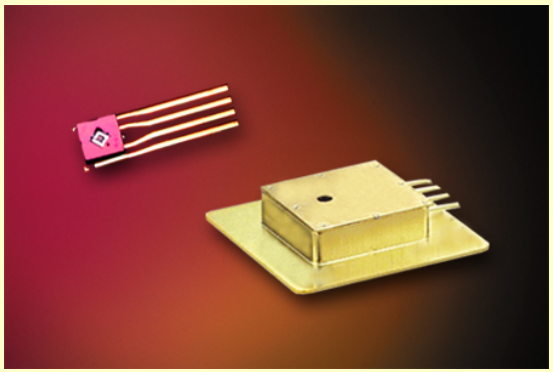
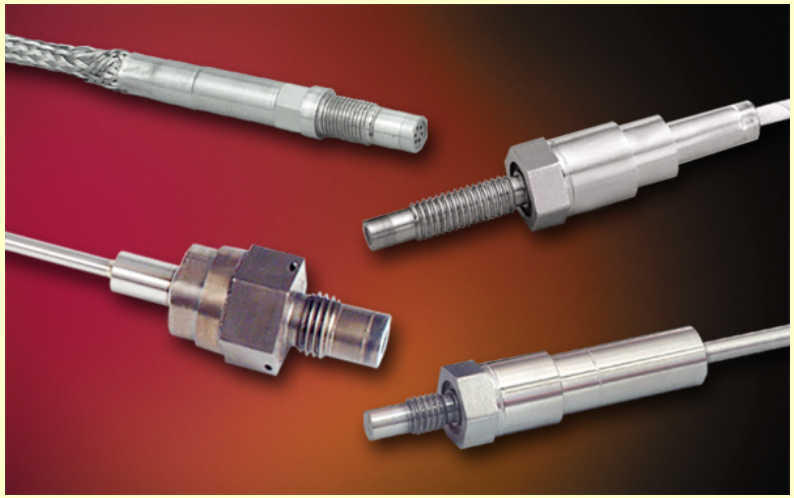
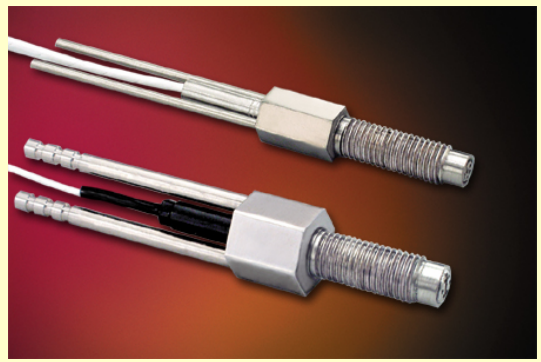
Latest Ruggedized Transducers for Extreme Environments with Static and Dynamic Capability

A.D Kurtz, and A.A. Ned







Kulite Semiconductor Products, Inc.
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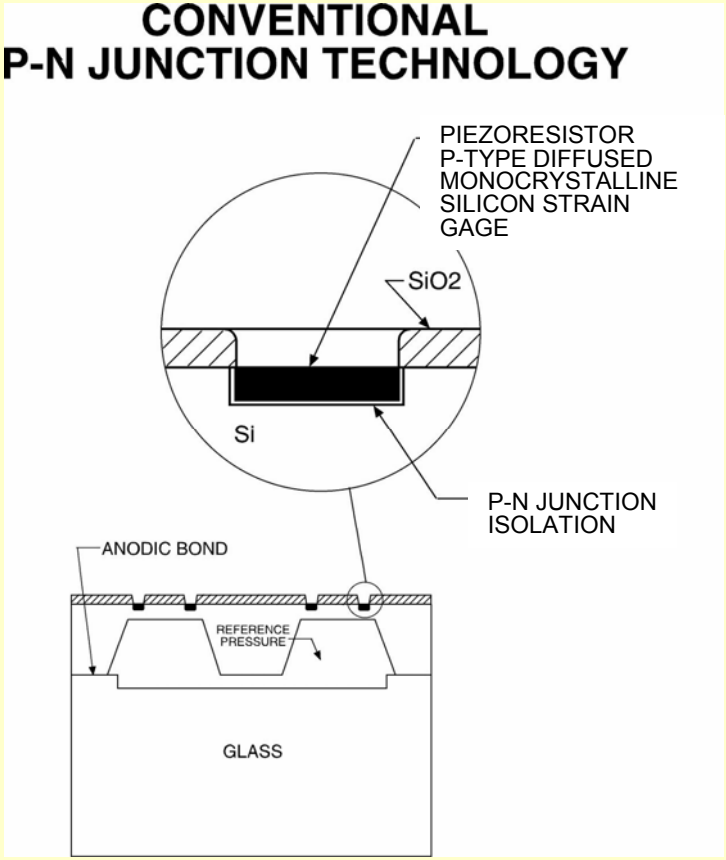
Fort Worth, TX June 20-21, 2006

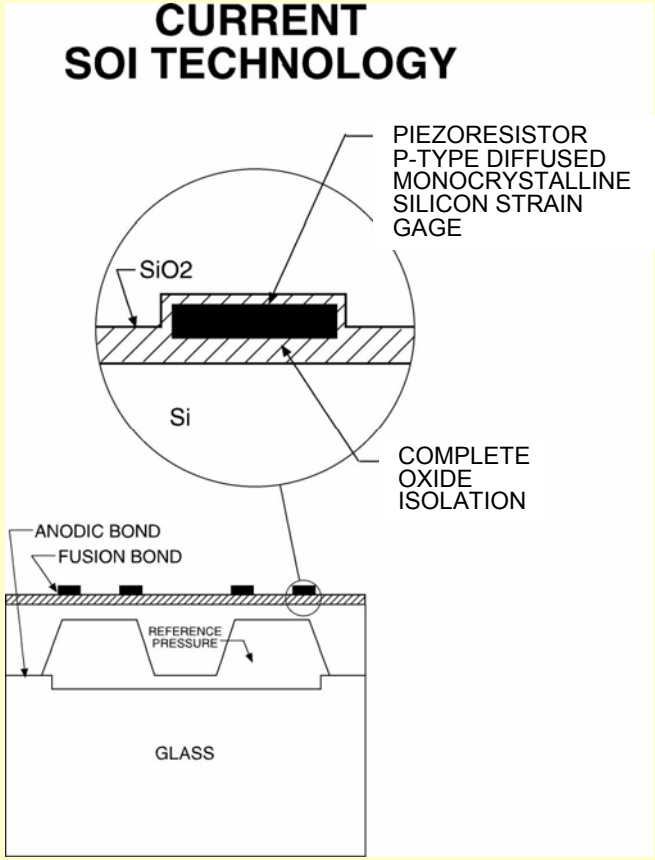
Industry Requirements

- Temperatures Up To and Above 650°C
- Harsh Environments
  - Acceleration Greater Than 1000g
  - Corrosive/Oxidizing
- Static and Dynamic Measurement
- High Frequency Response
- Vibration and Acceleration Insensitivity
- High Pressure >50,000 SOI Transducers

