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Sandia National Laboratories

Development of a high-temperature and high-pressure electrical feedthrough

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U.S. DEPARTMENT OF ENERGY | NNSA

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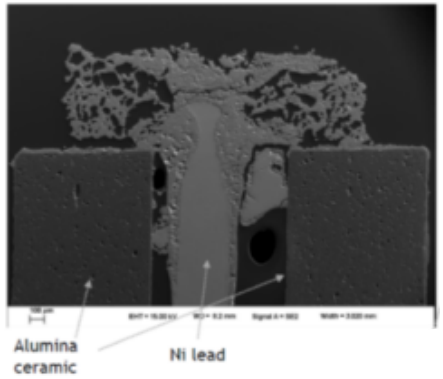
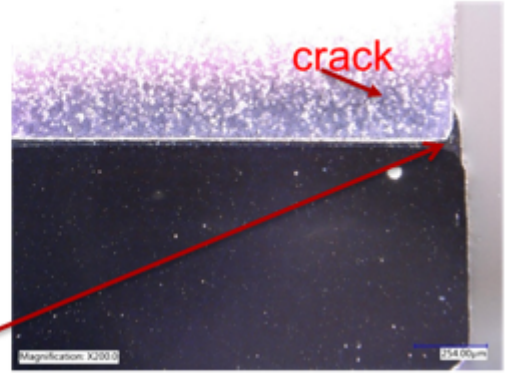
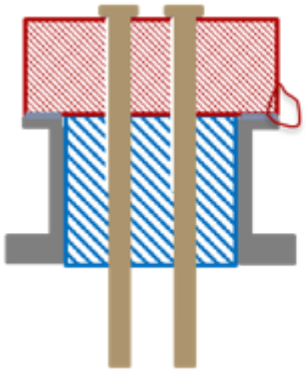
Problem statement – 1000°C and 1000 psi

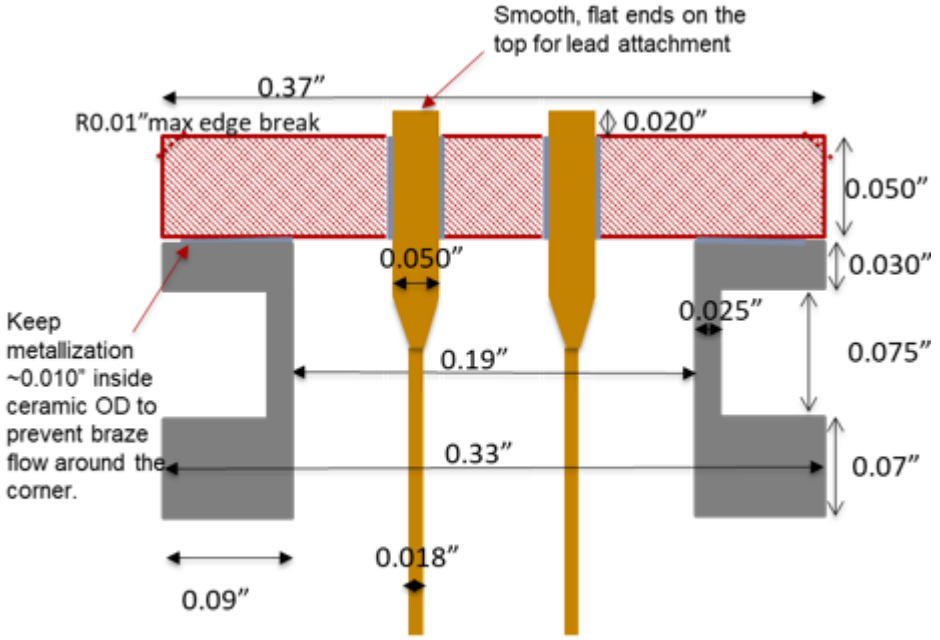
Design and build a small sized electrical feedthrough capable of maintaining hermeticity during and after high temperature and high pressure exposure.







- Avoid excess braze fillet near edges to prevent stress cracks.
- Leave ~0.010" clearance at OD during metallization.



