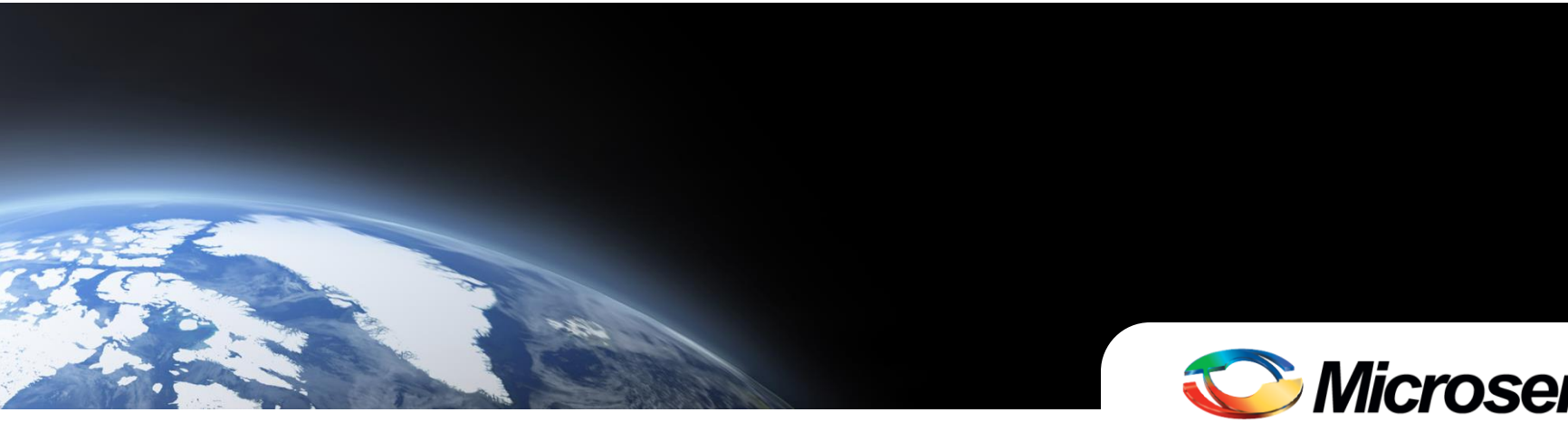
Power Matters.™



High Voltage / High Current Next Generation Satellite Requirements

Microsemi Space Forum 2015

Kent Brooten,
National Sales Manager

Microsemi
SPACE FORUM

Agenda

- HV / HC challenges in a space environment
- Review a HV development project
- The Approach
- The Challenges
- The results
- Questions

Switching High Voltage and High Current in Space

A customer looking for a solution

The Project

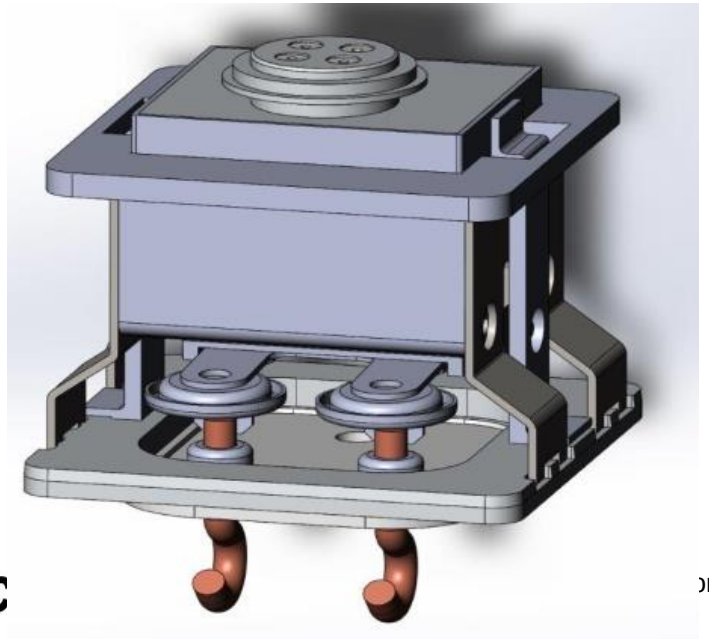
- HV space grade relay capable of 10,000 V isolation
- 30A continuous, 47A peak
- 200°C operating temp
- 25 year life: 5 years on the ground, 20 years in space
- High shock and vibe