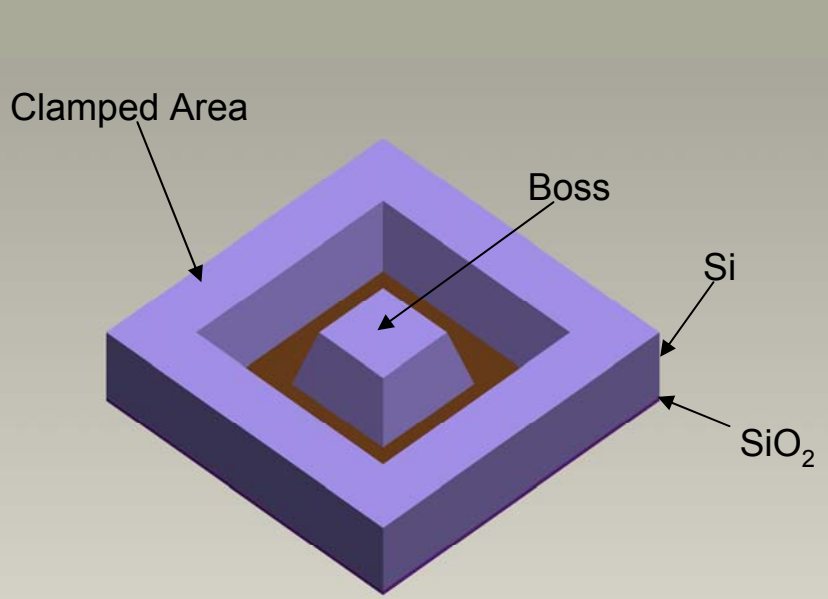
“Silicon Is The Ideal Choice”

