

7.3 Summary

7.3.1 Summary to 7: MEMS

MEMS are "Micro Electro Mechanical Systems" including also micro optics, micro fluidics and generally meaning micro systems.

MEMS uses **Si** substrates and technologies because "it is there and cheap" for the non-electronic part *and* because electronic components can be integrated on the same chip.

Examples of high-volume **MEMS** products are

- (Pressure) sensors.
- Accelerometers.
- Gyros
- "Beamer" chips (DLP)

More products are to come; **MEMS** is an *emerging* and often an *enabling* technology

Gyros are particular complex **MEMS** sensor products with a huge range of applications.

- There must be a physical principle behind the sensor design; different approaches can be used.
- One approach uses the **Coriolis force** causing detectable additional vibrations in an oscillator with two degrees of freedom if some rotation is experienced.

Many **MEMS** devices are either sensors or actuators.

Looking only at mechanical **MEMS**, there is a need to couple mechanical movements to electrical signals and vice versa.

Ways to do this include.

- Capacitive coupling
- Piezoelectric and piezoresistive coupling.
- Thermal coupling (expansion, resistivity changes).
- Magnetic coupling.
- Optical coupling.

There is no "ideal" coupling; all methods suffer from certain problems.

MEMS uses all of "known" **Si** technology and has some specifics of its own.

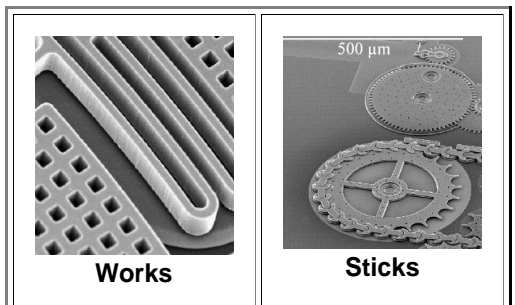
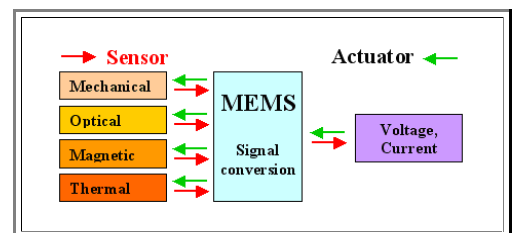
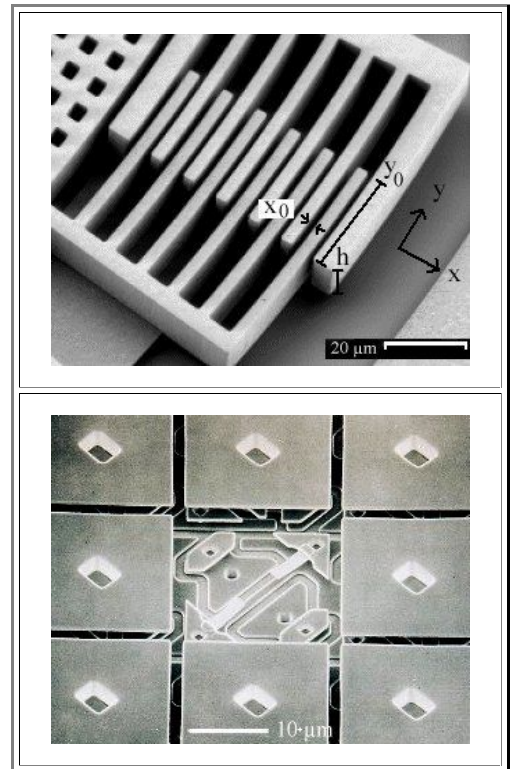
- Making cantilevers and membranes necessitates making "large" cavities.
- Staying absolutely planar and stress-free is essential
- Packaging can be far more demanding than for chips (e.g. transparent tops for **OMEMS**, keeping defined pressures for **> 10 a** in gyros).

The **bane** of **MEMS** is **stiction**.

If you can't lubricate, it will stick sooner or later. Never bring moving parts in contact!

MEMS design therefore cannot just miniaturize exiting mechanical designs; it must look for new approaches.

MEMS employs some special processes and materials; they are the drivers of progress



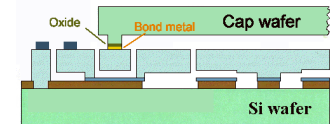
- Anisotropic chemical etching
- High-rate plasma etching ("Bosch process")
- Chemical-mechanical polishing
- Sacrificial layers and removal (including chemical etching with "vapors")
- Wafer bonding; in particular for packaging.

**Making "large" cavities and
extremely deep "holes"**

Planarization

Free-standing structures

Process integration looks simple if compared to an advanced **CMOS** process, but is actually rather involved due to the special processes needed and quality requirements



Exercise 7.3-1

All Questions to 7.