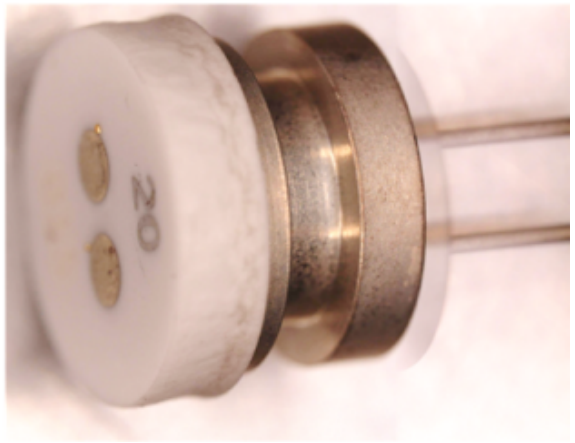
Two paths – Braze Pins and Cermet Vias

Brazed pins

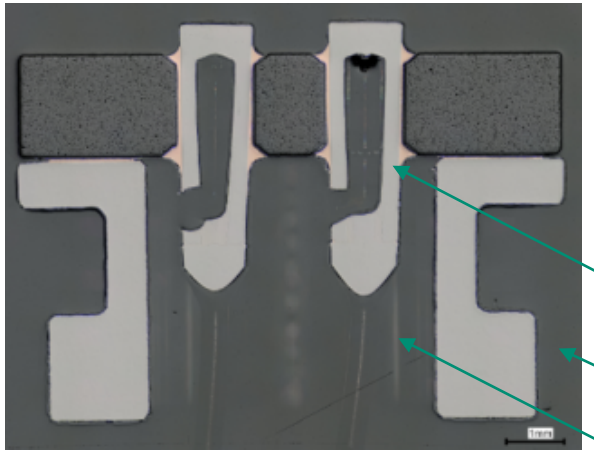
- Kovar or Ni pins
- Kovar or Ni leads
- Kovar flange
- Ni plate and Non

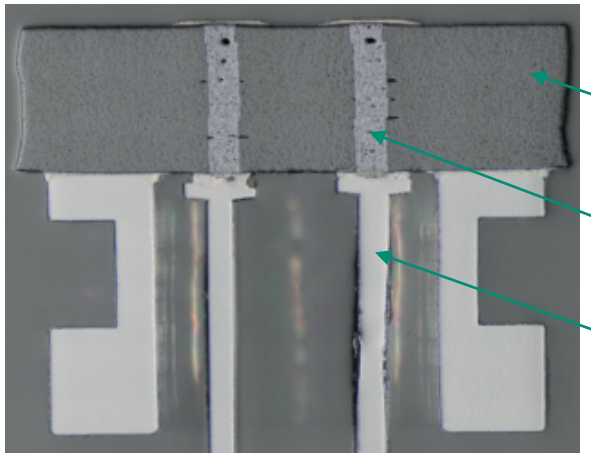
Cermet Vias

- Kovar leads
- Kovar flange
- Ni plated



Optical cross section





Pins

Flange

Leads

Alumina Ceramic

Cermet Via

Leads

Common braze filler metals:

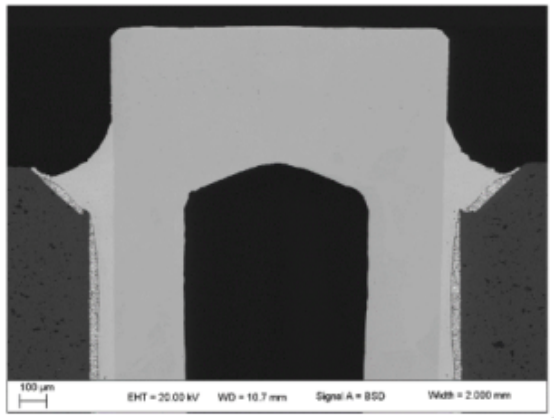
- Palni (1238°C)
- Palco (1219°C)
- Paloro (1200°C)
- Palniro-4 (1169°C)
- Palniro-1 (1121°C)
- Copper, 1084°C
- Gold (1064°C)
- Palsil-10 (1025°C)
- Silver, 985°C
- ***Silver-based, 650°C - 850°C***