Silicon (SOI) Integrated Sensors

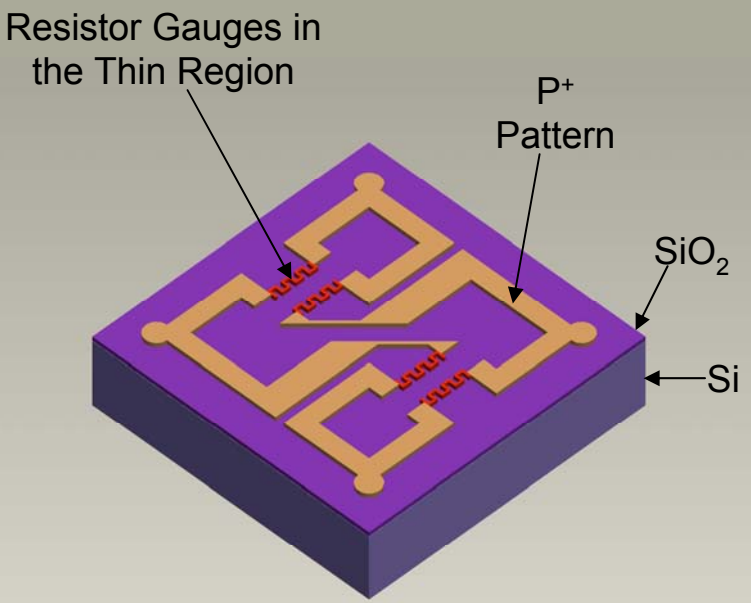




Silicon SOI Integrated Sensors



Diaphragm Side Isometric of Sensor Chip



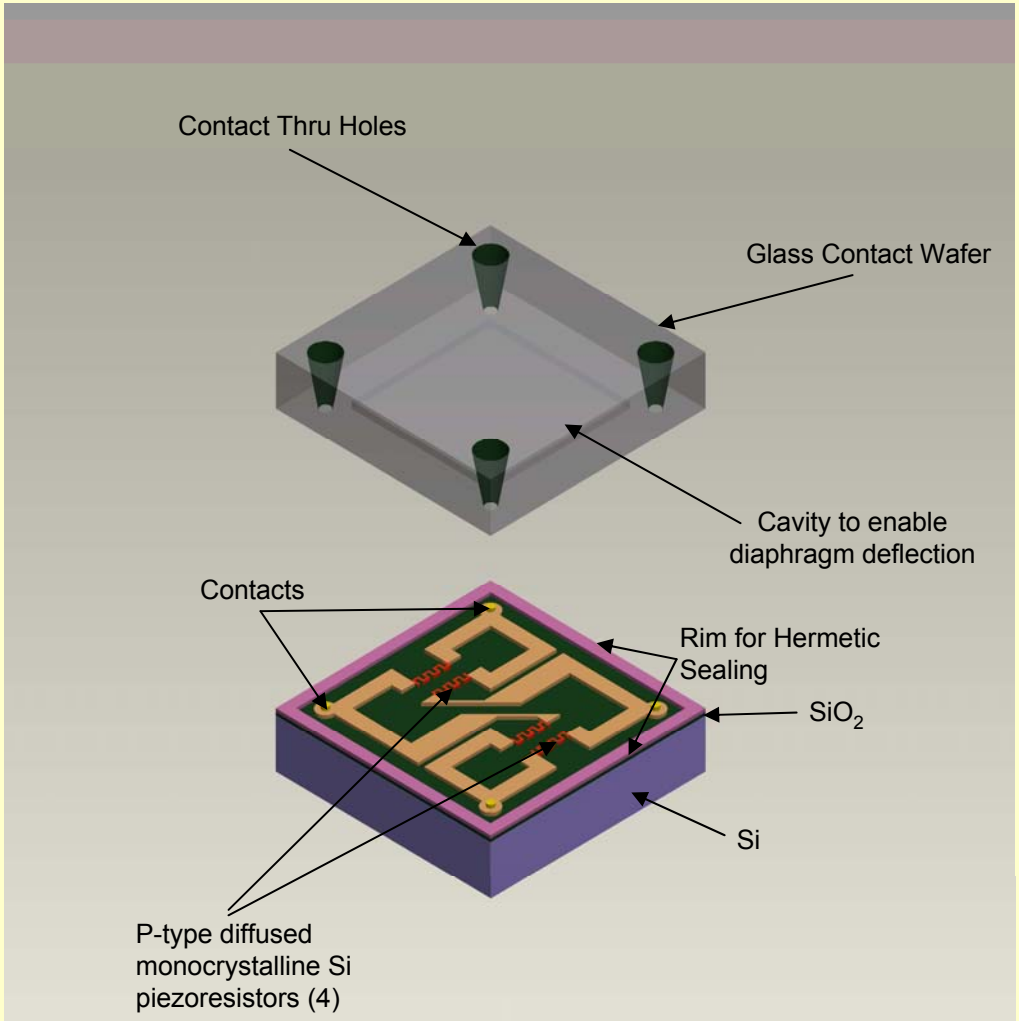
Gauge Side Isometric of Sensor Chip

Sensor Optimization

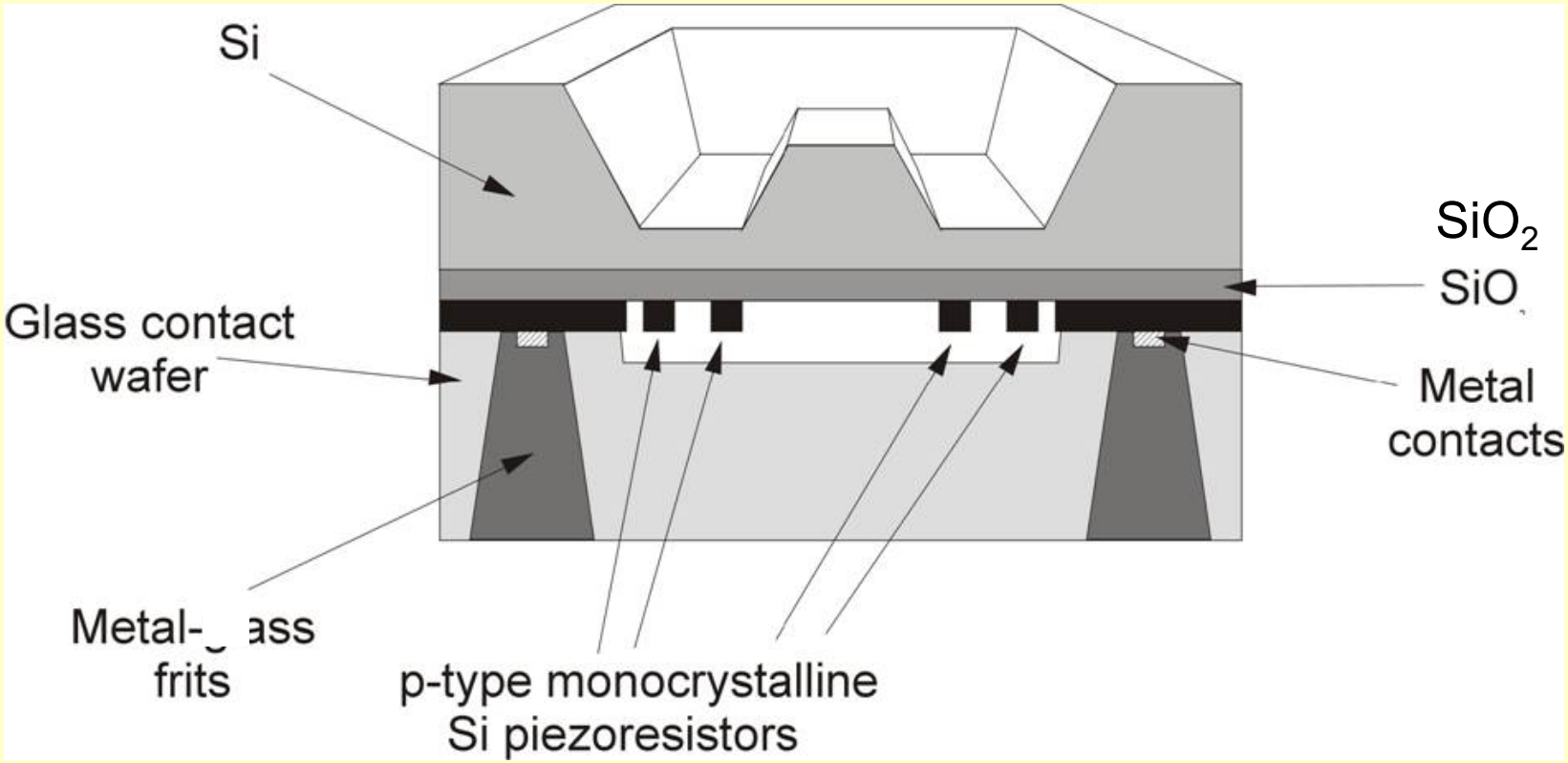
- Sensor Performance Characteristics
- High Temperature Capability
  - Electrical Interface
  - Dielectric Isolation
  - Mechanical Assembly
- Harsh Environment Capability – Leadless
- Ruggedized Construction

