“Performance Demonstration of THEON’s existing Pressure Modules for Space applications”

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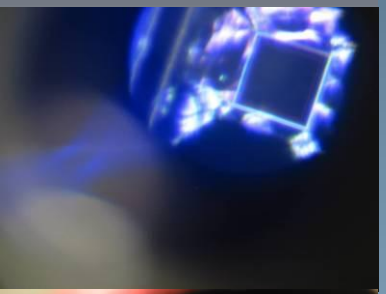
7th ESA ROUND TABLE ON MNT for Space Applications
ESTEC, 13-16 September

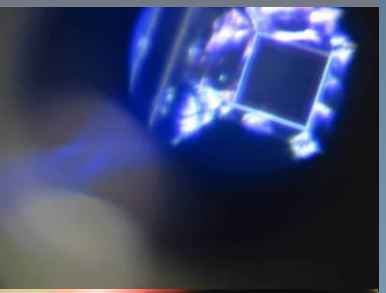
Outline

- Company Profile
- ESA Activity Overview
- THEON Sensors Technology for Pressure Sensors
  - MEMS sensor
  - Readout Electronics ASIC
  - Pressure Module
- Performance Assessment
- Future Work



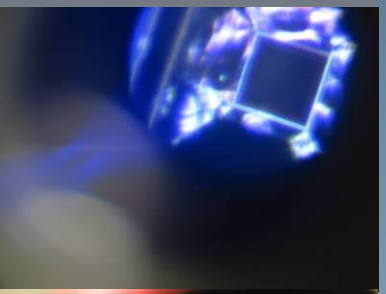
Company Profile

- Hellenic company established in 1997
- Business Units:
  - Electro-Optics: Design, develop and manufacture of Electro-Optical Systems
  - MEMS: Design, develop and integration of MEMS based modules



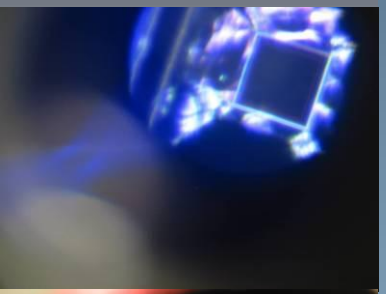
MEMS Business Unit

- Fabless design and development house of MEMS modules
- Prime scope of work is to design, develop and produce flexible and customer specific MEMS modules via qualified industrial processes employed for sophisticated monitoring and control applications
- Customer specific sensing modules for measuring:
  - Pressure
  - Acceleration
  - Flow



MEMS Business Unit
Capabilities

- Design and Simulation of Silicon based Micro Sensors (MEMS)
- Design and Simulation of Electronics, for Signal Conditioning and Interfacing of Micro Sensors
- Design and Manufacture of MEMS Modules' Mechanical Housing
- System Packaging / Wire and Die Bonding
  (Micro Assembly – Prototype and Demonstration units)
- Systems Testing and Characterization



ESA Activity Overview

"Performance Demonstration of THEON's existing Pressure Modules for Space applications"

Activity started on March 2009 and is still ongoing

Main Objectives

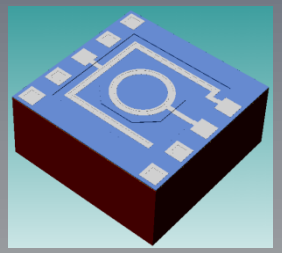
- **Overview of the pressure sensors used for terrestrial and space applications**
- **Identify space applications for pressure sensors**
- **Investigate the suitability of THEON's capacitive pressure sensing technology to serve space applications**
- **Demonstrate the technology performance and identify its limitations (MEMS, ASIC, Module)**
- **Design and simulation of a technology demonstrator for the target application**
- **Propose a development plan for the demonstrator**

