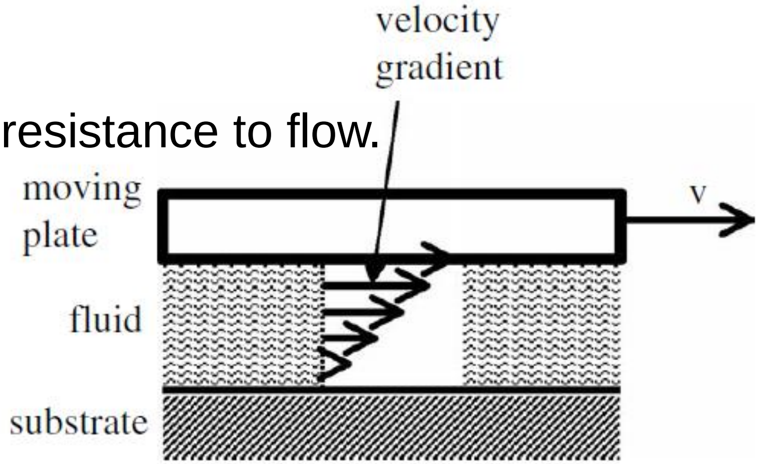
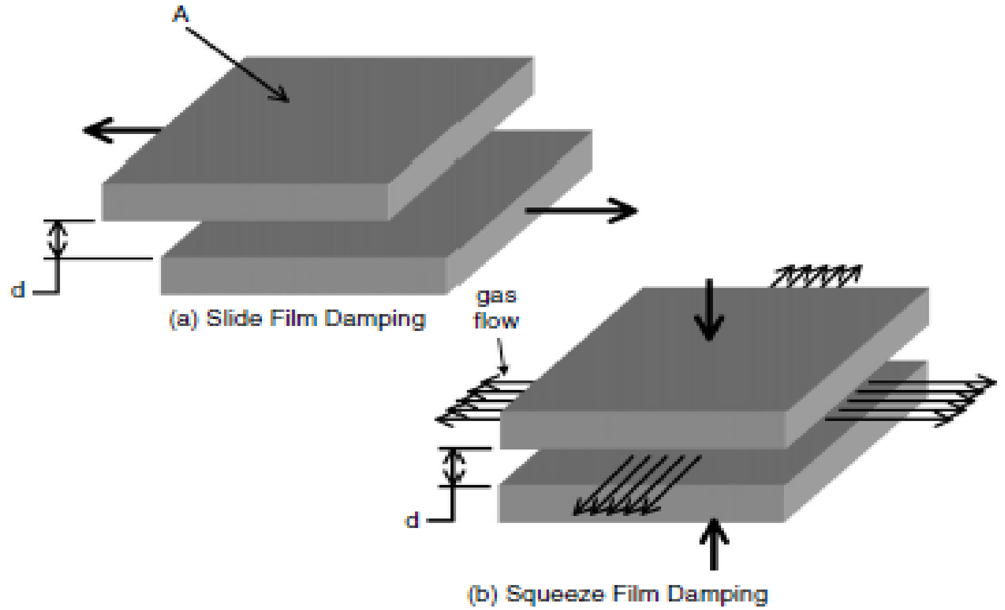
2^{nd} Order Systems, *damping*

- Many MEMS devices involve an oscillating structure in order to perform the measurements required.
- Damping form in MEMS could be either friction between structures or gas damping (like air drag).
- Gas damping, or air damping, is the source of most MEMS damping mechanisms.
- Air damping is a strong function of its viscosity.
- Viscosity of a fluid or gas, μ, is a measure of the resistance to flow.
- Air viscosity is 1.7×10^{-5} Kg/(m.sec).



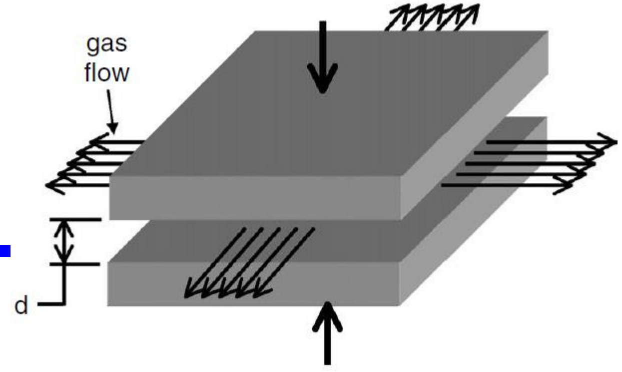
2nd Order Systems, *damping*

- There are two models of viscous damping in MEMS depending on the relative motion between structures.
  - Squeeze film damping occurs between closing gap structures.
  - Slide film damping occurs between structures move laterally w.r.t each other.



2nd Order Systems, *damping*

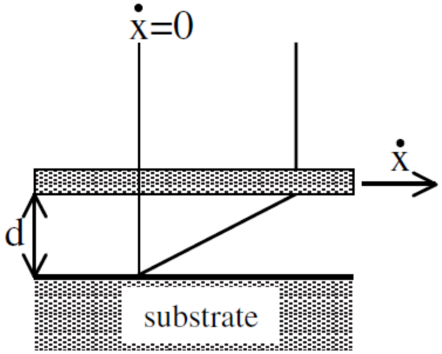
- **<u>Squeeze film damping:</u>**
- Could be found in many MEMS structures, pressure and inertial sensors.
- For large plates and thin gaps, the squeeze damping becomes large;
  - The gas is trapped between the plates due to viscous effects at the plate edges.
- Conversely, a small plate with a large gap will produce a small squeeze damping.
- Squeeze damping is large also at high frequency operation since the gas will have greater difficulty escaping the plate gap at higher excitation frequency.
- Squeeze damping can be reduced by vacuum packaging and opining holes in the oscillating plate.



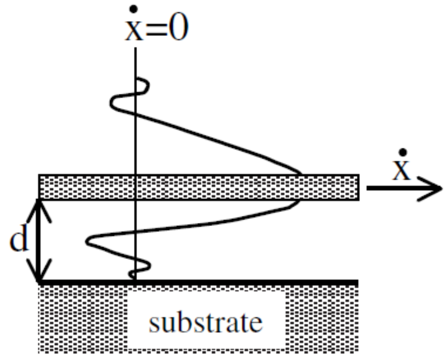
2nd Order Systems, *damping*

- **<u>Slide film damping:</u>**
- Laterally oscillating mass above a substrate and interdigitated fingers are examples where this kind of viscous damping occurs.
- Two models are used to find an expression for the damping coefficient as shown in figure below.
- Couette flow damping is more frequently used.

$$b = \mu \frac{A}{d}$$



a) Couette Damper Velocity Profile



b) Stokes Damper Velocity Profile