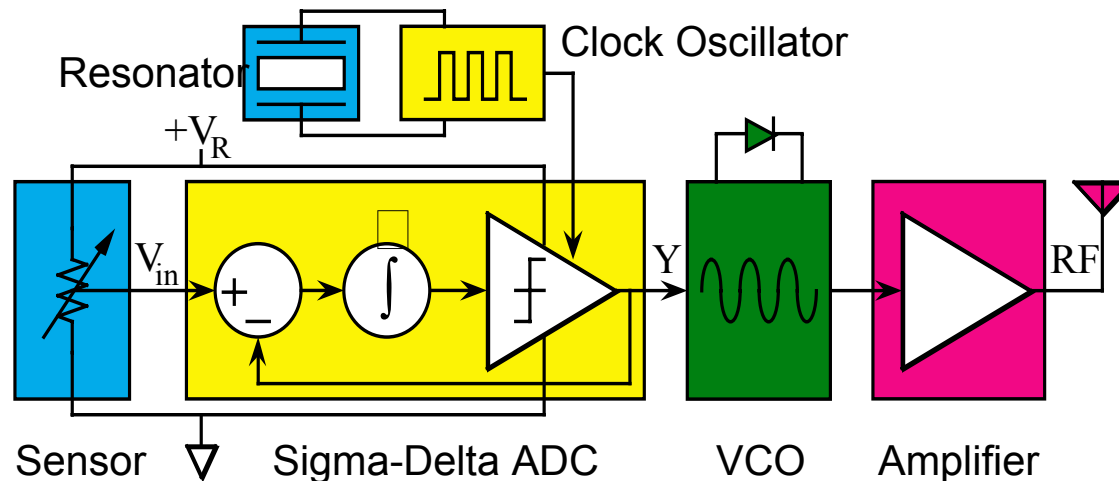


Overview

- Approach: SiC transducers + SOI circuits

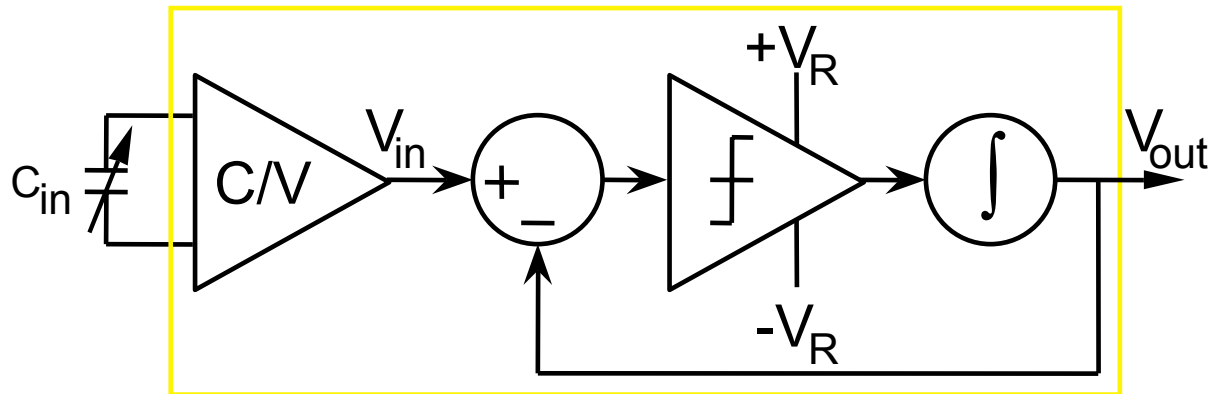


- Application: high-temperature sensing for
 - Automotive (150 – 200 °C)
 - Aerospace (300 °C)
 - Geothermal (250 – 420 °C)

