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Static response of deformable microchannels IVAN C. CHRISTOV, TANMAY C. SIDHORE, School of Mechanical Engineering, Purdue University —
Microfluidic channels manufactured from PDMS are a key component of lab-on-a-chip devices. Experimentally, rectangular microchannels are found to deform into a non-rectangular cross-section due to fluid–structure interactions. Deformation affects the flow profile, which results in a nonlinear relationship between the volumetric flow rate and the pressure drop. We develop a framework, within the lubrication approximation ($\ell \gg w \gg h$), to self-consistently derive flow rate–pressure drop relations. Emphasis is placed on handling different types of elastic response: from pure plate-bending, to half-space deformation, to membrane stretching. The "simplest" model (Stokes flow in a 3D rectangular channel capped with a linearly elastic Kirchhoff–Love plate) agrees well with recent experiments. We also simulate the static response of such microfluidic channels under laminar flow conditions using ANSYS© Workbench. Simulations are calibrated using experimental flow rate–pressure drop data from the literature. The simulations provide highly resolved deformation profiles, which are difficult to measure experimentally. By comparing simulations, experiments and our theoretical models, we show good agreement in many flow/deformation regimes, without any fitting parameters.

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