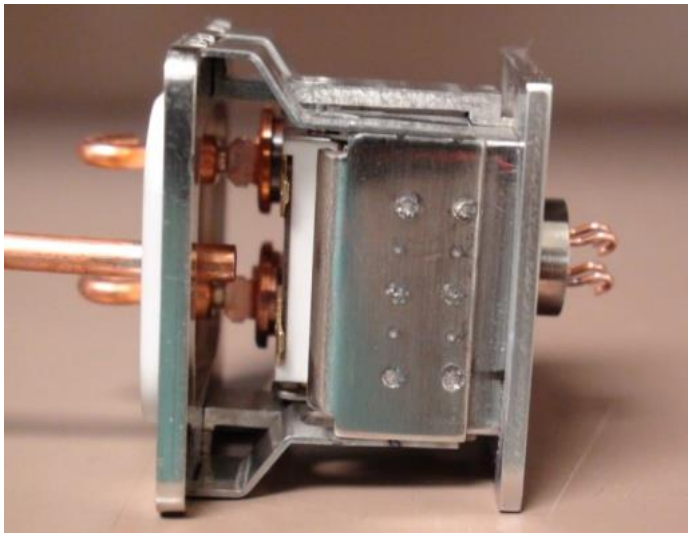
Microsemi Legacy Products

- Space Grade electromechanical relays since 1957
- Ultra high reliability
- Excellent performance in severe shock and vibe
- 25A devices in production
- 5A to 200A contactors (Military grade) with current sensing and remote control
- Longtime experience with hermetically sealed stainless steel cases
- Longtime experience with space application latching relays

Microsemi Design Approach

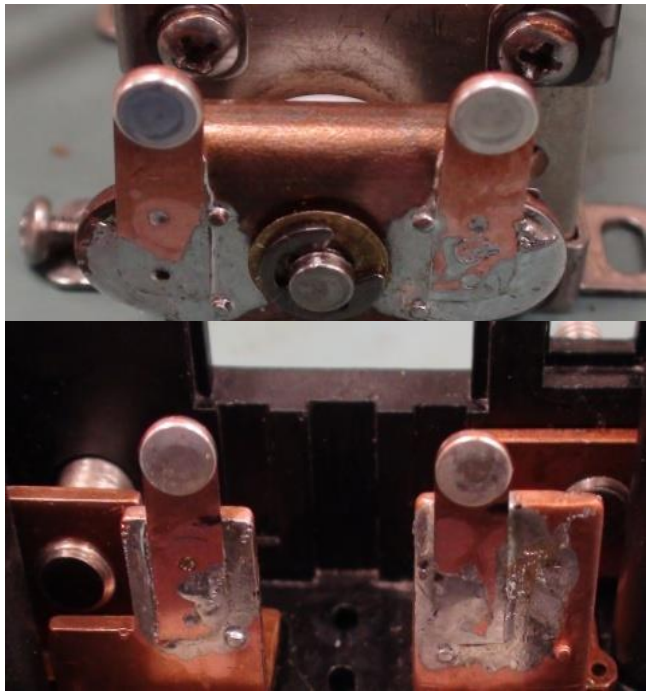
- Use legacy structure, just larger
- Use legacy contact materials with larger contacts
- Use legacy coil structure inside a sealed chamber
- Use high vacuum sealing
  - Up to 10^{-10} torr
- Use same vendor for ceramic header, same terminal types, same sealing procedure

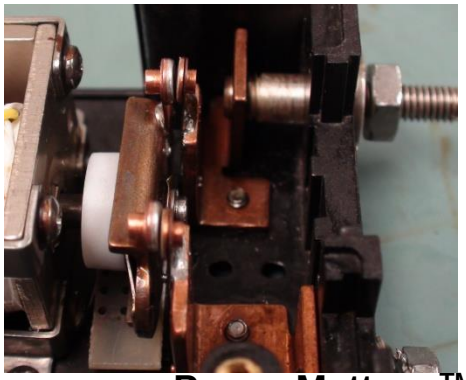




Heat Issues

- Contact size, material and shape all influence thermal performance
- Terminal design conducts heat away from the contacts
- Customer interconnect assists in thermal transfer
- Wear of contacts is both simulated and tested to insure long life over temp range