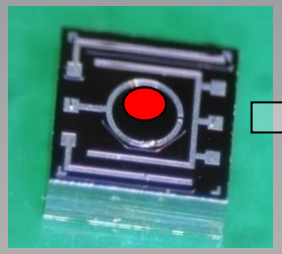
THEON's Technology Overview

Pressure Sensing Element

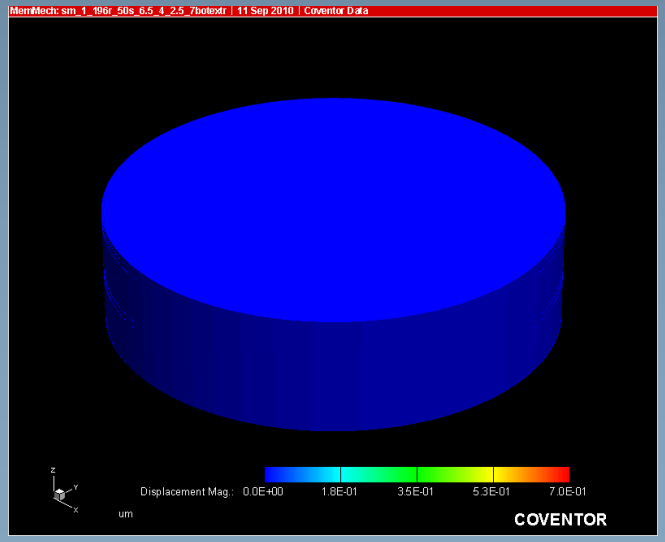
- Bulk Micromachining of SOI wafers
- Industrialized Frozen Process developed together with X-FAB
- THEON is the owner and exclusive user of the process
- MEMS Capacitive silicon pressure sensors
- THEON has already produced pressure sensors for different ranges from 0,5 up to 100 bars
- Small size(2mm X 2mm, 1mm X 1mm, custom), low power

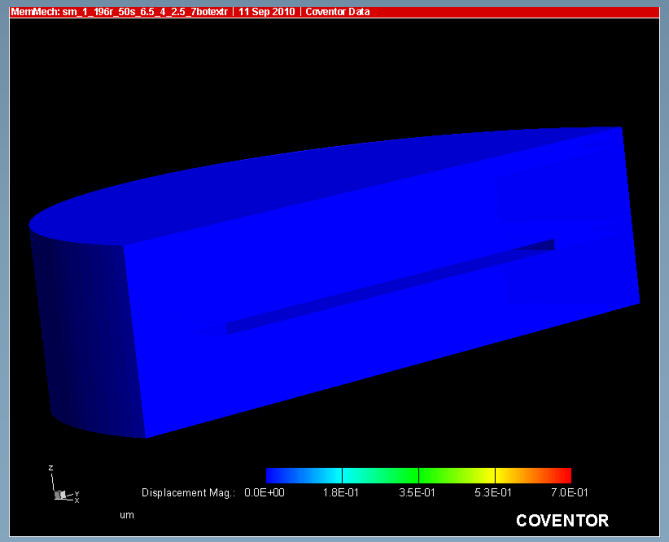
Principle of operation





- Motion of flexible silicon membranes under external pressure
- Vacuum sealed cavity for absolute operation





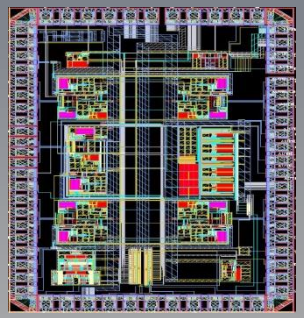
THEON's Technology Overview

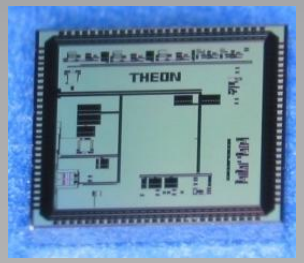
Signal Conditioning Electronics ASIC

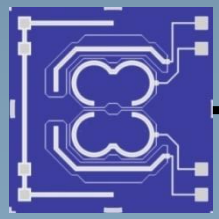
- Full custom design of analog and mixed-signal integrated circuits for signal conditioning of MEMS sensors
- Second generation of ASICs (0.18um CMOS process of X-FAB)
- THEON is the IP owner of any design
- THEON has already produced mixed analog/digital integrated circuits for the signal conditioning of the MEMS pressure sensors