furnace limit: ~1200C

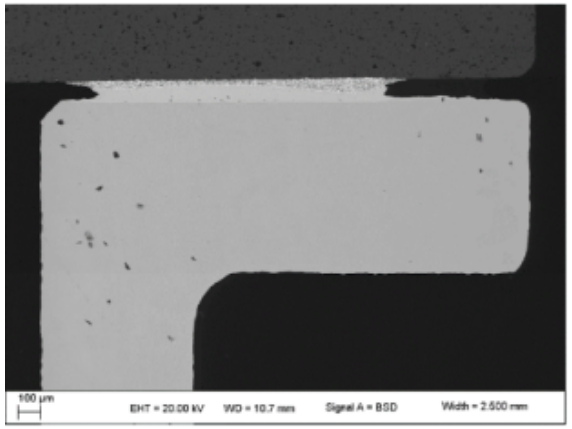
$T_{solidus}$ adequate

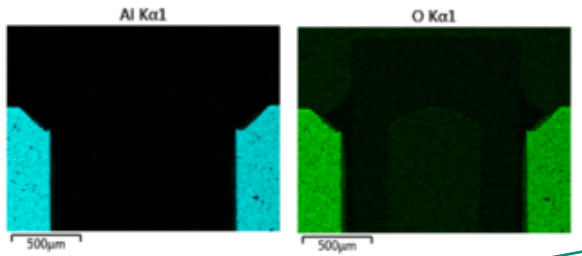
$T_{solidus}$ too low

EDX maps of Pin type feedthrough – as manufactured

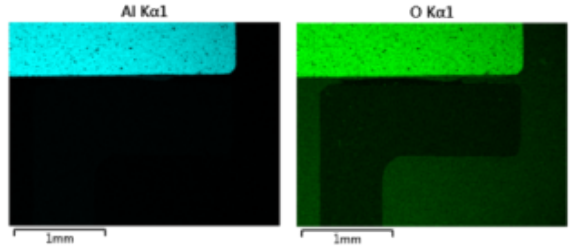


Back scattered SEM

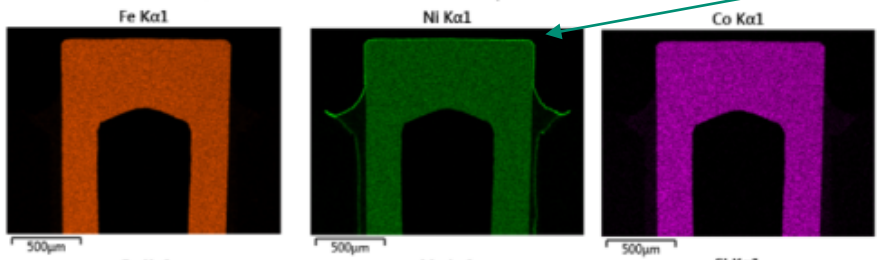