Leadless Sensor Design

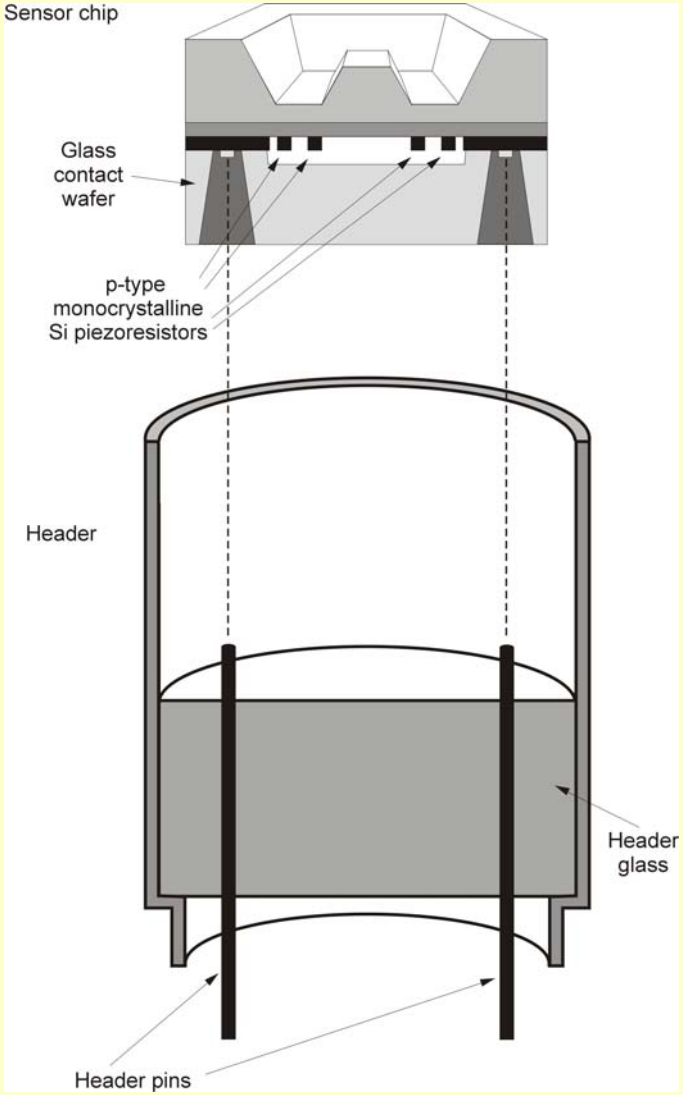
- **Patented Design**
- **Eliminated Wirebonds**
- **Hermetically Sealed Piezoresistive Network**
- **All High Temperature Materials**

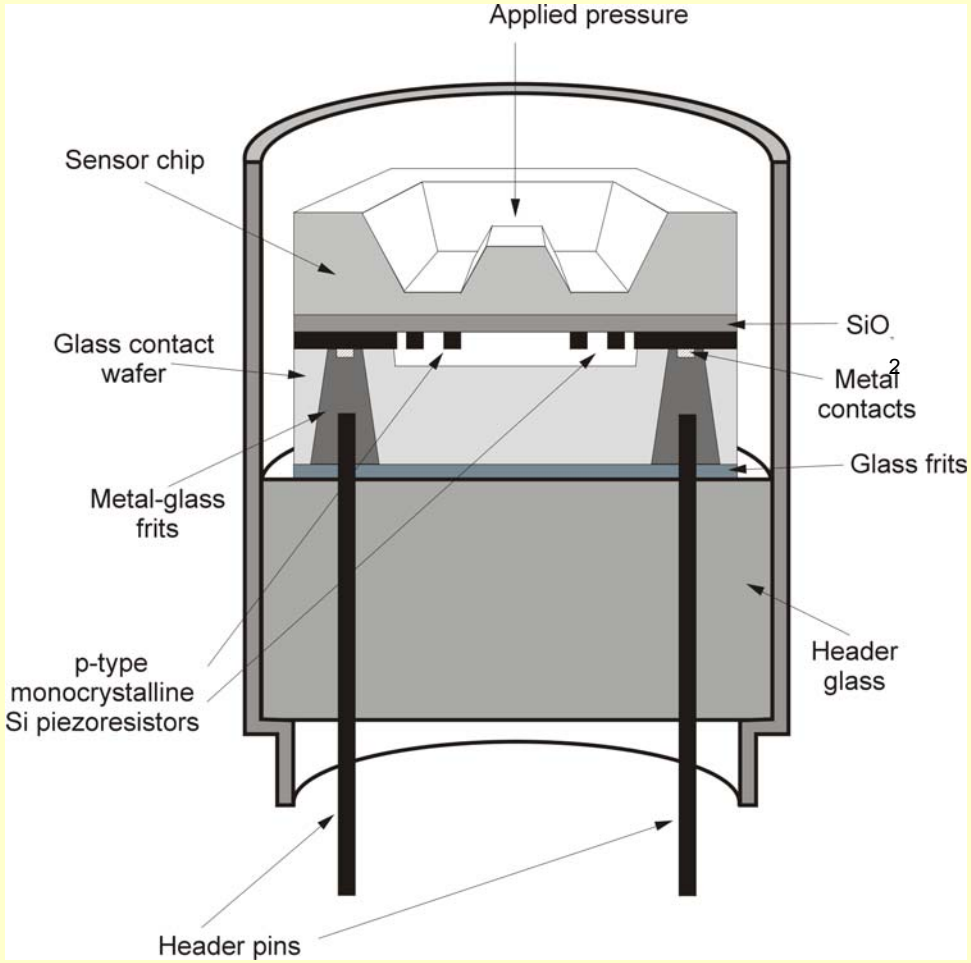


Side View of the “Leadless Chip Composite” after Filling with Glass-Metal Paste for Contacting