Capacitive Sensing Integrated Circuit

Principle of Operation

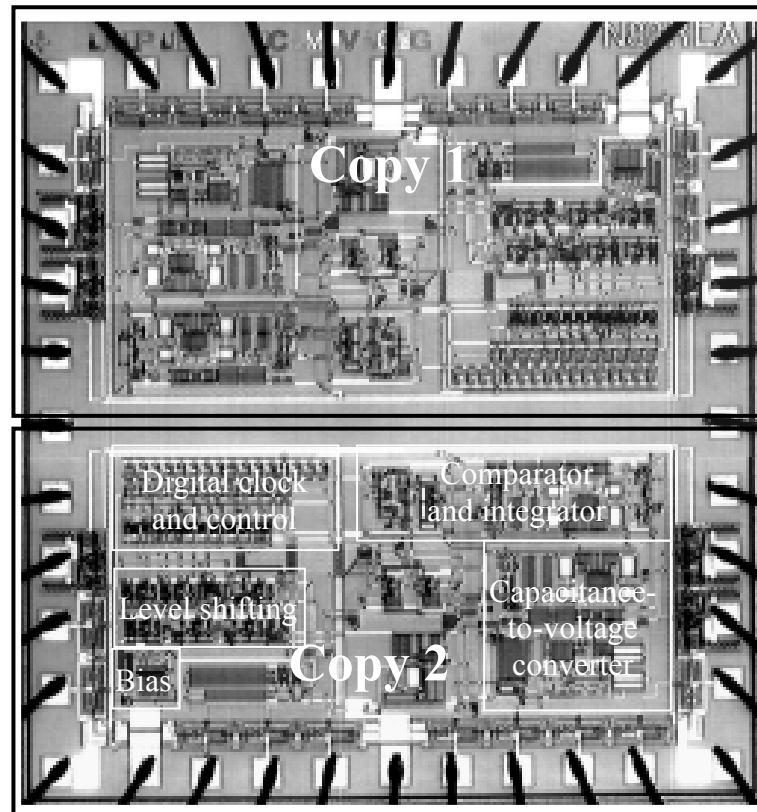
- Correlated double sampling is used to remove offset and reduce flicker noise
- Oversampling (delta modulation) is used to reduce thermal noise



- Gain is set by voltage reference of C/V
- Bandwidth is set by integration capacitor

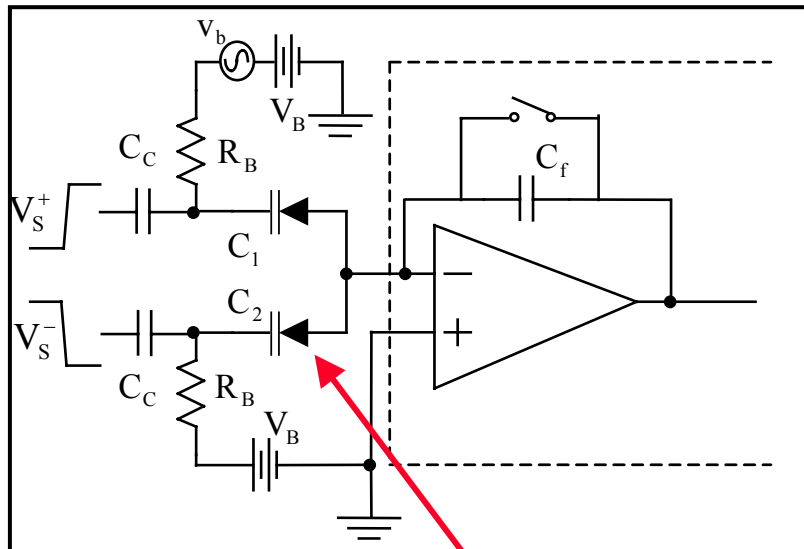
Capacitive Sensing Integrated Circuit IC Photomicrograph

- Fabrication
 - 1.5-micron CMOS
- Die size
 - 1.0 by 2.0 mm
- Packaging
 - 20-pin DIP
 - chip-and-wire
- Supply Voltage
 - 5-V digital
 - ± 3.5 -V analog



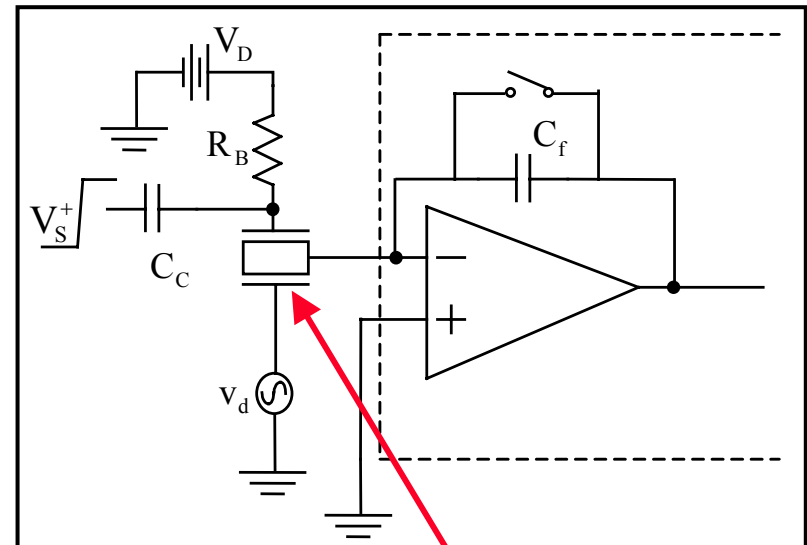
Capacitive Sensing Integrated Circuit Test Configurations

