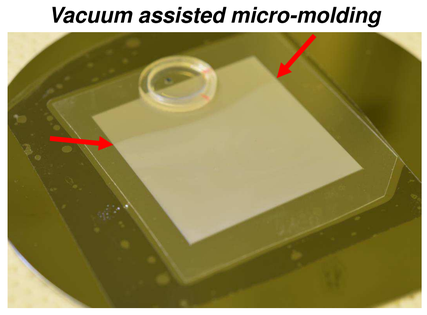
Picture of the final mold after UV exposure.

Air extraction



Mold in degassing chamber, as air escapes, bubbles form and burst. The elastomer ring prevents the MD 700 droplet from sliding away from the inlet.

Vacuum assisted micro-molding

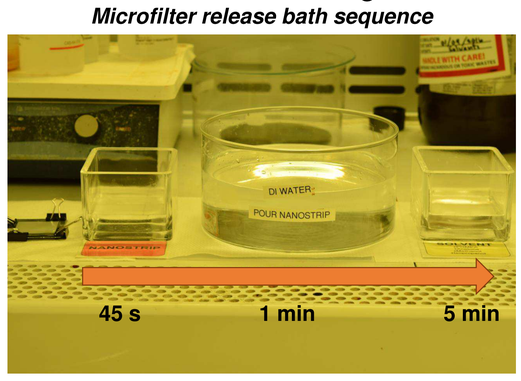


Upon pressurization, MD 700 fills the mold. Arrows indicate the resin filling front.

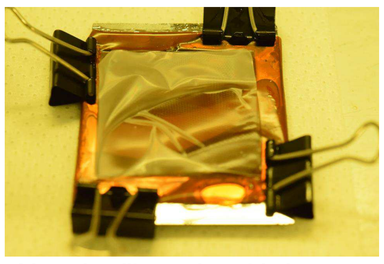
3 Microfilter release

- Once the pre-polymer has filled the entire mold, it is exposed to 3 min of UV radiation. The cover layer is then peeled off.
- The mold is subjected to a 45 s acid bath (Nano-Strip 2X®), followed by a 1 min DI water wash, and a 5 min acetone bath, which leads to spontaneous release of the free-standing microfilter membrane.

Microfilter release bath sequence



Microfilter detached from mold

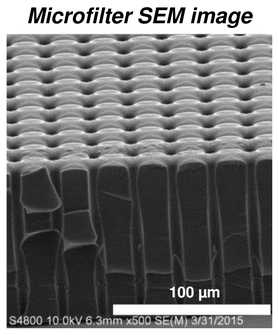


After the filters demold they can be easily picked with tweezers. They are cleaned with methanol and dried under a nitrogen stream.

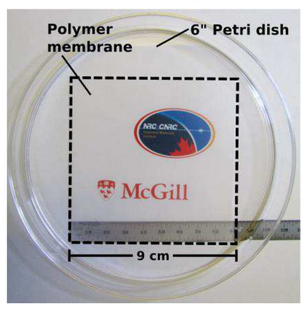
4 Microfilters

- Microfilters with thickness from 8 to 100 µm, size from 4×4 to 9×9 cm^2, pore size from 3 to 50 µm, different pore shapes, and porosity as high as ~60% have been successfully fabricated using the proposed method.

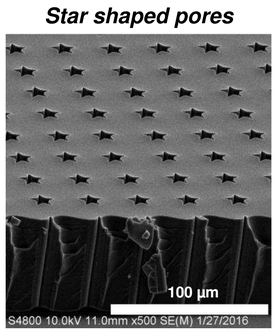
Microfilter SEM image



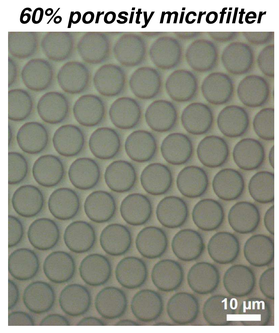
9×9 cm^2 microfilter



Star shaped pores

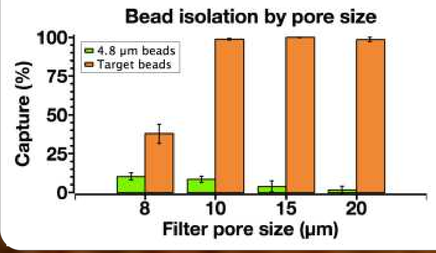


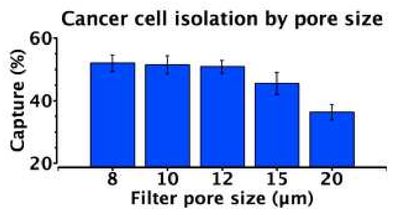
60% porosity microfilter

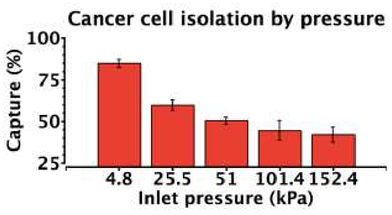


5 Microfiltration experiments

- The MFs were used to filter microbeads (8 – 20 µm) and MDA-MB-231 cancer cells suspended in PBS. Filtration performance was analyzed by characterizing pre- and post-filtration samples using flow cytometry.
- The MFs are essentially defect-free, rigid (E=10 MPa), and tough, enabling filtration at high flow rates and without failure.
- Separation of CTC-like cells from blood is reported elsewhere.[5]







C Conclusions

- We present a powerful method for **fabrication of robust and transparent polymer MFs** with pores down to 3 µm, porosity up to 60%, and filter size up to 9×9 cm^2 large.
- The MFs were used for bead and cancer cell isolation.
- **The MFs are cheap, tough, have a precise pore size, are easy to manipulate and cut to size, chemically resistant and compatible with chemical functionalization,** which collectively should make them useful for a wide range of chemical and biological applications.

Acknowledgements

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