Accelerometers MEMS: vibrating (Quartz Rate Sensor)

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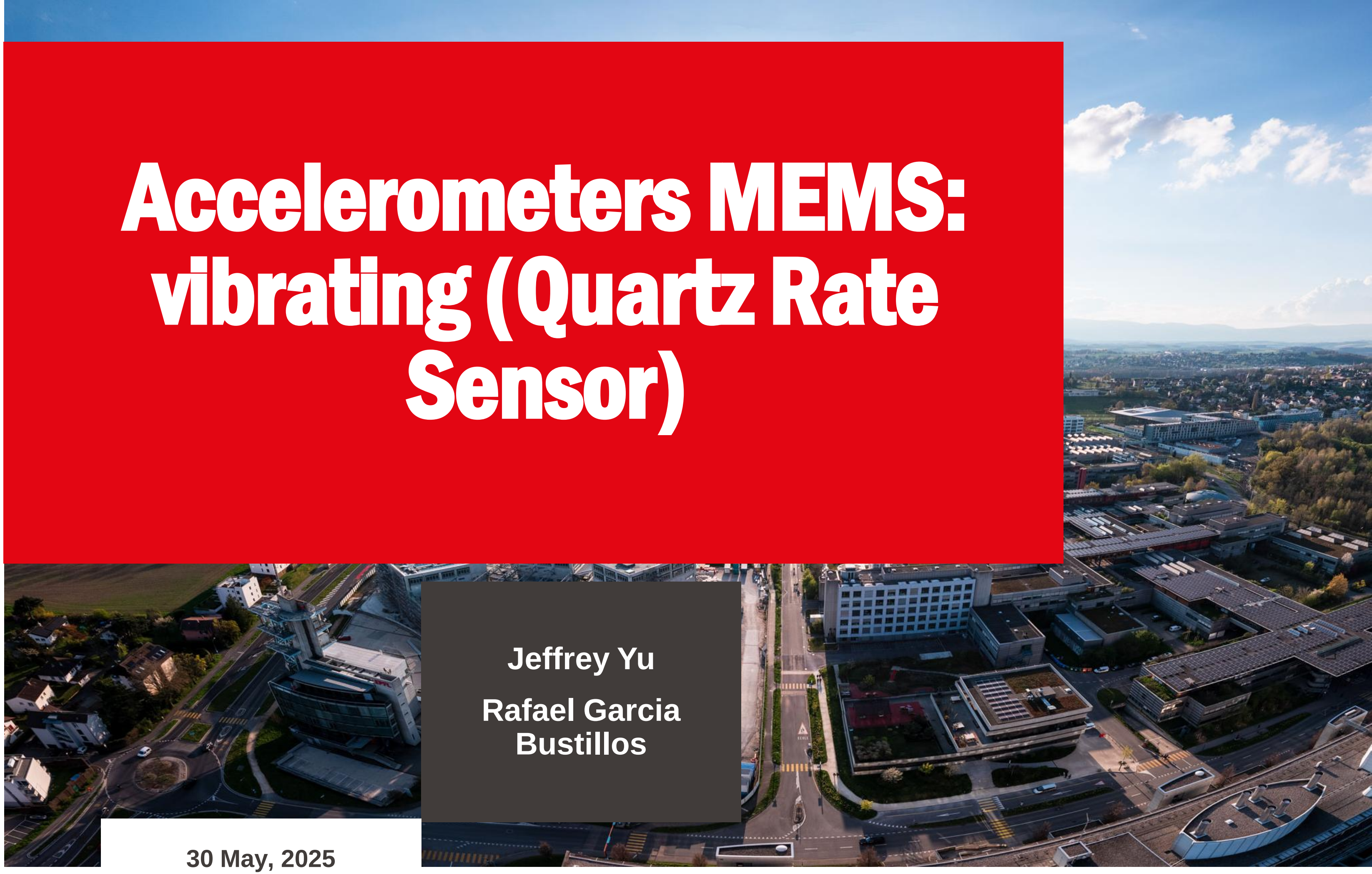