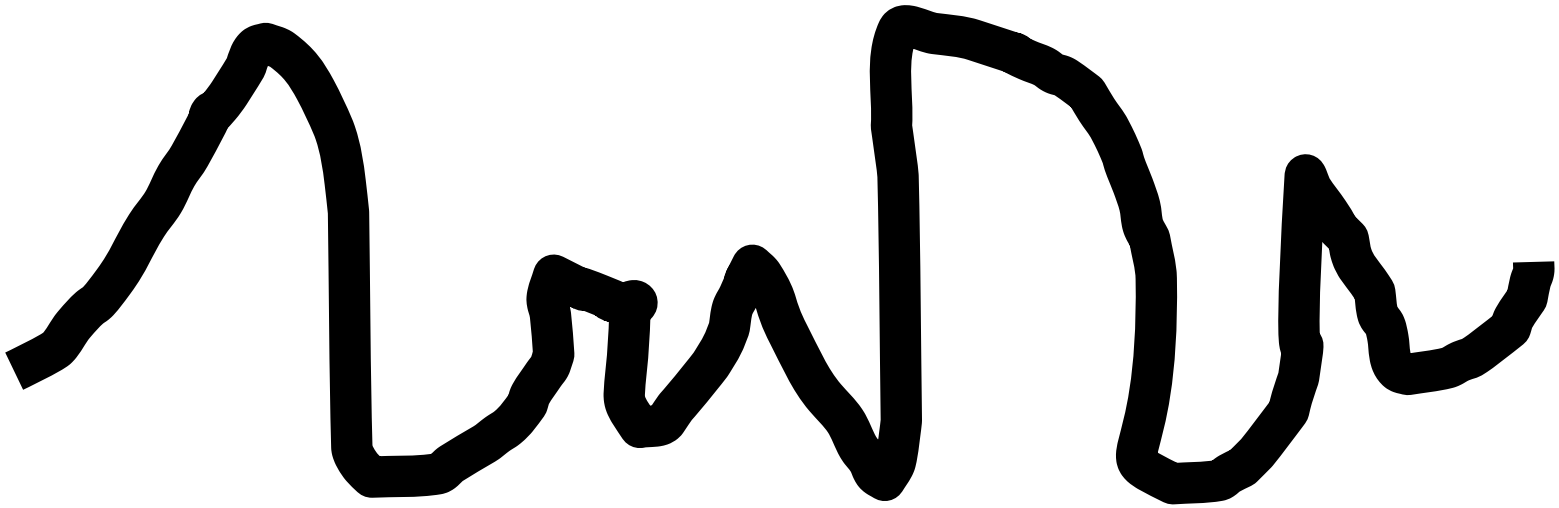




Stainless Steel Case – Low Voltage Assembly

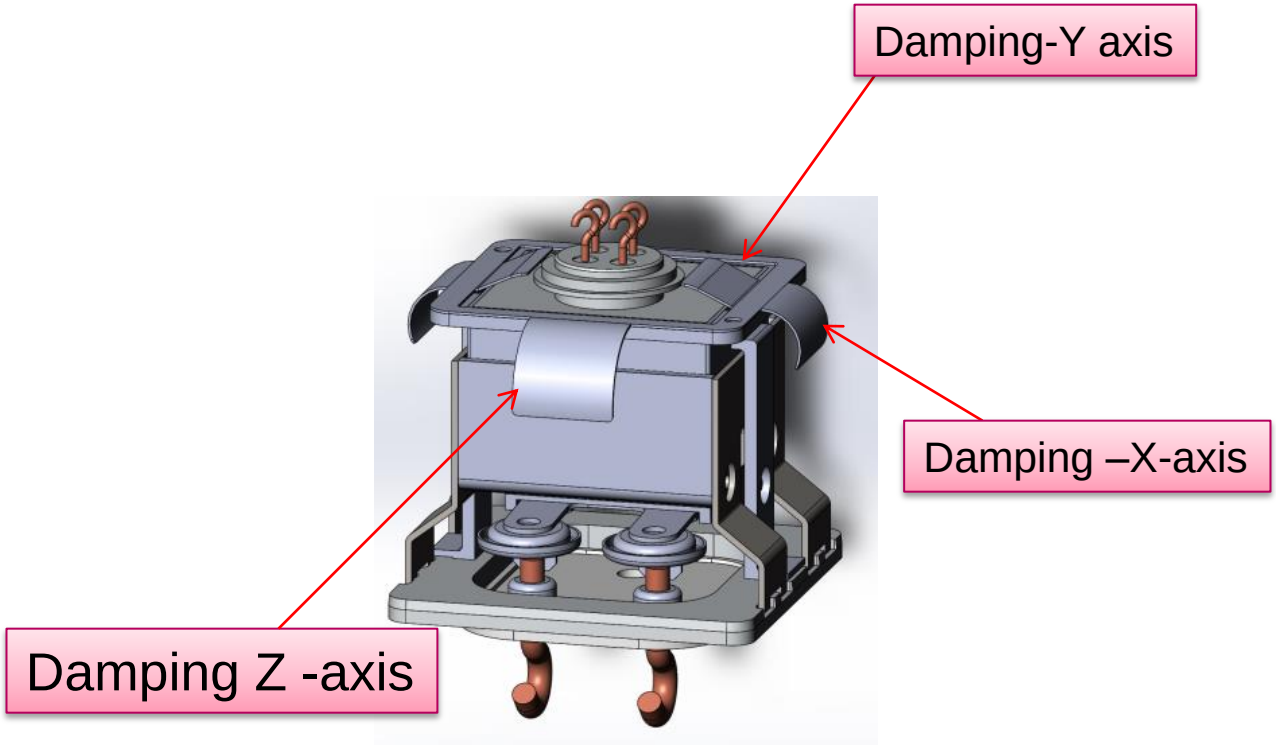
- Historically baked the stainless case for 72 hours
- This drives out any surface gases trapped in metal surface microstructures
- All space units are assembled in clean room
- Unit is Electron Beam welded
- Mechanical life test results were initially poor – the size of the LV assembly was not sufficiently anchored