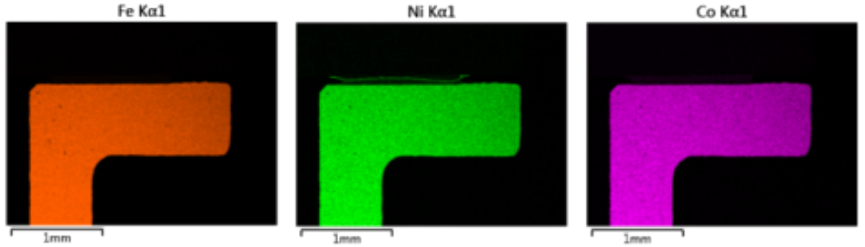
Alumina Ceramic

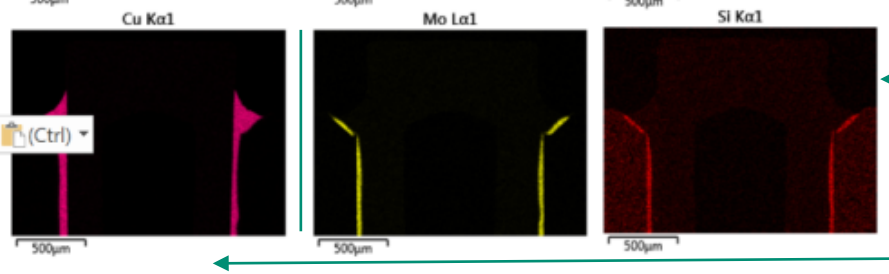


Ni-plate



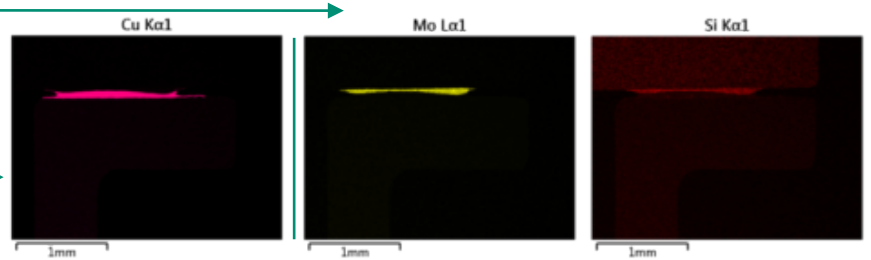
Kovar



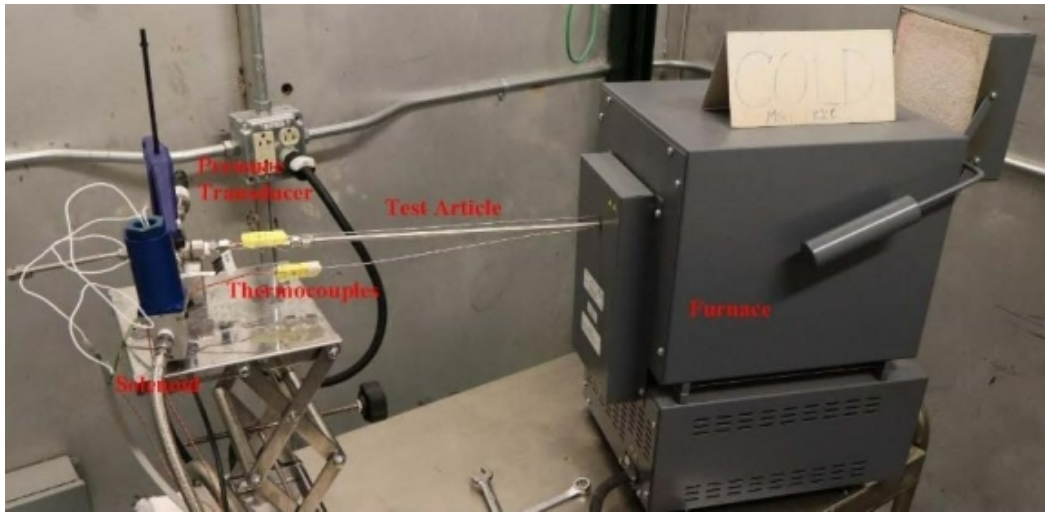


Metallization

Cu braze

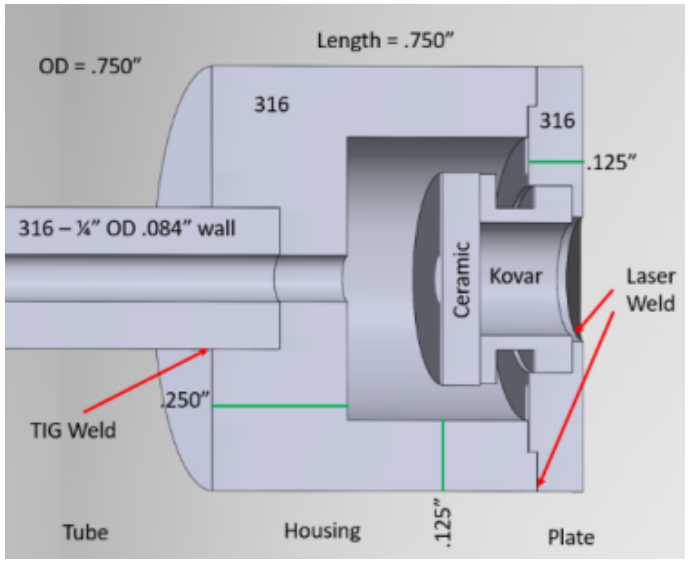


High temperature and pressure testing