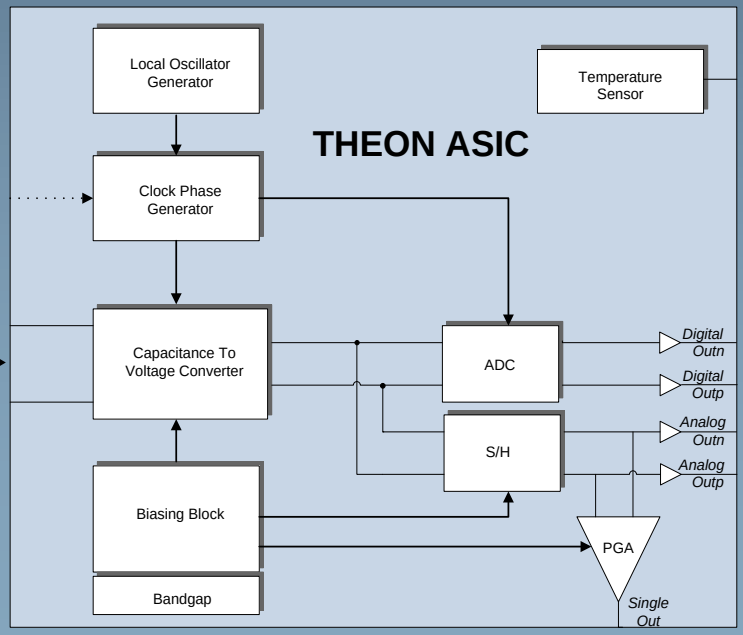
Features

- Fully balanced differential Capacitance to Voltage (CtoV)
- A balancing circuit is used to null offsets due to capacitor mismatches
- Digital control of the CtoV gain
- Noise reduction techniques
- ΣΔ A/D Converter
- Embedded temperature sensor



