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PoroFluidics: Deterministic fluid control in porous microfluidics

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Microfluidic devices with open lattice structures, equivalent to a type of porous media, allow for the manipulation of fluid transport processes while having distinct structural, mechanical, and thermal properties. However, a fundamental understanding of the design principles for the solid structure in order to achieve consistent and desired flow patterns remains a challenge, preventing its further development and wider applications. Here, through quantitative and mechanistic analyses of the behavior of multi-phase phenomena that involve gas-liquid-solid interfaces, we present a design framework for microfluidic devices containing porous architectures (referred to as *poroFluidics*) for deterministic control of multi-phase fluid transport processes. We show that the essential properties of the fluids and solid, including viscosity, interfacial tension, wettability, as well as solid manufacture resolution, can be incorporated into the design to achieve consistent flow in porous media, where the desired spatial and temporal fluid invasion sequence can be realized. Experiments and numerical simulations reveal that different preferential flow pathways can be controlled by solid geometry, flow conditions, or fluid/solid properties. Our design framework enables precise, multifunctional, and dynamic control of multi-phase transport within engineered porous media.

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References

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