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Theory of the bulging effect of soft microchannels with thick walls[1] XIAOJIA WANG, IVAN C. CHRISTOV, School of Mechanical Engineering, Purdue University, West Lafayette, Indiana 47907, USA — Long and shallow microchannels embedded in thick soft materials have been widely used in microfluidic devices. However, the bulging effect due to the fluid–structure interactions between the internal viscous flow and the soft walls has not been thoroughly understood. Previous models either contained a fitting parameter or were specialized to channels with thin walls. We present a theoretical study of the steady-state response of a deformable microchannel with a thick wall. Using lubrication theory for low-Reynolds-number flows and the linear elastic theory for isotropic solids, we obtain perturbative solutions for the flow and deformation. Specifically, only the channel's top wall deformation is considered, and its thickness-to-width ratio is assumed to be $(t/w)^2 \gg 1$. Then, we show that the deformation at each stream-wise cross-section can be considered independently, and that the top wall can be regarded as a simply supported rectangle subject to uniform transverse pressure at its bottom. The stress and displacement fields are found using Fourier series. Then, the channel shape and the hydrodynamic resistance are calculated, yielding a new flow rate–pressure drop relation without any fitting parameters. Our results agree favorably with previously reported experiments.

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