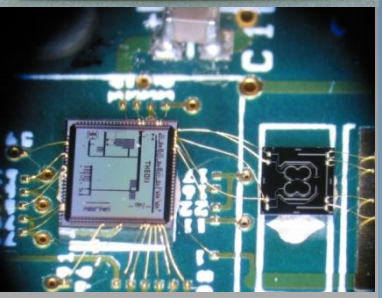


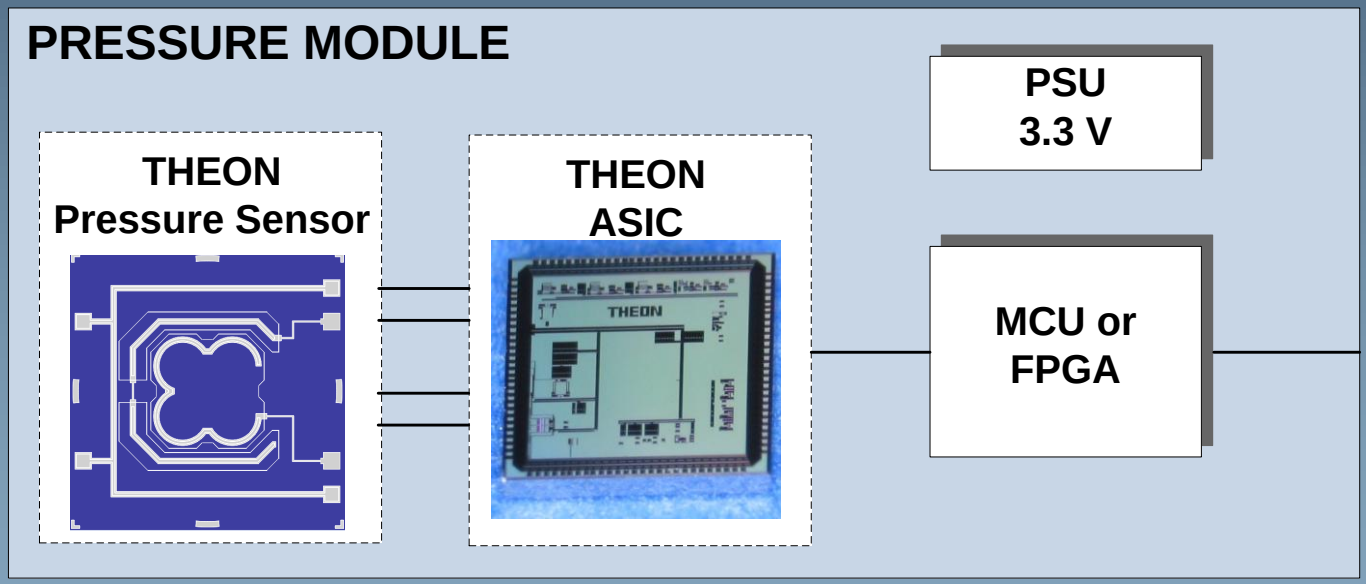




THEON's Technology Overview
Pressure Module Architecture

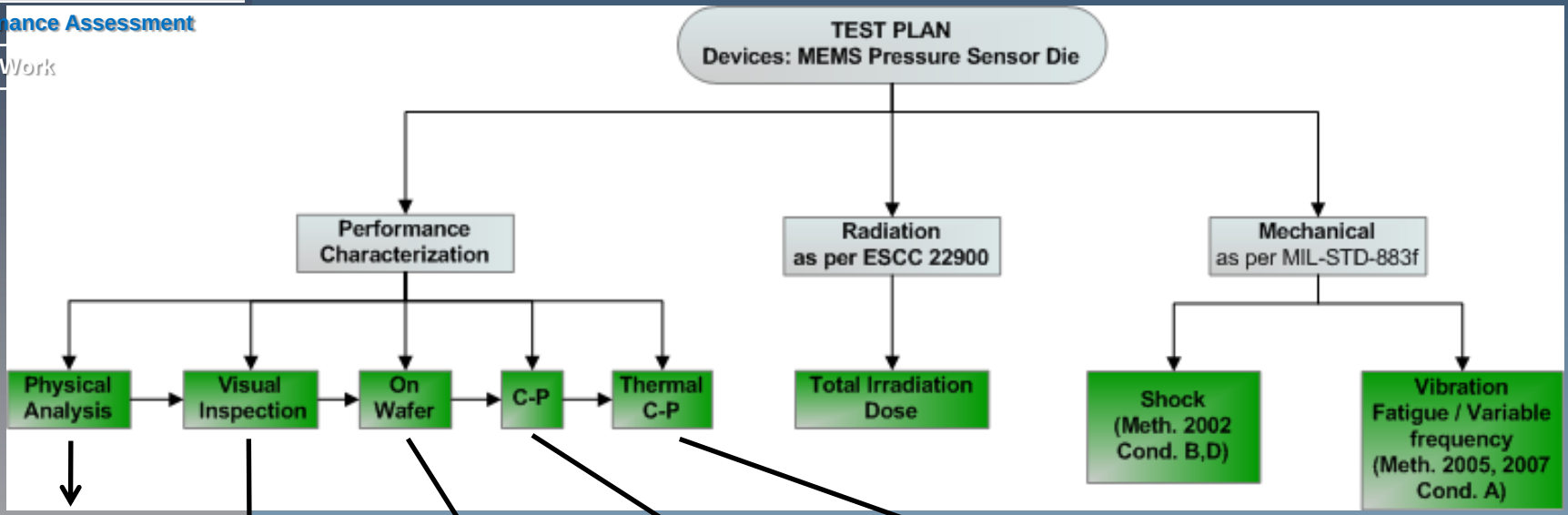
- MEMS sensor and ASIC co-integration
- Digital Calibration/Temperature Compensation Algorithms
- Packaging Solutions are under evaluation

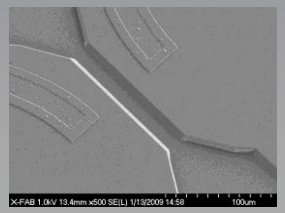


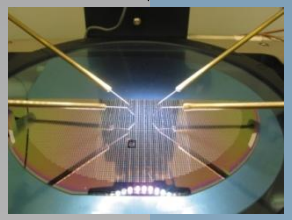


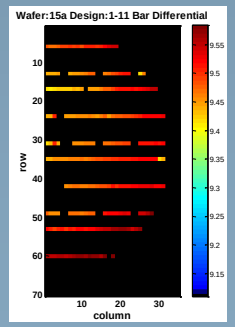
Performance Assessment MEMS Sensor Die

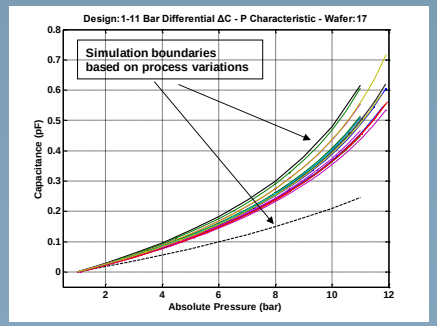
Tested Devices: 0,5 – 1,2 bar
1 – 3,7 bar
1 – 11 bar