Shock Video



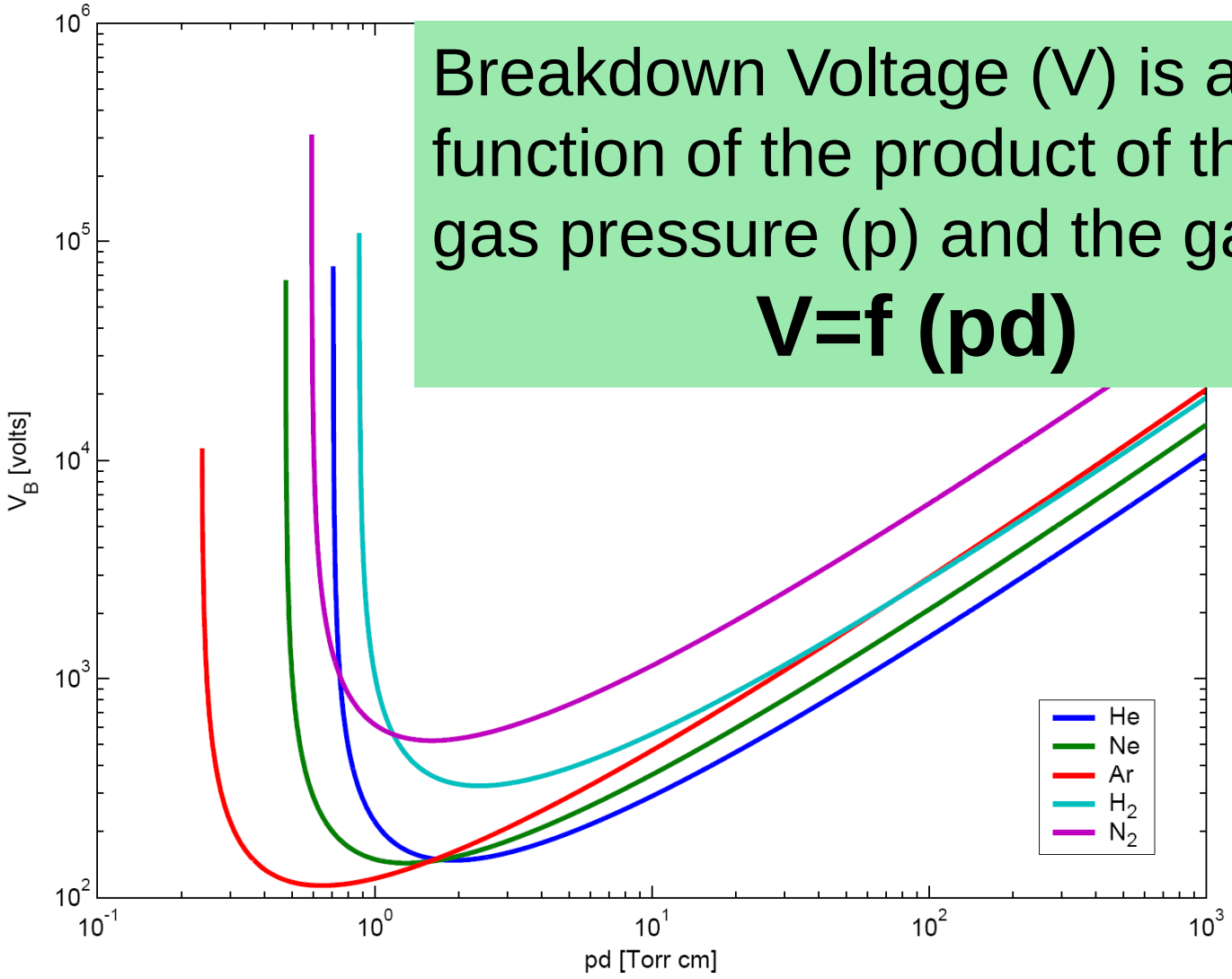
Preliminary Shock and Vibe

- Size of unit increased 3X from legacy unit
- Initial testing didn't survive shock and vibe
- Sturdier mounting spring clamps needed to be designed and implemented to meet requirements



