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Optically induced natural convection in a cylinder using conducting metal oxide films BRIAN J. ROXWORTHY, Department of Electrical & Computer Engineering, University of Illinois at Urbana-Champaign, KIMANI C. TOUSSAINT, SURYA P. VANKA, Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign — We present a computational study of light- driven natural convection in a cylinder. We solve the coupled electromagnetic, heat transfer, and fluid mechanics equations in an axi-symmetric geometry with heating and fluid flow induced by optical absorption in a conducting metal oxide film comprised of Indium-Tin-Oxide (ITO). Calculations are performed as a function of the relevant optical input parameters including the wavelength of the illumination source (λ), the input power of the input light (P) which is assumed to have a Gaussian intensity distribution, and the numerical aperture of the focusing lens, defined as NA = $n\sin\theta$, where $n$is the index of refraction of the local medium and θ is the half-angle of the focused light cone. Due to the localized, spatially non-uniform illumination, fluid flow is induced for any finite Rayleigh number Ra > 0 and the resulting flow closely resembles a toroidal Rayleigh-Bénard convection pattern. The maximum fluid velocity scales linearly with Pand increases with increasing AR up to AR ~ 2; above this value, increasing h_{fluid} has no effect on the peak velocity. The optical actuation enables dynamic reconfigurability of the heating and convection patterns, which benefit lab-on-a-chip fluid mixing and particle manipulation.

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