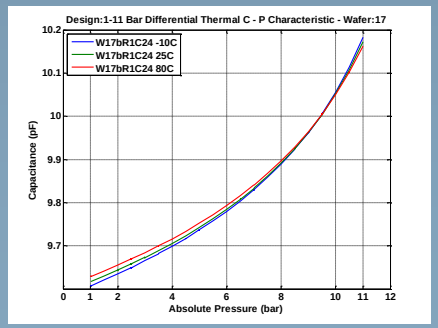








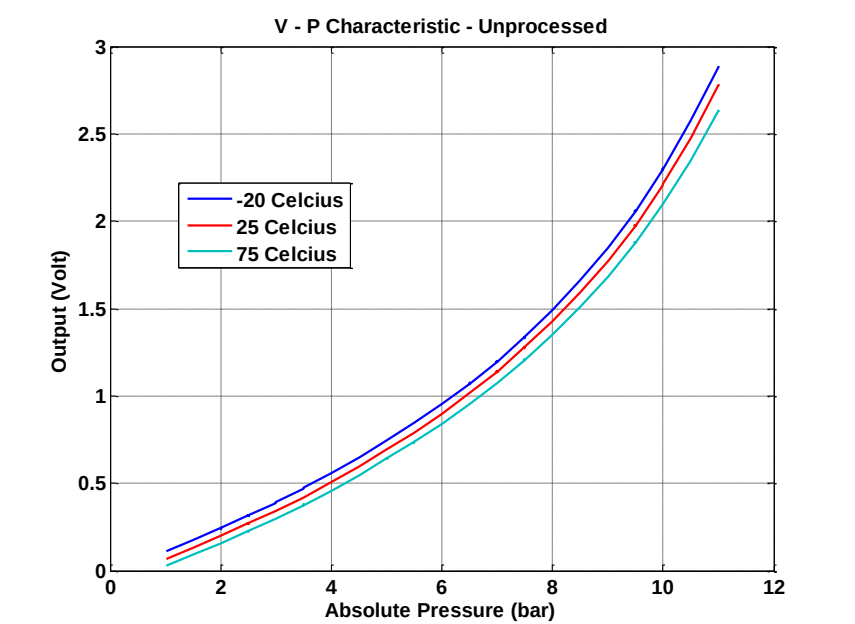




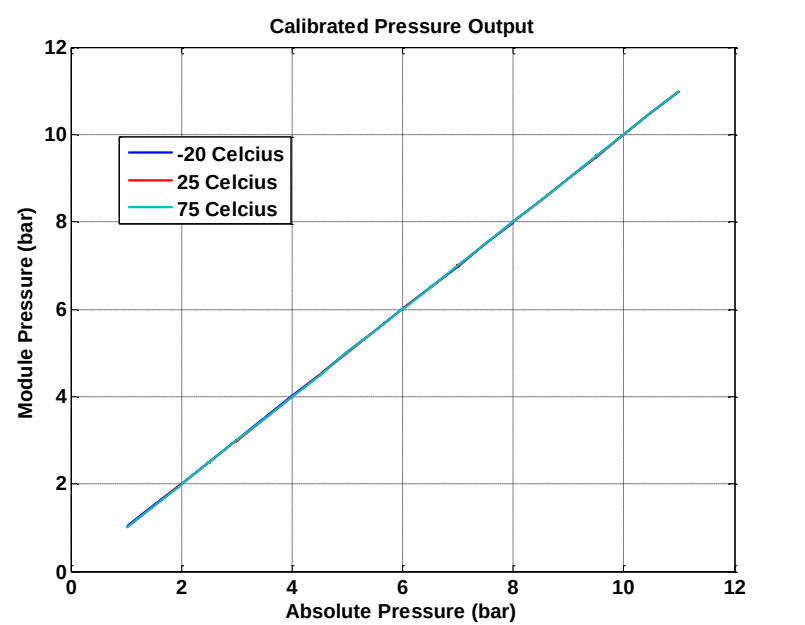
Performance Assessment
Pressure Module

Pressure Range: 1 - 11 bar
Temperature Range: -20ºC to +75ºC

V-P Output - Unprocessed

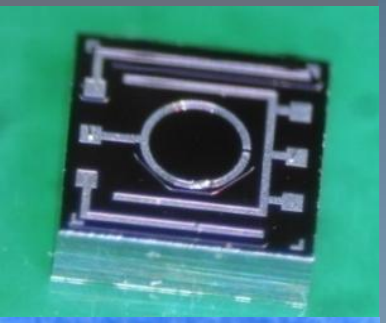


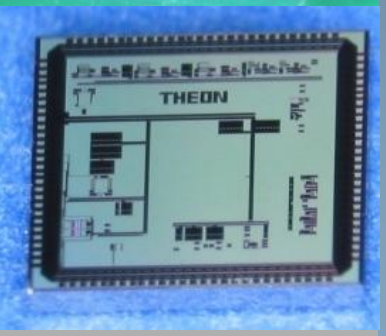
Calibrated/Compensated P Output



Total Error including repeatability, hysteresis, linearity, thermal effects

Error (mbar)	Error (% FS)
~60	~0,6