Paschen's Law, Paschen's Curve

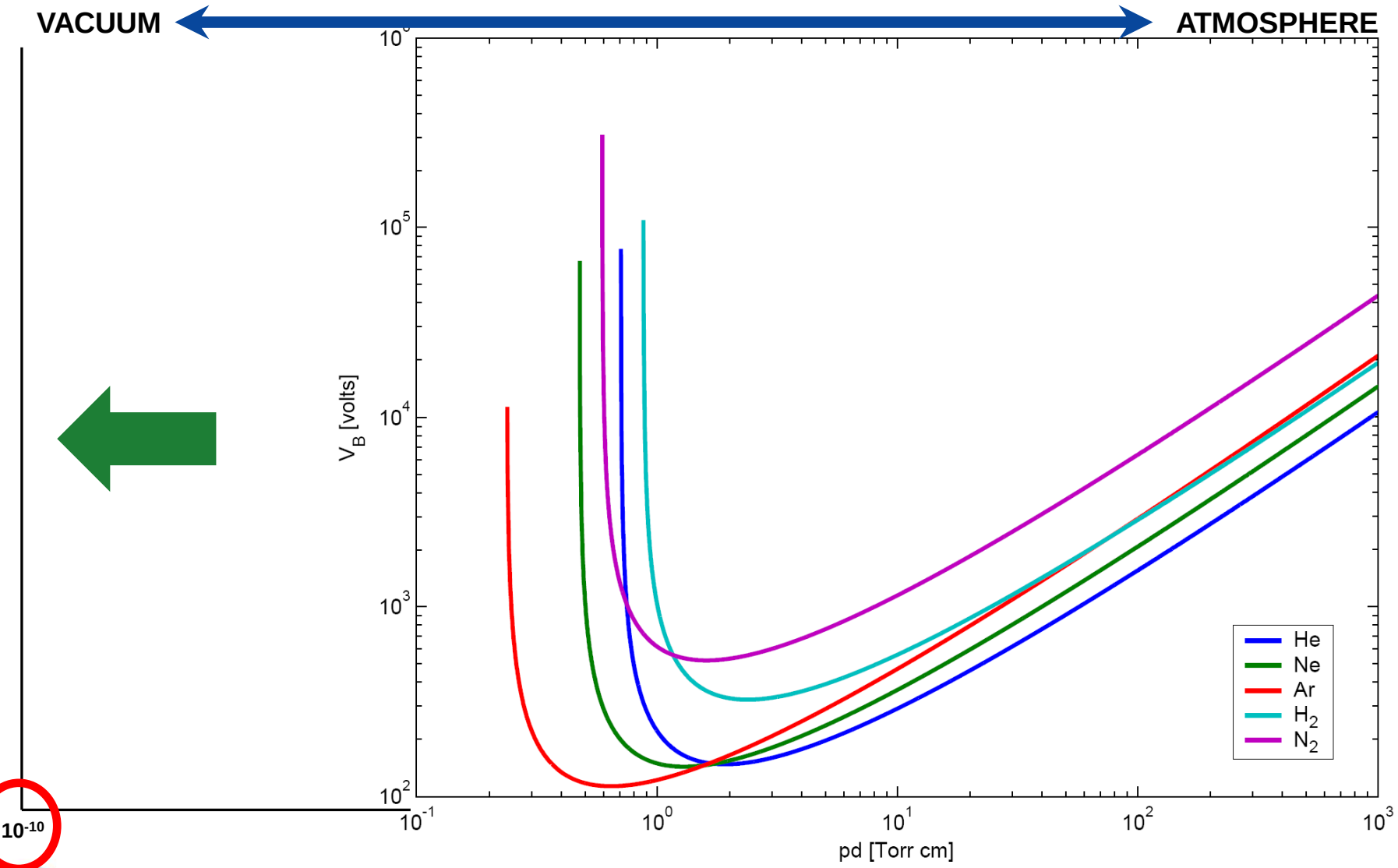
VACUUM **ATMOSPHERE**



Breakdown Voltage (V) is a function of the product of the gas pressure (p) and the gap (d)

V=f (pd)

