Development of Electronic Packages with Integrated Environmental Mitigation

Presented by Carl Rudd [EngeniusMicro]
On Behalf of Artie Bond, Brian English, Benoit Hamlin [EngeniusMicro] and Mark Adams, Robert Dean [Auburn University]
Problem

• Micro-electromechanical-systems (MEMS) can be highly sensitive to external vibration and temperature environments

• Common mitigations compromise the size and weight of the entire electronics system
Objective

Protect micro-electromechanical-systems (MEMS) sensors

• Mitigate fracture from environmental shock and vibration.

• Mitigate sensor errors caused by external temp changes

• Maintain MEMS size and power advantages

• Maintain or improve sensor performance
Principal of Operation

- MEMS Sensor packaged on microfabricated silicon isolation platform
- Platform has flexures compliant in X, Y, and Z directions
- Platform performs as a mechanical low pass filter
- Damper provides shock and vibration attenuation

View of MEMS sensor and isolator components
Nickel Mesh Damper

- Damper material should be compatible with hermetic packaging
- Experimentally determined damping ratios range from 0.1 to 0.21 with increasing fiber diameter
- Reflow soldered to isolator and bottom of package cavity. Have also glass frit bonded mesh to packaged
Isolator Design Process

- **Static Analysis**
  - Max VM Stress < 160MPa
  - Max total strain <2%
  - Max displacement/no contact

- **Modal Analysis**
  - Promote translation modes 1-3
  - Demote rotational modes
  - Mass participation >80% in translation modes

- **Harmonic Analysis**
  - Determine transmissibility of input displacement to platform center
  - Ensure max strain at resonance <2%
  - Maintain yield stress safety factor of 1.5

- **Vibration Spectrum Analysis**
  - Test structure at maximum PSD for all phases of operation

- **Mfg Tolerance**
  - Effects of sensor misalignment
  - Effects of assembly tolerance
  - Design of Experiments and Analysis of Variance Methods used
Isolator Fabrication

Fabrication Results
Testing

*Testing done at Auburn University

Test Results

Undamped Response

Damped Response

Output/Input Displacement vs. Frequency [Hz]

Output/Input Displacement vs. Frequency [kHz]
Errors from Temperature Instability

Ovenization:
How would you like your MEMS cooked?

Phosphorus doped polysilicon microheaters added to further improve sensor long term stability by maintaining constant sensor temperature.
Preliminary Development & Testing

• Heaters designed for total max power of 100mW.

• Simulations shown that heaters can maintain platform temperature of 20°C with ambient of -20°C and a 10 W/m²K convective coefficient.

• Developed PID feedback controls for maintaining a set temperature. Characterization of the RTDs and microheaters was required to do so.
Summary

- Mitigated vibrational noise errors via application of a chip scale micromachined isolators in combination with a microfibrous metal mesh damper
- Mitigated thermal strain errors via ovenization of isolator platform
Thank you!

www.engeniusmicro.com
+1 256-261-1260
Carl.Rudd@engeniusmicro.com
Brian.English@engeniusmicro.com
Benoit.Hamelin@engeniusmicro.com