Static/Dynamic Performance



Varactor

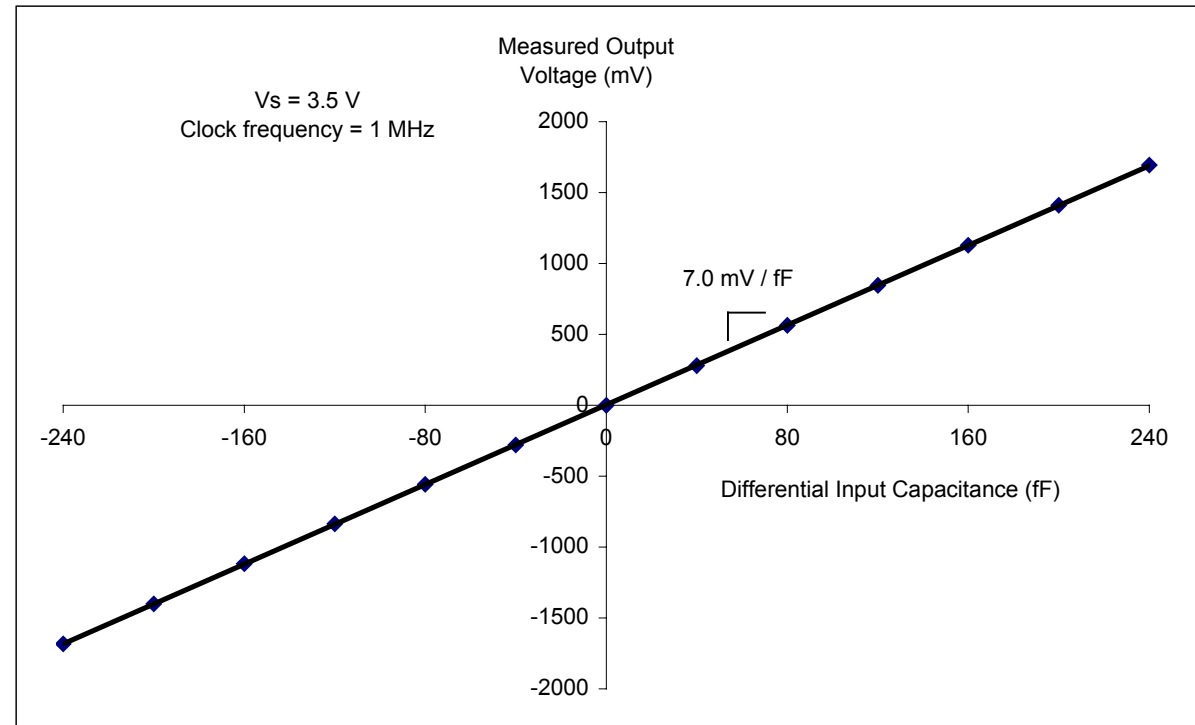
MEMS Resonator Characterization



Resonator

Measured Performance

- Stimulus
 - trim-caps
 - varactors
- Sample rate
 - 6 ksps
- Sensitivity
 - 7 mV/fF
- Resolution
 - 190 aF
- Dynamic range
 - 68 dB
- Nonlinearity
 - 0.16 %