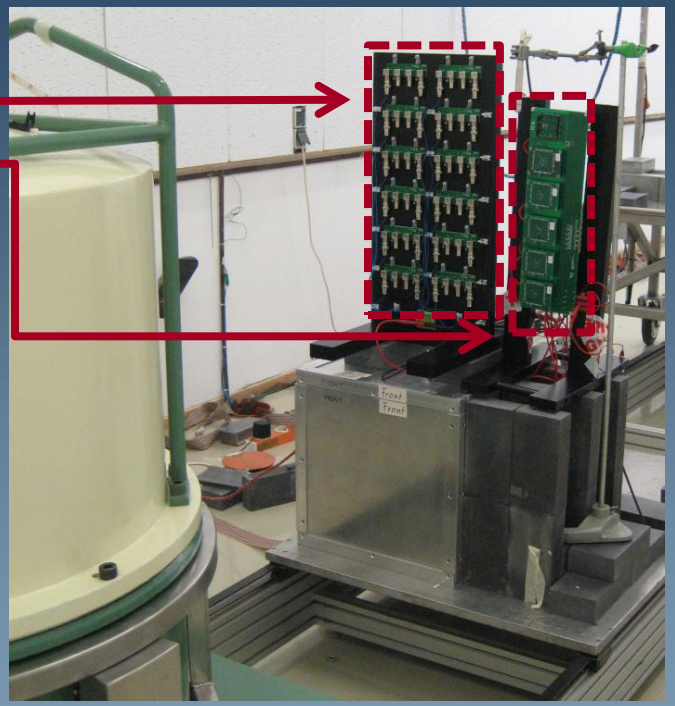


Performance Assessment
Total Irradiation Dose Tests

- **ESA/ESTEC facilities (10/1/2010 – 18/1/2010)**

Tested Devices

- **12 MEMS sensors**
- **5 ASICs**

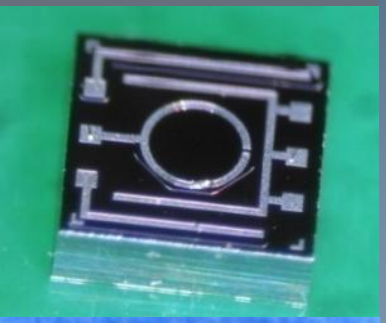


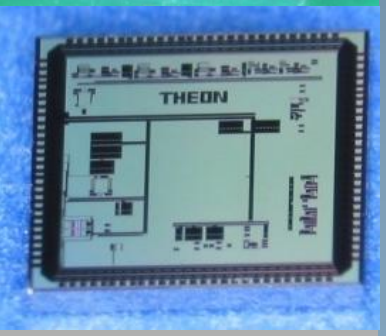
Irradiation Step	Accumulated Dose (rads Si)	Dose Rate (rads Si/min)
0	0	0
1	13500	11,34
2	27000	11,34
3	45612	11,34
4	94572	11,34

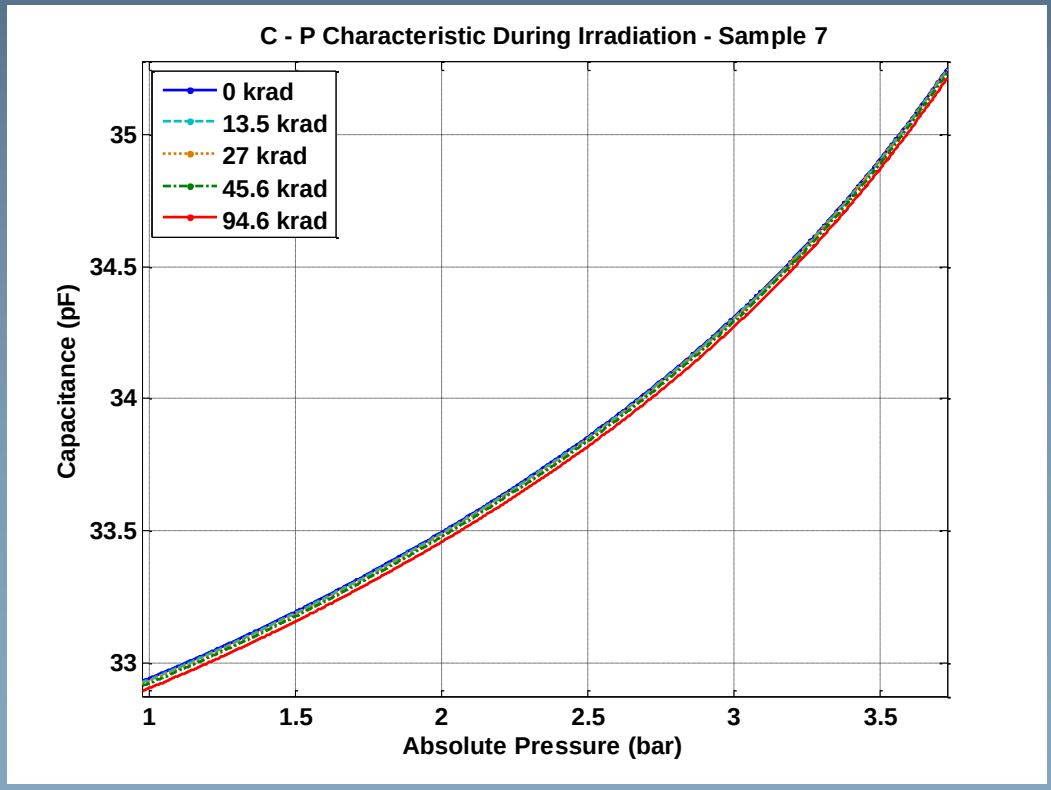
Performance Assessment
Total Irradiation Dose Tests