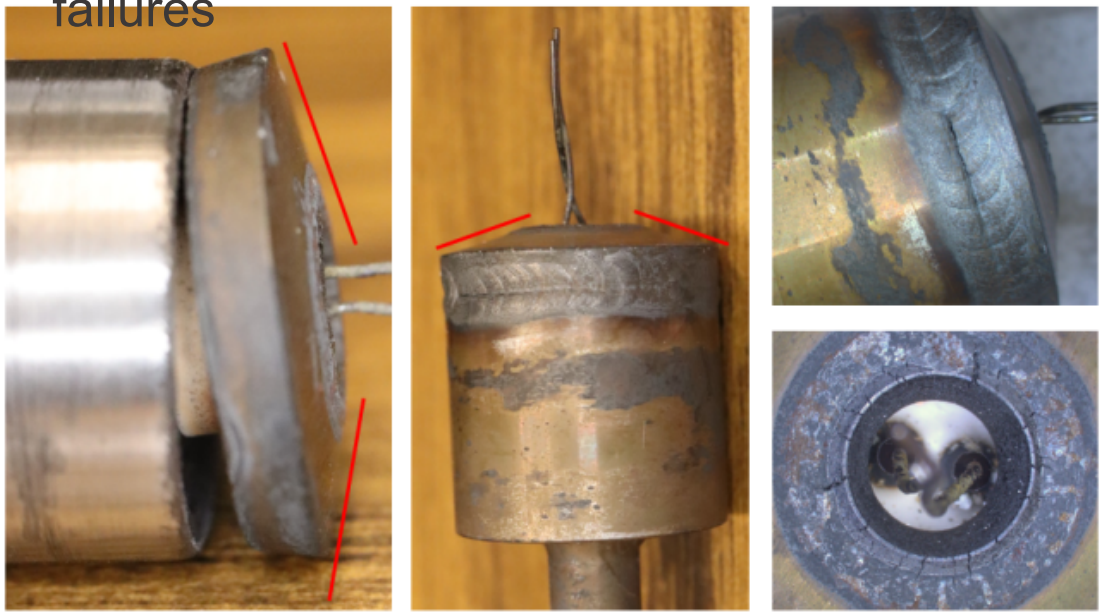


Furnace and pressure experimental setup

Thermocouple setup

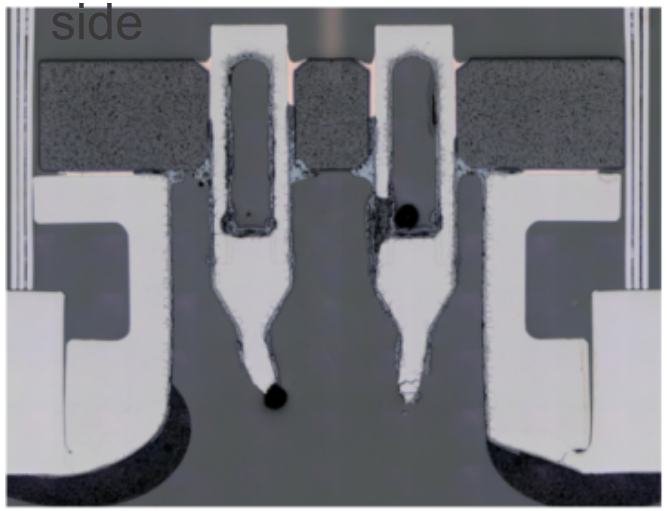


Pressure test housing design & first round failures



Pin type – after high temperature and pressure

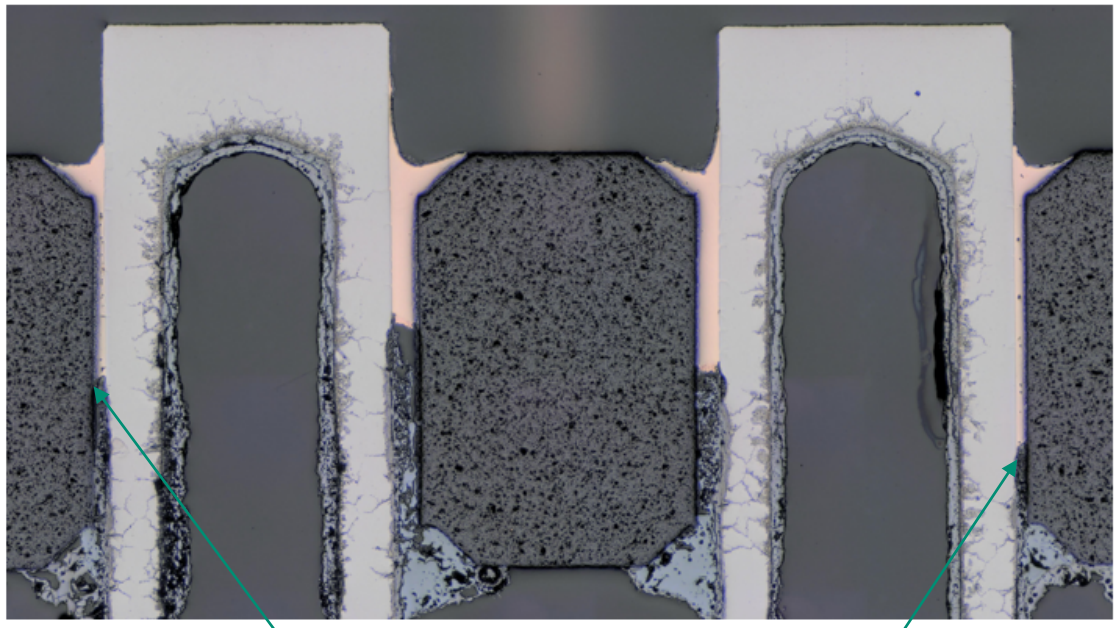