Paschen's Curve



The Secret Ingredient

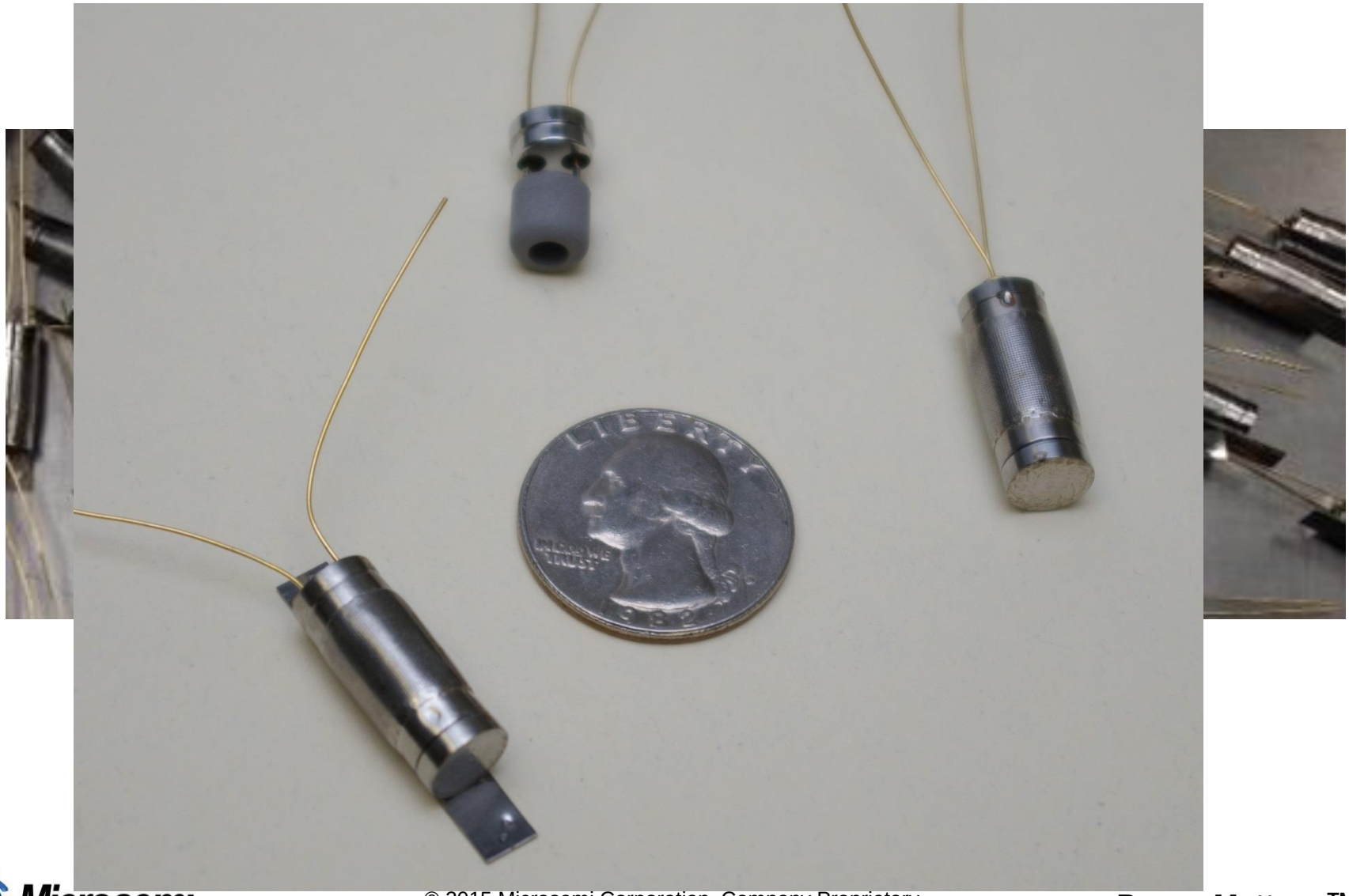
- Even when baked at high temp for an extended period of time under high vacuum, it isn't enough
- Stainless steel will slowly release (desorb) molecules into the chamber. Outside atmosphere will leak through the welded joints eventually. 2 ½ yrs @ 1 atm (760 torr) is limit
- If molecules in the chamber increase by a few orders of magnitude, the contacts will arch, causing transfer of materials from one contact to the other which results in a smaller gap and more arching
- How to re-clean the environment inside the sealed chamber?
- The problem was solved in the 1940's when vacuum tubes were the building blocks of electronics
- Enter the Getter

The Getter

- The Getter, when heated will cause a electrochemical reaction which will bond the stray molecules to the getter materials, effectively cleaning the unit on the inside.
- The user can activate the getter just before final assembly or launch (or even while in orbit) to return the chamber to near original factory condition.
- A patented[1] all stainless steel package had to be build that would keep the getter particles from getting out and still allow the gas in.
- A Packaging structure was designed to secure the getter during shock and vibe

