Laser manufacturing of glass “lab-on-a-chip” devices to study multiphase flow in porous media

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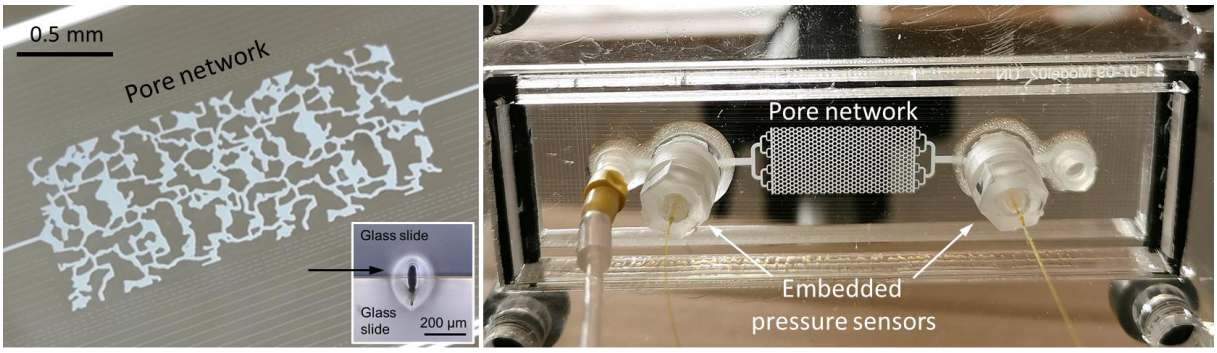
Glass “lab-on-a-chip” devices are widely used in many biomedical disciplines, but also in petroleum engineering and carbon storage research where they are used as physical models of porous media to study multiphase flow, transport and reactive processes at microscale (i.e. at the level of pores) [1]. Porous media models can be manufactured using a conventional method that usually combines photolithography, etching and thermal bonding [2], or by using an ultrashort pulse laser [3]. With such a laser, it is possible to rapidly manufacture porous media models with arbitrary patterns, as shown in Fig. 1a, from low-cost optical glass slides. Patterns are generated by ablating the glass substrate, while hermetic sealing is achieved by closing the pattern from the top with a second glass plate and welding two glass slides together [3].

In this paper, we demonstrate that an ultrashort pulse laser can also be used to manufacture porous media models with embedded fibre optic sensors (see Fig. 1b). Such sensors enable real-time measurement of physical and chemical parameters, providing valuable insight into microscopic events and processes inside the models, thereby helping to explain various phenomena associated with multiphase flow in subsurface systems such as depleted hydrocarbon reservoirs and saline aquifers.



(a) *(b)*

Figure 1. Laser-manufactured porous media models made of two borosilicate glass slides with: (a) pattern resembling a Berea rock microstructure and (b) homogeneous pattern and embedded fibre optic pressure sensors. Insert in (a) shows a cross-section of the laser-generated welds that ensure hermetic sealing of two glass plates.

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