High pressure - Inert gas side



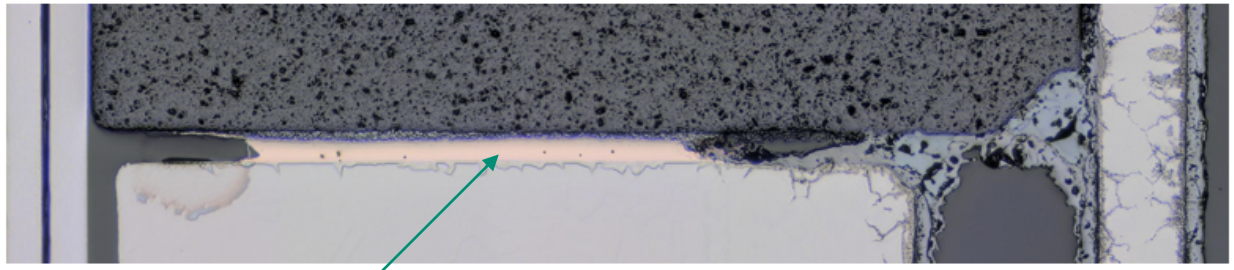
Oxidation side

Cu braze material still present and NDL (no detectable leak).

Kovar although Ni plated is still heavily oxidized.

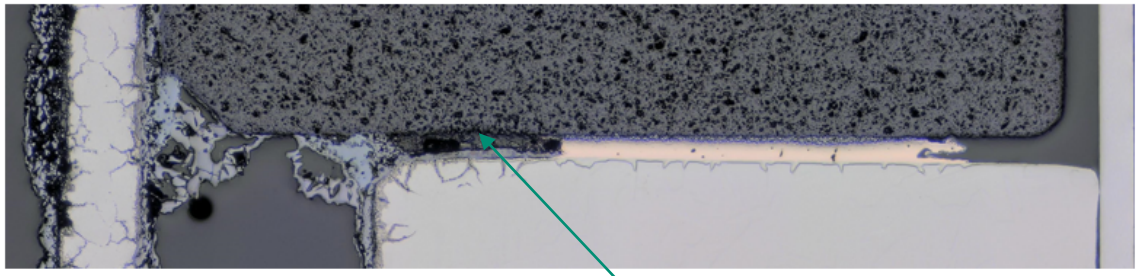


Oxidation is less on thinner side of braze joint.