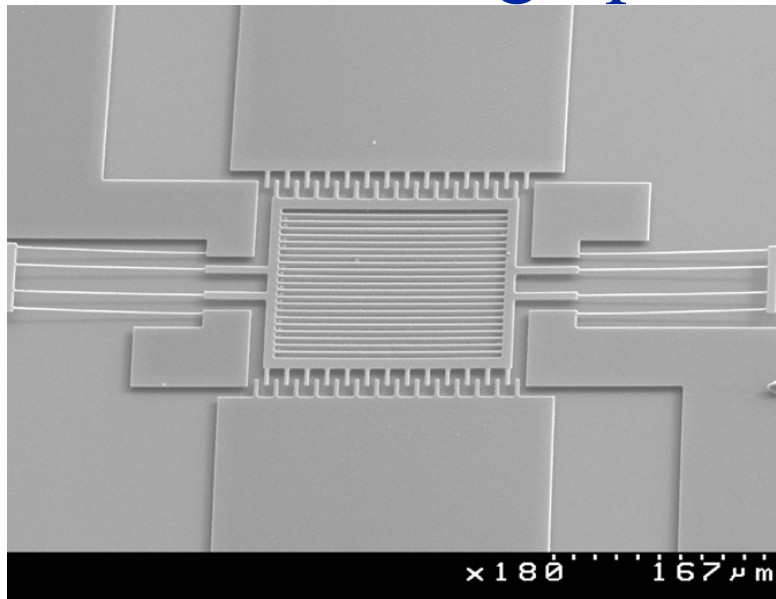


Note: offset was nulled using trim-cap

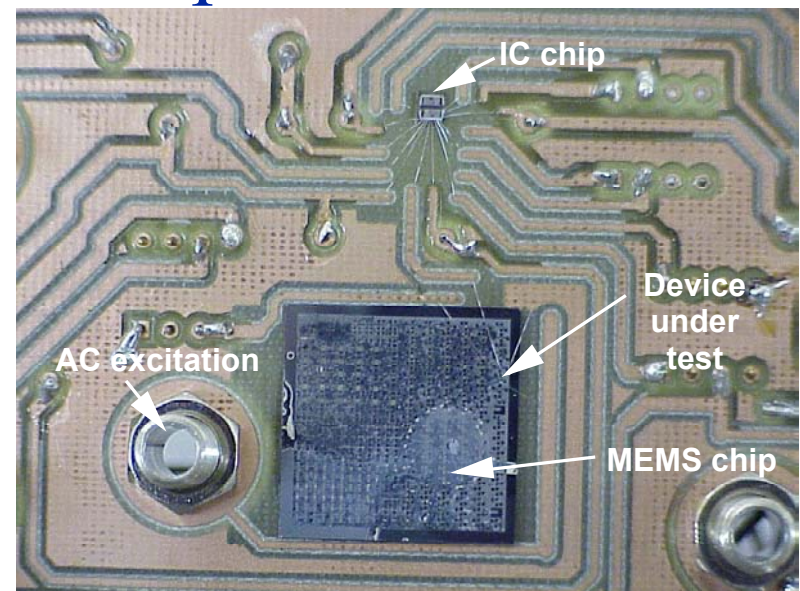
Capacitive Sensing Integrated Circuit SiC MEMS Resonator

- Lateral, comb-drive design
- 3C-SiC-on-SiO₂ substrates
- Patterned using RIE in CHF₃/O₂/He plasma