MEMS Sensor

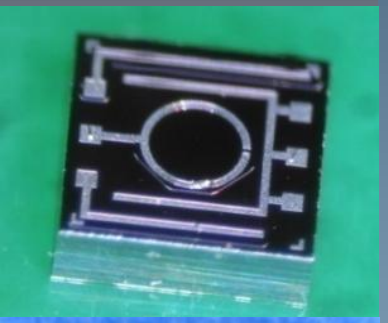
- **Test method: Remote Testing (C – P characteristic before and after each irradiation step)**
- ***Radiation effect is mainly observed as a negative offset in sensor's capacitance (< 2% FS)***
- ***Change in sensitivity is less than 0,4% FS***
- ***All dies remained functional throughout the procedure***

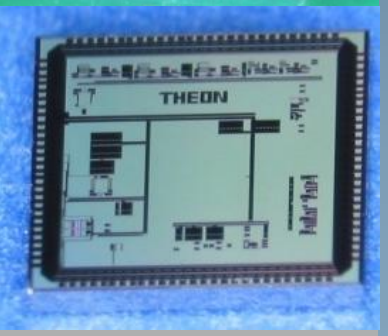






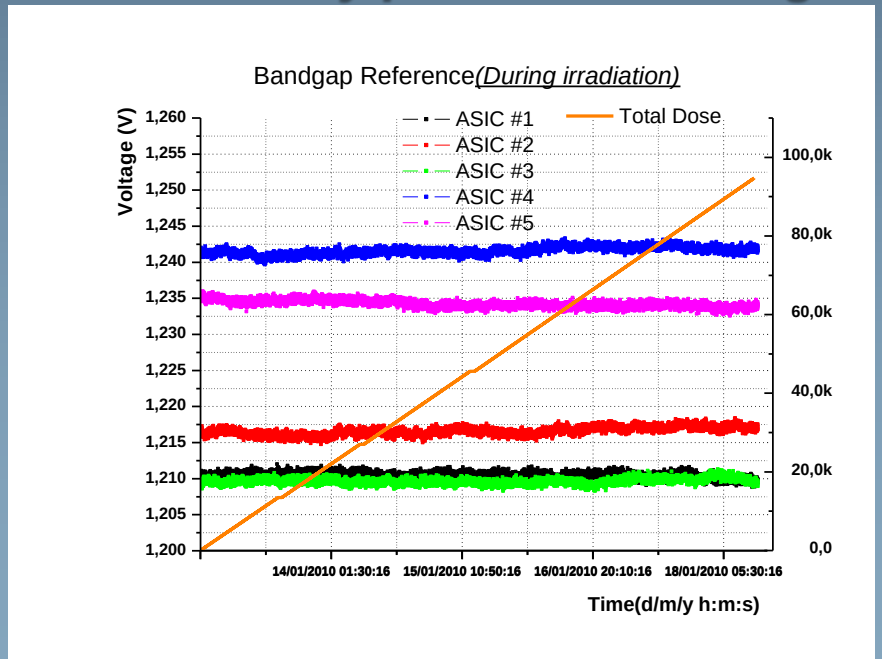
Performance Assessment
Total Irradiation Dose Tests





