Squeeze Fluid Film Phenomena in Micro-Systems

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The seminar concerns itself with the pressure forces which arise when two plates which are in close proximity, trapping a fluid in-between them, exhibit a relative motion which is principally normal to their surfaces. When the surfaces approach one another, pressures develop which resist the motion of the surfaces to come together. The resulting pressure forces are sometimes called "squeeze forces" which are usually split according to two main characteristics forces "squeeze restoring and damping forces". When relative velocity between the surfaces is low, the film is effectively incompressible and has sufficient time to escape from in-between the surfaces. At high velocities, the film approaches a purely compressible state with no fluid flow. Consequently, at low velocities, squeeze film damping forces are pre-dominant, whereas at high velocities squeeze film restoring forces take over.

Therefore, the effect of surface forces (most notably the damping forces of the surrounding air), which may be neglected when dealing with machines of macro dimensions, may play an important role with micro-machines and the significance of the effect becomes greater as micro-machined structures decrease in size. As a result, the motion of small parts in a MEMS device can be affected by the surrounding fluid significantly. The fluid presents a counter reactive force to the plates' movement. Hence, for most MEMS devices for which an out of plane motion is required, the squeeze film effect is the most important damping effect on its dynamic behavior, because of the technologies used for which narrow fluid gaps are required. For MEMS devices with a plate (a proof mass) that moves against a trapped film, squeeze film fluid damping has been a problem of great significance as the mechanism dominates the damping and thus substantially affecting the system frequency response.

In this seminar I will explain in detail the governing equations (Reynolds equation) and the required assumptions, rarefied fluids' continuum limitations, force transitions and modified parameters. Then, I will exhibit four different research and development micro-systems and their dynamics, which I have dealt with, where squeeze film played a dominant role.