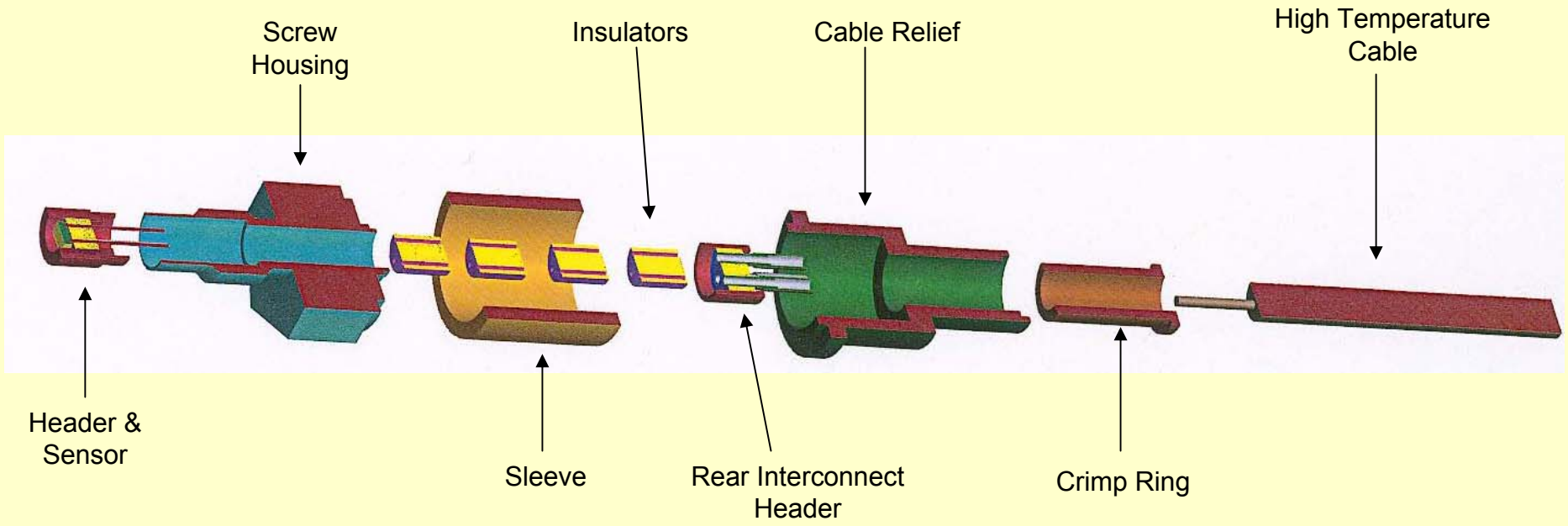


Leadless Packaging

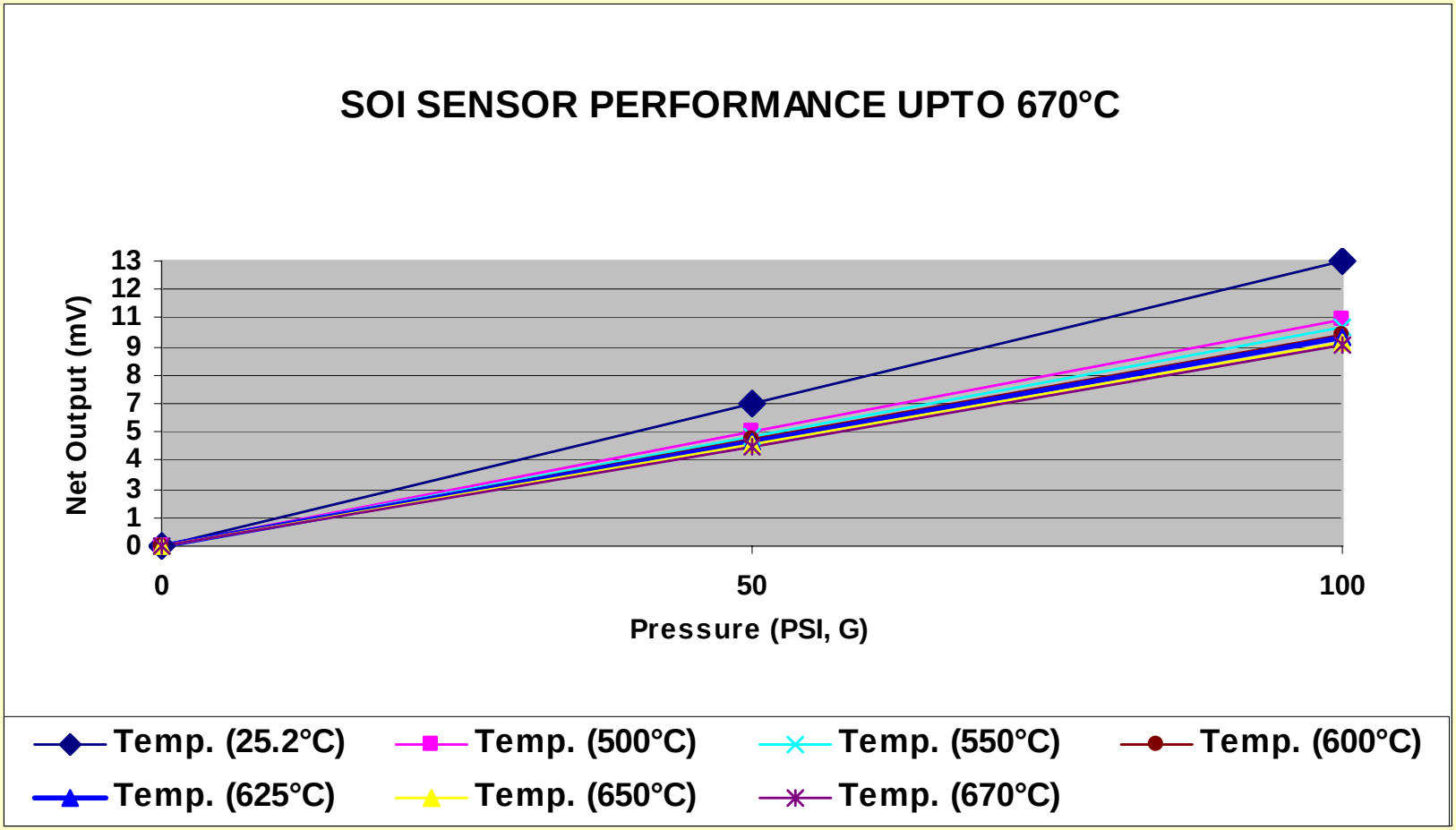




High Temperature Leadless Assembly



Sensor Performance



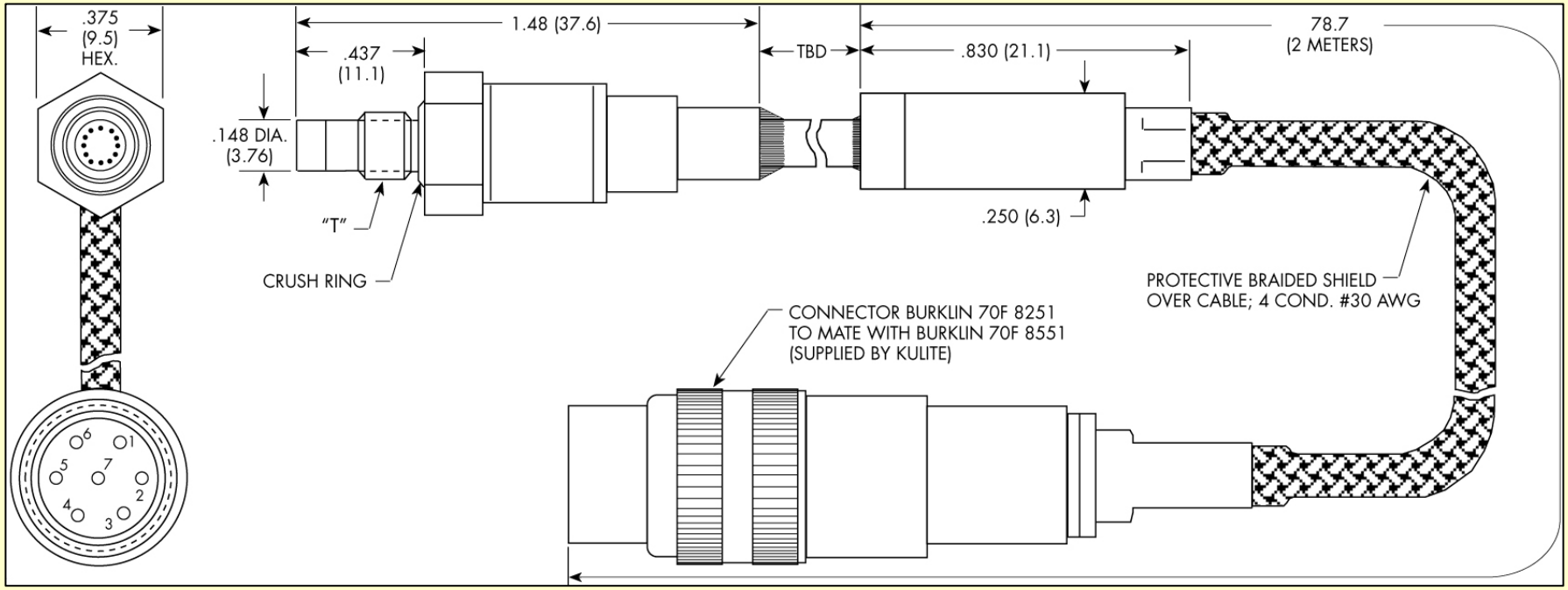
Dynamic Performance

- Evaluated Sensors Ranging From 5 psi to 1000 psi
- Excellent Dynamic Performance
- Dynamic Response Ranged From 150 KHz to MHz Range

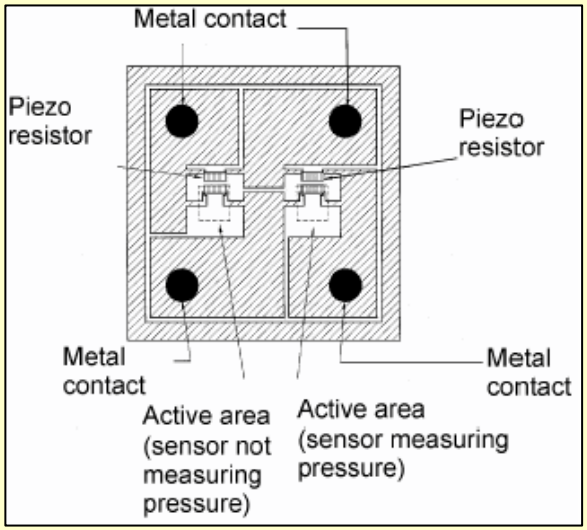
HIGH TEMPERATURE MINIATURE RUGGEDIZED PRESSURE TRANSDUCERS WITH SEPARATE STATIC AND DYNAMIC OUTPUTS