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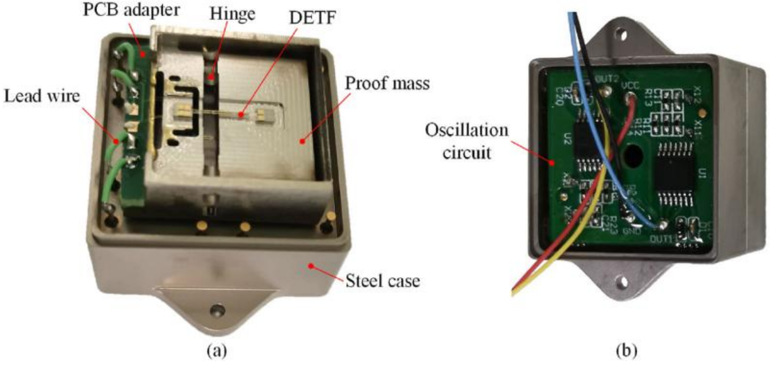
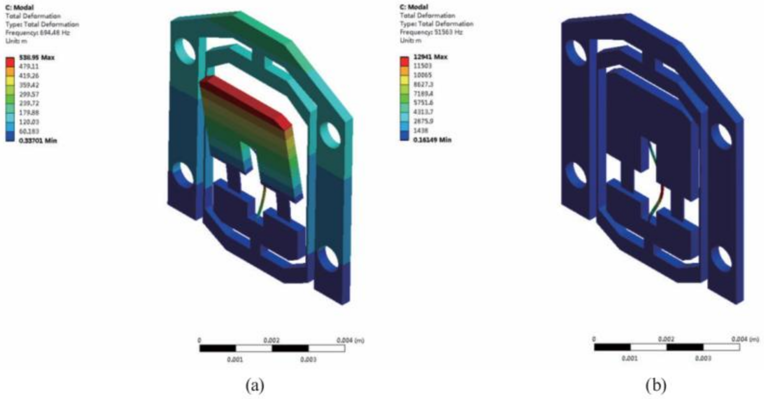
OUTLINE

Introduction

- The **sensing principle** is based on **monitoring resonant frequency shifts** in **vibrating beams**
- MEMS (microelectromechanical system) based packaging
  - Silicone and Quartz based systems



~10mm x ~10mm



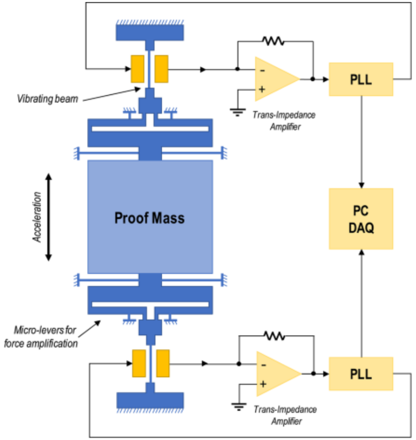
Sensor under external force

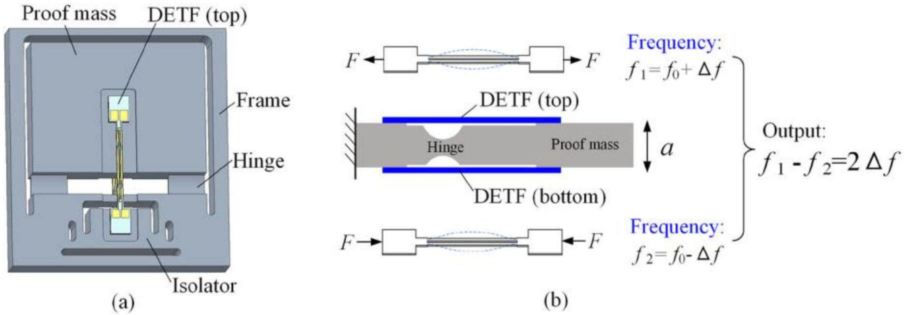
Vibrating Beam Mechanism

- Consists of the basic components:
  - Proof mass
  - Vibrating beam(s)
  - Resonators
  - Lever

$$f = \frac{4.73^2}{2\pi l^2}\sqrt{\frac{EI}{\rho A}}\sqrt{1 + \frac{0.2949 l^2}{E t w^2} F}$$

Equation expressing resonant frequency from force.





2 designs of vibrating beam accelerometers

Operation Statistics

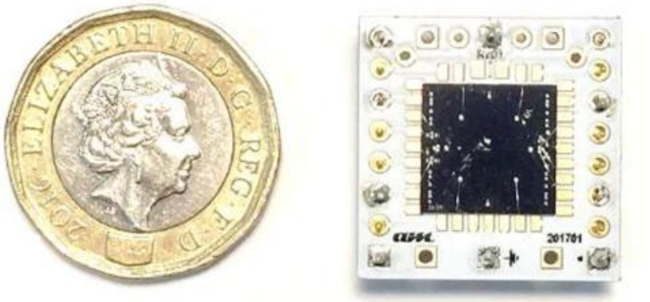
Specifications	
Size	~10mm x ~10mm
Drift	< 0.5µg
Sensing range	±200 g
Bandwidth	~1,000 Hz
Bias stability	~7 ng
Noise floor (Resolution)	~10 ng/√Hz