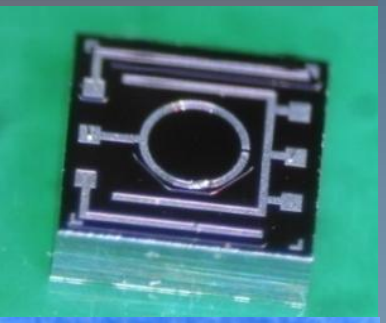
ASIC

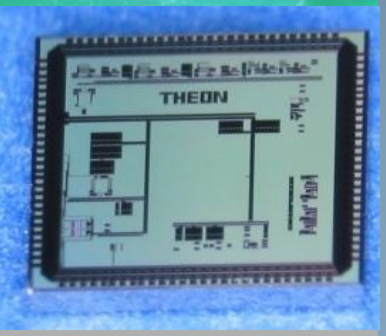
- Test Method: In-Situ monitor of V and I
- Basic key sub-circuits were tested:
  - ✓ Bandgap voltage reference
  - ✓ Temperature sensor
  - ✓ Buffer
  - ✓ Instrumentation amplifier
- *No change in power consumption and DC levels observed*
- *All ASICs remained functional after 7 days of continuous Irradiation without any performance degradation*



Future work

- Perform 2nd set of TID tests to assess the module's performance(including low dose rate)
- Requirements Definition of the target application
- Design and development of a technology demonstrator based on the requirements of the targeted applications

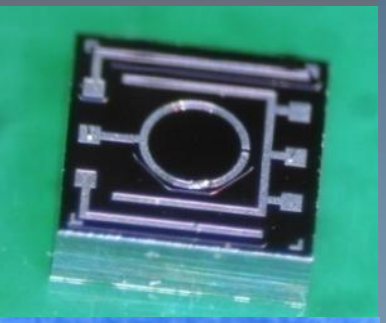


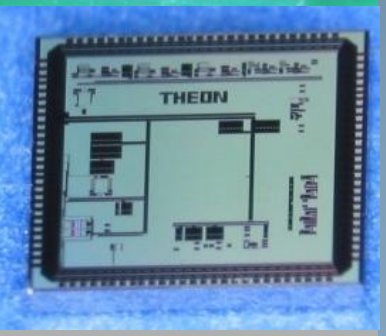


Summary

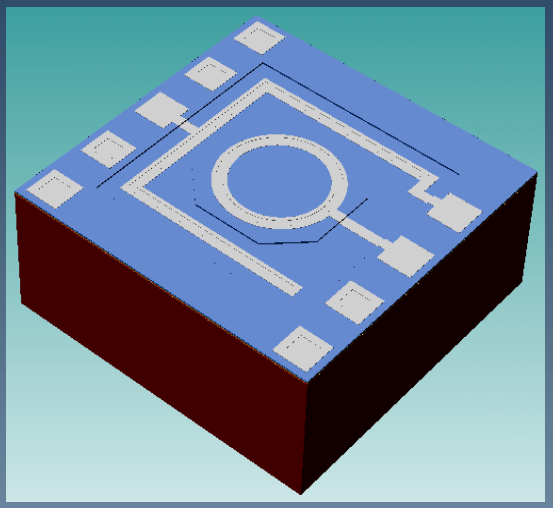
- THEON Sensors Technology for Pressure Sensors
  - MEMS pressure sensor
  - Readout Electronics ASIC

- Tests performed so far
  - Physical Analysis
  - Wafer/die/system level C-P characterization
  - Radiation tests (TID up to 100Krad)
  - Mechanical vibration and shock





…indicate that THEON's capacitive pressure sensing technology is a potential candidate for space applications



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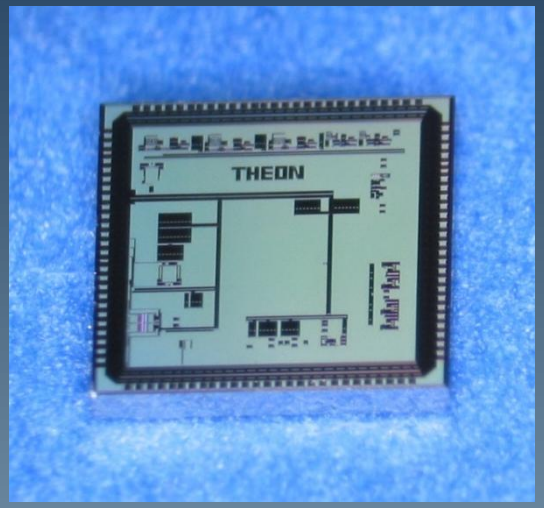

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