ETLH-SR-190

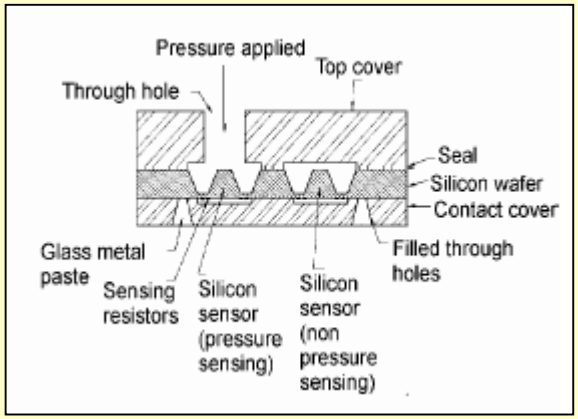
- Miniature, Robust Construction
- High Temperature
- Acceleration & Vibration Insensitive
- High Bandwidth Amplifier (150 KHz)
- Separate DC and AC Outputs

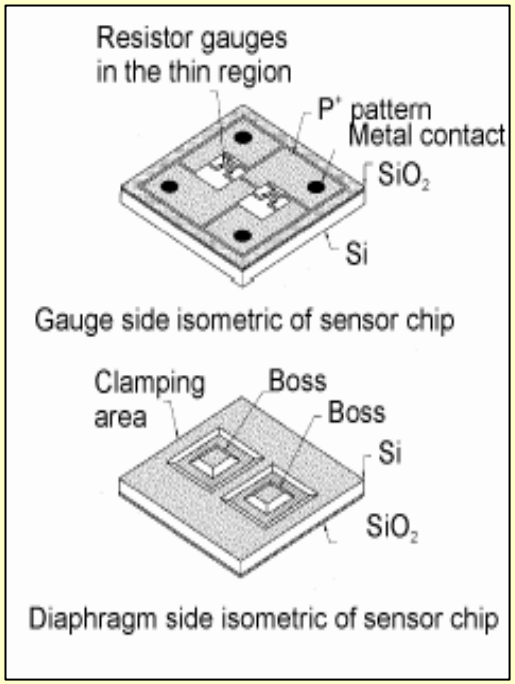


g-insensitive Pressure Transducer



- **US Patent Application Allowed 9/459,238**
- **Testing by Roger Ainsworth, University of Oxford**
- **G-sensitivity: < .000001% FS/g vs. old style: .0004% FS/g**





