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Manufacturing a micro-model with integrated fibre optic pressure sensors

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ABSTRACT
Two-phase flow in porous media is a process encountered in various applications such as oil recovery, soil remediation, CO2 sequestration and many other industrial systems. Multiphase flow in porous has been experimentally investigated with the use of micro-models, as well as natural porous media. Up to now, fluid pressure measurements during two-phase flow experiments in micro-models have been mainly performed in external lines or in inlet/outlet areas of the micro-model. For example, absolute or differential pressure between the inflow and outflow reservoirs of the micro-model has been measured with dedicated pressure sensors 1–3. However, external pressure measurements, despite being valuable, are not representative of the pressure distribution inside the micro-model pore space.

I order to achieve pore scale pressure measurements, we combined soft lithography and fibre optic pressure sensors. The PDMS micro-models was manufactured based on the procedure described by 4. The pressure sensors were miniature Fibre Optic Piezometers M260-SHEATHED (Smartec). These sensors had a diameter of 260mm and they were covered with a protective sleeve, resulting to an overall diameter of 320μm. Their measurement range is from -40kPa up to 40kPa, with a resolution of 40Pa and accuracy of 0.6% of the full range, which makes them ideal for monitoring pressure at the pore scale. Moreover, the acquisition rate of 250Hz is sufficient for fast monitoring of pressure changes commonly encountered in dynamic two-phase flow experiments.

In this work, we describe the fabrication of a micro-model, made of PDMS, with integrated fibre optic piezometers. We demonstrate that these sensors provide pore-scale pressure measurements during two-phase flow. We show that the sensor shows an almost linear pressure distribution during steady-state single phase flow. The variation of pore pressure with time at each sensor location clearly show the effect of minor and major pore-filling events as well as breakthrough of the fluids when they reach the micromodel outlet.

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