Advantages

Feature	Benefit
Symmetrical Arrangement	Reduces frequency-prone errors caused by: 1. Temperature changes 2. Ageing of the quartz 3. Anisotropic inertia 4. Vibro-pendulous effects 5. Bias drift We get long-term precision (Scale factor stability error ~100 ppm) + obtain linear relationship between frequency and acceleration.
High Q-factor resonators	• Low noise floor • Precise frequency measurement
Large dynamic range	• Can measure large and subtle vibrations. • Wide dynamic range ensures high resolution for small accelerations
Open Loop	• Simple control design

Disadvantages

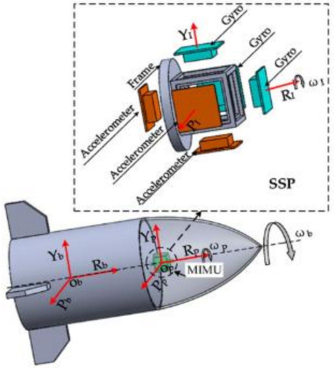
- Typically, larger than MEMS accelerometer
  - MEMS accelerometer: µm to mm
  - QVB accelerometer: mm

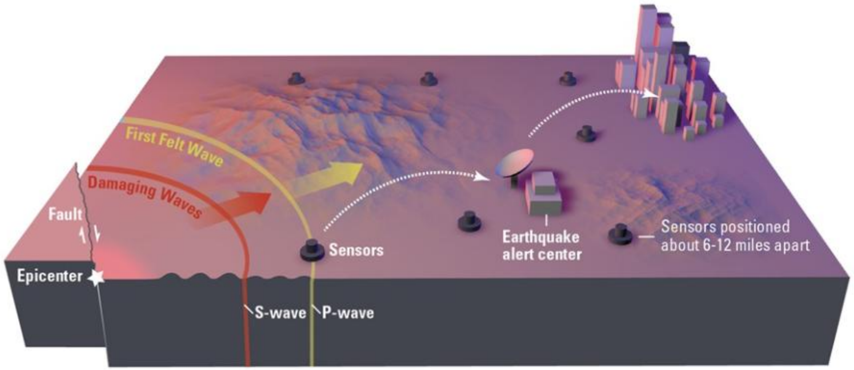


- Expensive (>$5,000)
- Not available off the shelf
- Requires careful mechanical construction
  - Small flexible components
  - Chemical etching & wafer bonding can be moderately complex

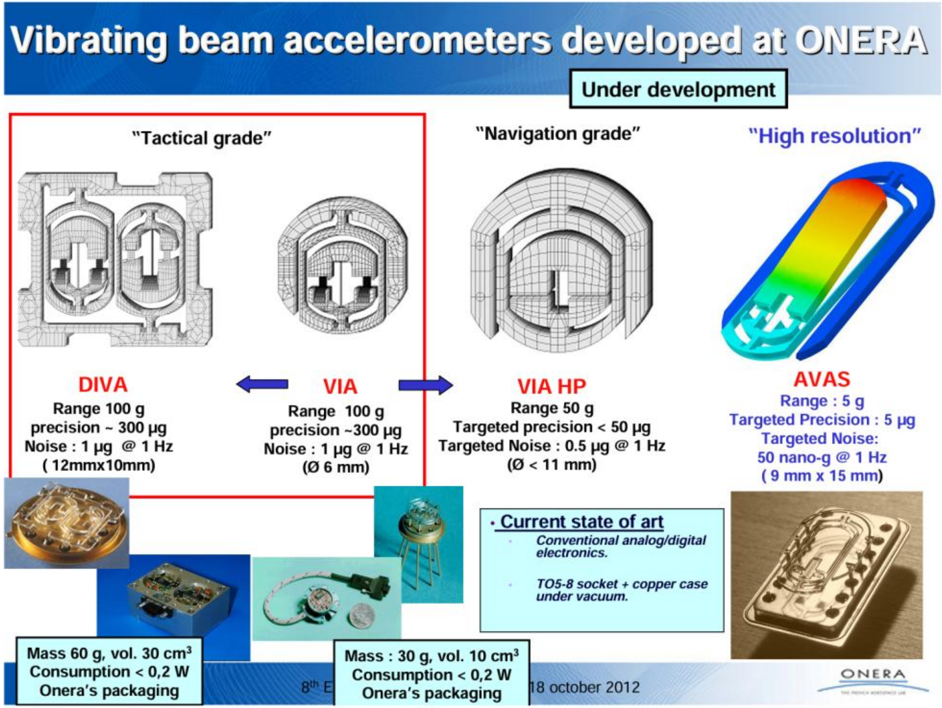
Applications

- Seismology and gravimetry applications
- Navigation systems for autonomous vehicles
- Aerospace/Space missions
- Military purposes
  - Attitude control of tactile missiles
  - Aircraft inertial navigation





Market Products



Sources

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