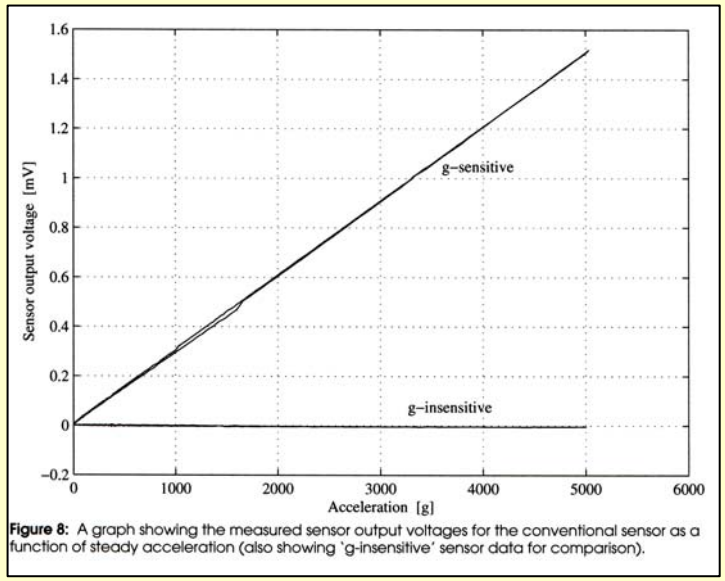
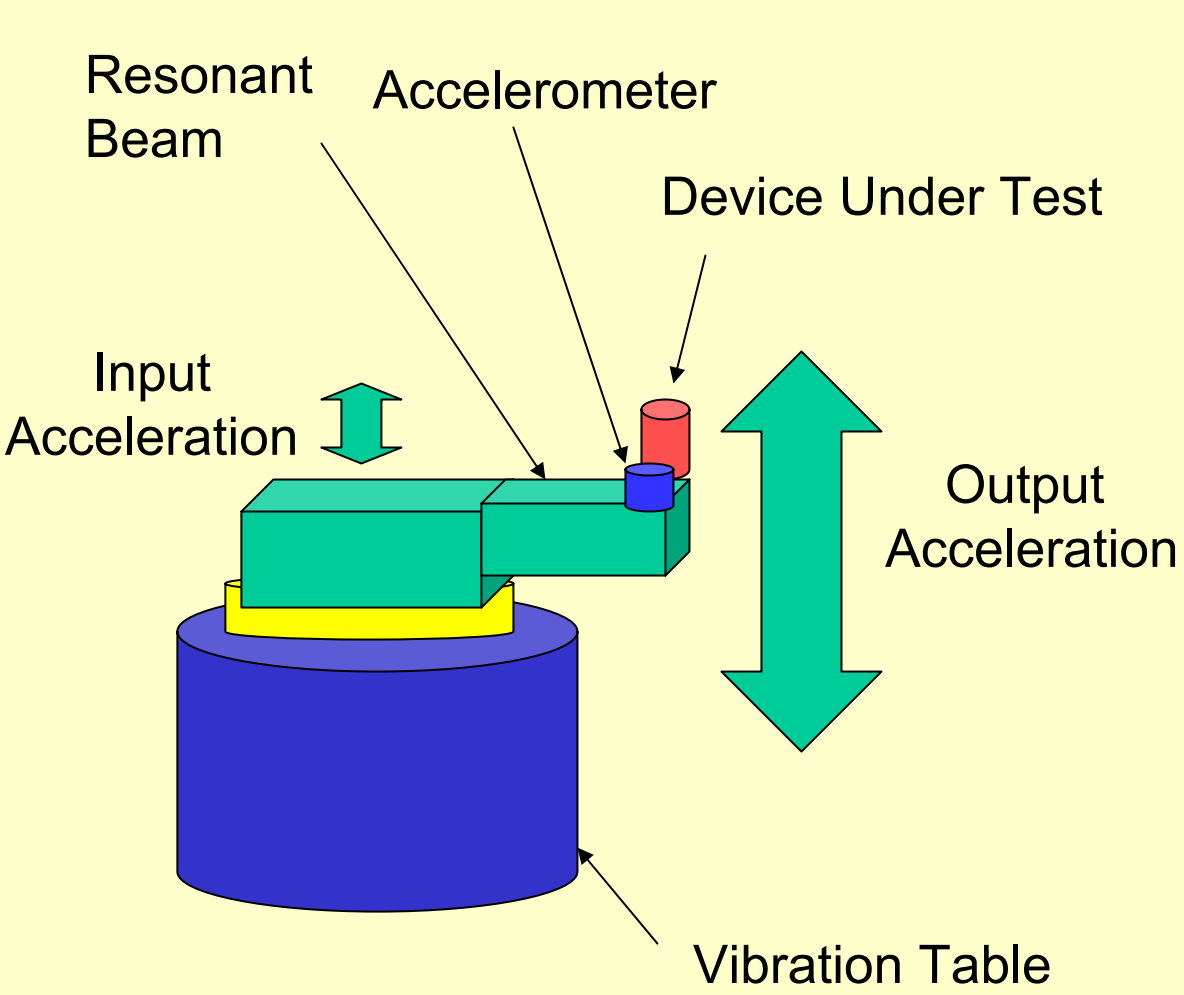
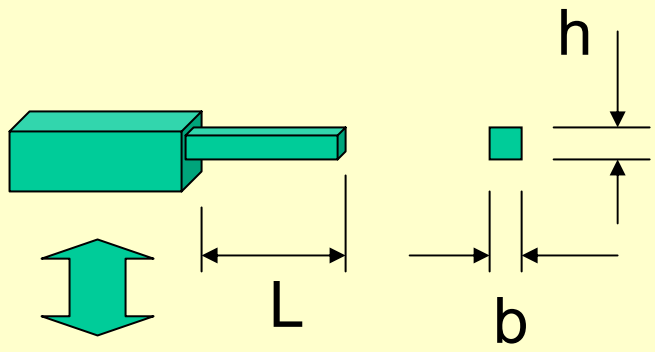


Figure 8: A graph showing the measured sensor output voltages for the conventional sensor as a function of steady acceleration (also showing 'g-insensitive' sensor data for comparison).