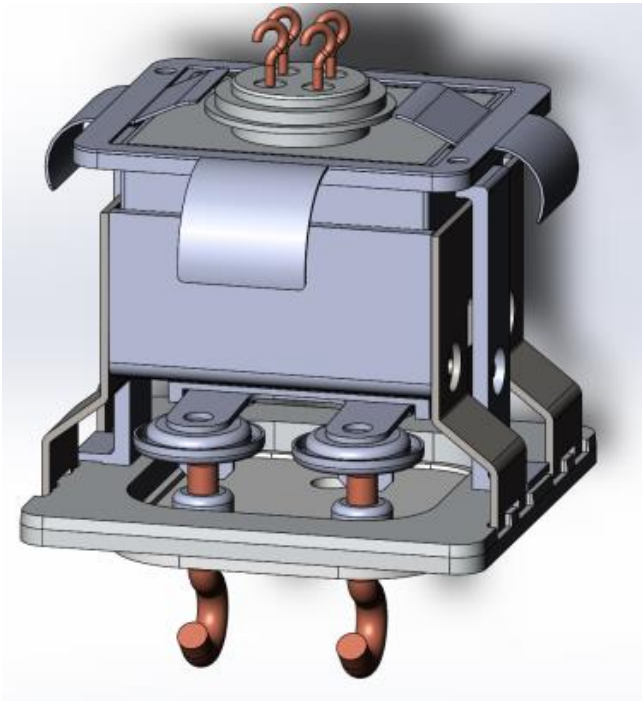
Note 1: patent pending

The Getter

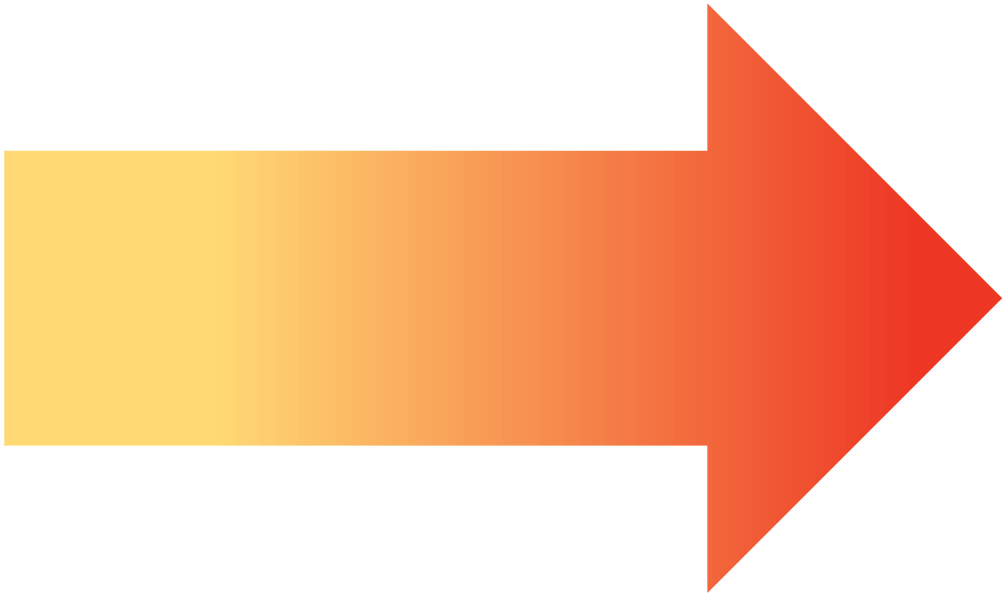


The Final Hurdle

- During qual it was discovered a small number of units would bind during life testing.
- After significant analysis and simulation it was discovered that since the coil box was sealed at a different pressure than the contact assembly, there was a minor deflection of the relay hinge (0.001 to 0.003)
- Sealing both assemblies at the same vacuum solved the problem



Vibration Video



The Final Result

- HV isolation is 8,000V to 10,000V
  - Can design to >10kV
- Constant Carry Current is 30A with 47A peak
- Life is 25 years
- Contact life is 100,0000 cycles
  - Can be designed to 1,000,000 if necessary
- Mass is 120 grams
- Size is 1.5” X 1.5” X 1.25”
- Coil resistance is 150Ω
- Coil Voltage is 28V
- Shock is > 400G’s, 0.5 mS pulse
  - Survivability up to 800 G’s 0.25 mS
- Vibration is > 24G sine, 25 g_{RMS} Random Vibe,
  - Survivability up to 35 g_{RMS}
- Chatter < 500 µS
- Transfer = none

Modified or Customized Relays

- Microsemi presently builds space grade relays from 1A to 50A in multiple output configurations, latching or non-latching, optional suppression diode, with a large variety of mounting options and termination styles
- Please contact us if you have electromechanical power switching needs that are not satisfied by existing catalog products
- If you are in need of a high current (~450A) space grade contactor, or high current relay (~50A), or high voltage (~15KV), with stringent shock and vibe testing requirements we'd like to understand and support your needs.
- Can modify for DPDT, 3PDT, 4PDT

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Thank You

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