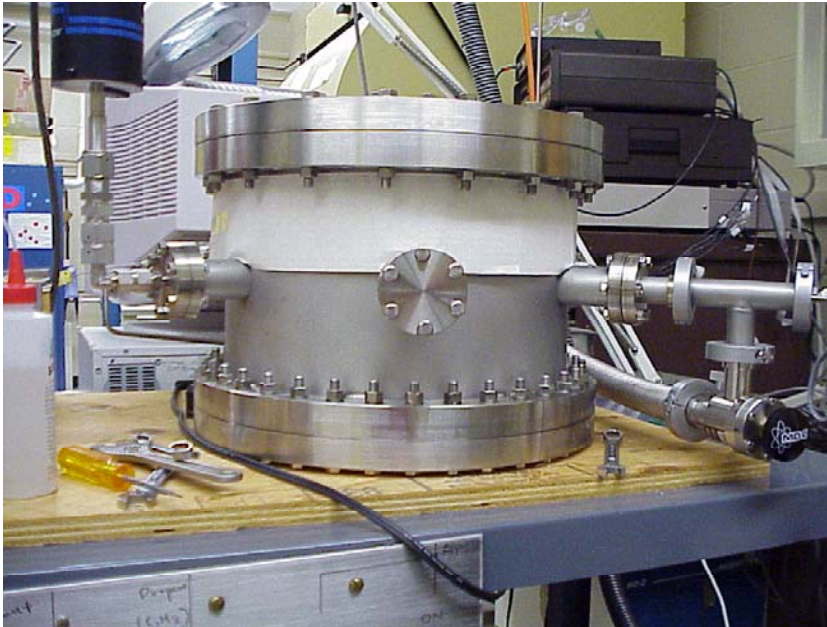
Photomicrograph



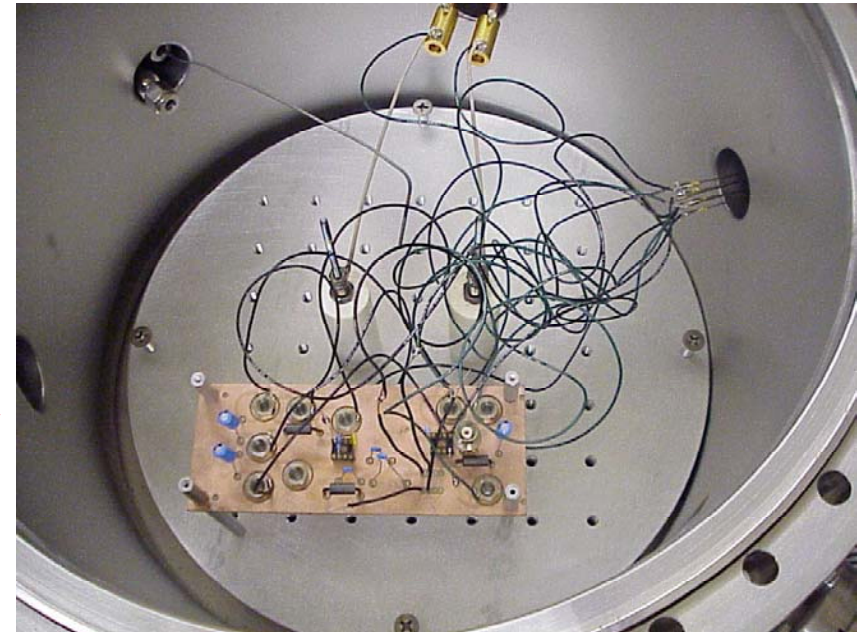
Chip-and-wire PCB



Capacitive Sensing Integrated Circuit Vacuum Test Setups



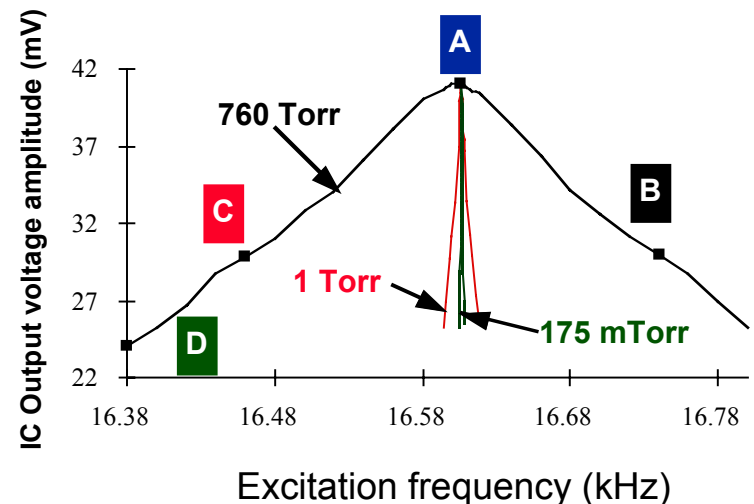
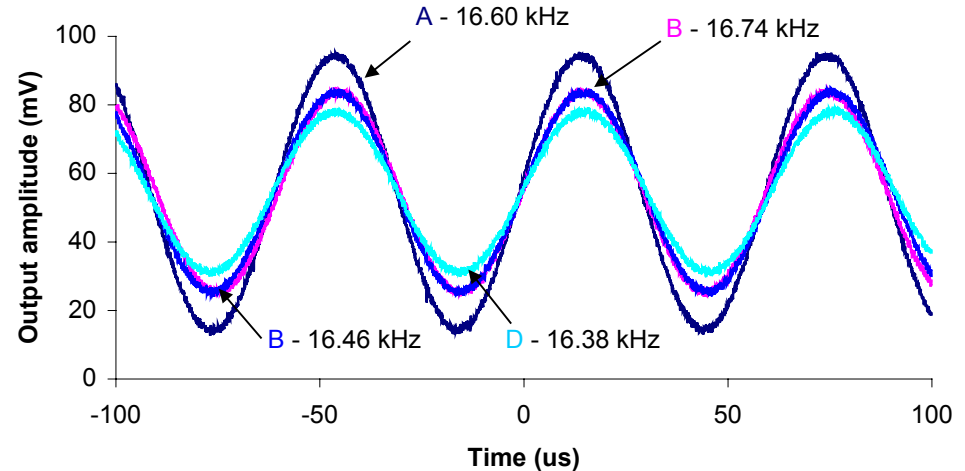
← Vacuum Chamber



Spaghetti Network →

Capacitive Sensing Integrated Circuit Resonator Test Results

- Time Domain
 - Sinusoidal drive
 - Sweep frequency
 - Step the pressure
 - 760 Torr to 175 mTorr
- Frequency Domain
 - Resonant frequency is independent of pressure
 - 16.60 kHz
 - Quality factor is
 - 51 at 760 Torr
 - 6900 at 175 mTorr



- **Electronics**
 - Shuyu Lei, Ph.D., 2001
 - Prof. Steven L. Garverick
- **SiC MEMS**
 - Sorin Stefanescu, Ph.D., 2001
 - Prof. Chris Zorman
 - Prof. Mehran Mehregany

Performance Comparison to Literature