Resonant Beam Apparatus





$$I = \frac{bh^3}{12}$$

$$K = \frac{3EI}{L^3}$$

$$f_R \approx (1/2\pi)\sqrt{[K\ G/W]}$$

$$R = \frac{1}{1 - (f/f_r)^2}$$

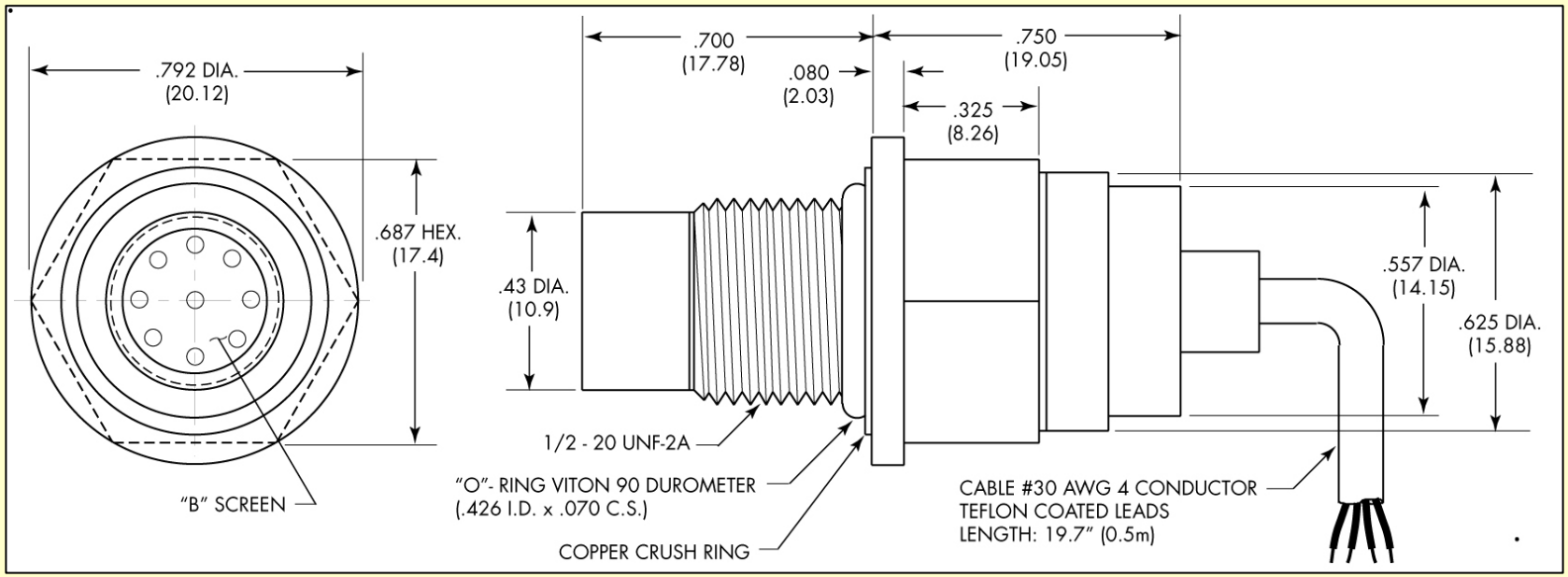
Mechanical Robustness Evaluation

- All Transducers Evaluated Up To 1000G for long term use.
- Extreme G-Level transducers are established.
- For Measurement In High Acceleration/Vibration Environments the Vibration Insensitive Sensor (VIS) Should Be Incorporated.

MINIATURE ULTRA HIGH PRESSURE IS®

HKM-15-500 (M) Series

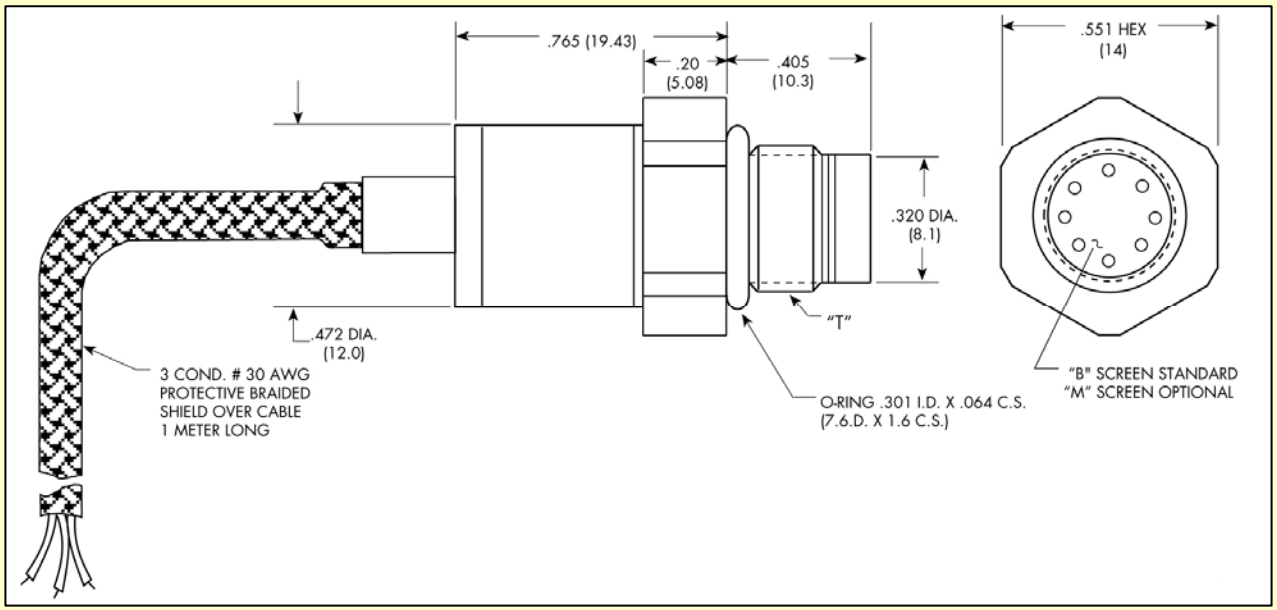
- Excellent Stability
- All Welded Construction
- Robust Construction
- High Natural Frequency



ULTRA HIGH TEMPERATURE AMPLIFIED MINIATURE IS®

ETM-UHT-375(M)

- Smallest High Performance Amplified Transducer Worldwide
- Highest Temperature Electronics 500˚F (260˚C)
- Rugged Design Provides Compatibility with Most Corrosive and Conductive Media
- High Bandwidth



Summary

- Latest Generation of High Temperature Leadless Transducers Designed, Fabricated and Evaluated
- Operability Above 650ºC Demonstrated
- SOI Leadless Design – Harsh Environments
  - Excellent Static Performance
  - Excellent Dynamic Performance
  - Highly Robust Design
  - Truly Vibration Insensitive
- Suitable To A Variety Of Transducer Applications.