# Dynamics of an Electrostatic Microactuator Operating in High Viscous Dielectric Media

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Electrostatic actuators are the physical systems comprising of mechanical and electrical components that generate mechanical motion at micrometer scale (on the order of human hair thickness). These actuators have the potential to physically manipulate biological (human and plant) cells suspended in viscous culture media. An in-depth understanding of actuator behavior in viscous media is very beneficial for designing actuators for probing and manipulating the cells. Most research efforts were directed towards understanding the actuator behavior operating in low viscous media (e.g., air). Understanding the actuator behavior in high viscous media will help optimize actuator performance for biological applications. In this project, we analyze the behavior of the actuator by deriving a physics-based model and solve it by employing the Galerkin method and linear undamped mode shape function. For accurate modeling, we incorporate the inertial loading effect and squeeze film damping by the media, nonlinear mid-plane stretching forces in the actuator, and nonlinear contact forces. We describe the actuator characteristics in terms of response time, actuator displacement, and frequency response over a broad range, two orders of magnitude of viscosity and two orders of magnitude of relative permittivity of the media. Our results show that the electrostatic actuators are capable of achieving large displacements (5 micrometers) at low actuation voltages (< 2 V) in high viscous media such as water —making them suitable for biological applications.