_90R.png _90R.bb _90R.png height

Contribution ID: **871** Type: **Poster + 3 Minute Pitch**

High-Resolution, Rock-Based, 2.5D Polymer Micromodels

Thursday, 17 May 2018 12:02 (2 minutes)

Micromodels have been widely used to study the transport mechanism of fluids at pore-scale for subsurface engineering applications such as enhanced oil recovery. Micromodels with small feature sizes can be manufactured by lithography-based microfabrication on Si or glass, but they are in general restricted to 2D representation of pore network geometry. Recently our group demonstrated more realistic 3D representation of an actual reservoir rock-derived sample in a 2.5D polymer micromodel using micromilling of a brass mold and hot embossing of polymethylmethacrylate (PMMA). However the resolution of this micromodel was limited to 25 µm due to minimum usable milling tool size.

In this work, we present fabrication of high-resolution, rock-based, 2.5D polymer micromodels, and flow visualization in such micromodels for the investigation of fluid transport mechanisms at pore-scale. In order to improve the minimum resolution of 25 µm in the 13-layered micromodels made from the micro-computed tomography images of a Boise rock, the same pore geometries were scaled down to the resolution of 5 µm and 10 µm to demonstrate the manufacturing feasibility of high-resolution, rock-based, 2.5D micromodels. The original low-resolution micromodel was included. Additional features such as fluidic ports, the inlet and outlet regions, and fluidic distribution channels were added. The flow connectivity of pores from the inlet to the outlet was provided by the 12th and 13th layers.

Multilayer lithography of SU-8 with a target thickness of 5 µm for each layer was carried out on seed layer coated Si substrates with process optimization to obtain 13-layered SU-8 molds. After processing of the 1st SU-8 layer, flycutting-based process was tested for the next 12 layers. Flycutting method after spin-coating of thick SU-8 allowed the tight control of the overall thickness variation within ± 1.5 µm without pattern distortion even for 5 µm resolution. Electroforming of nickel was performed in SU-8 molds prepared by flycutting-based lithography process. Electroforming in the SU-8 molds revealed the high-quality pattern formation in the 13 nickel layers, thus confirming the excellent feature fidelity control down to 5 µm resolution. The nickel mold was used for hot embossing of PMMA to make high-resolution, rock-based, 2.5D polymer micromodels. The micromolded 2.5D micromodels showed significant resolution improvement by up to 5-fold from the previous 2.5D micromodels and rendered the real pore network geometry of the 3D reservoir rock.

The hot embossed 2.5D micromodels in PMMA were sealed by thermal fusion bonding and used for flow visualization. The dye-filled polymer micromodels (10 µm and 5 µm resolution) showed the flow connectivity and pore depth variations. Fluidic experiments were carried out by injecting fluorescent nanoparticles and particle transport was observed. Several preferential flow paths were similarly observed for both the 10 µm and 5 µm resolution micromodels. There were some differences in local particle accumulations over time between the two micromodels. Further characterizations to investigate the correlations of fluid flow to the pore depth variations and the pore space resolution will aid in understanding of the complicated fluid transport in the real 3D reservoir rocks.

References

Acceptance of Terms and Conditions

Click here to agree

Primary authors: Dr PARK, Daniel (Louisiana State University); Mr UPADHYAY, J. (Louisiana State University); THOMPSON, Karsten; NIKITOPOULOS, Dimitris (Louisiana State University, Mechanical and Industrial Engineering Department)

Presenter: NIKITOPOULOS, Dimitris (Louisiana State University, Mechanical and Industrial Engineering Department)

Session Classification: Parallel 10-D

Track Classification: MS 3.05: Advanced methods for micromodel fabrication and diagnostics within