Most of braze material is present

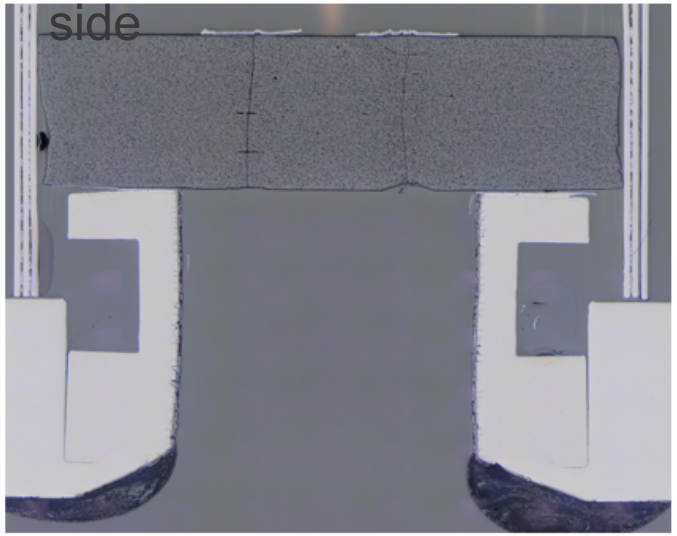
Oxidation side



Metallization removed with braze

Via type – after high temperature and pressure

High pressure - Inert gas side

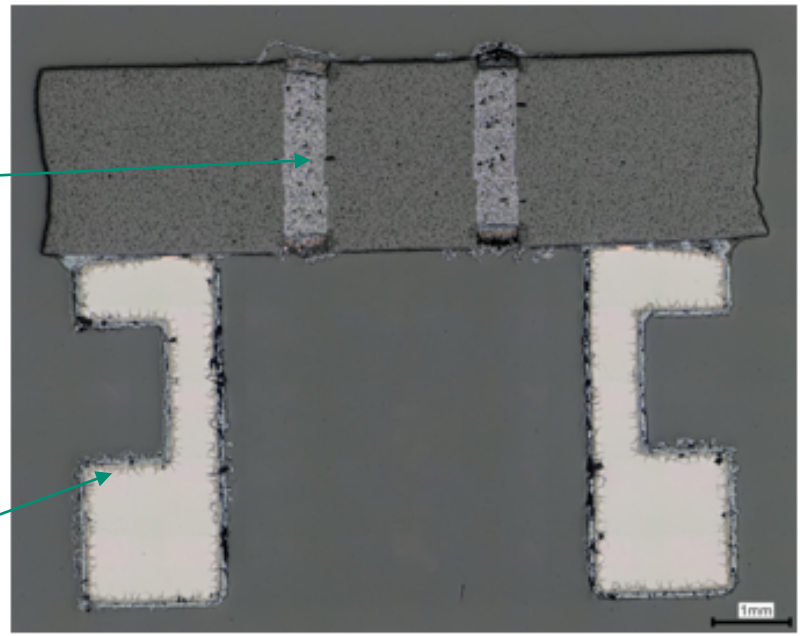


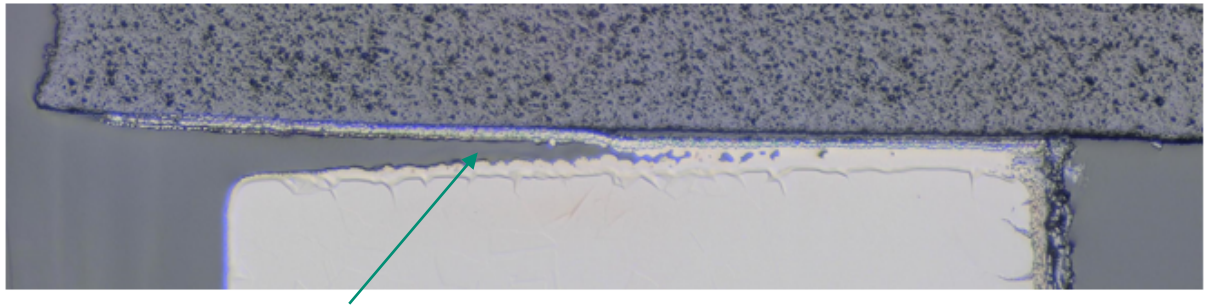
Oxidation side

Sample exposed to air on both sides. Minimal oxidation of vias.

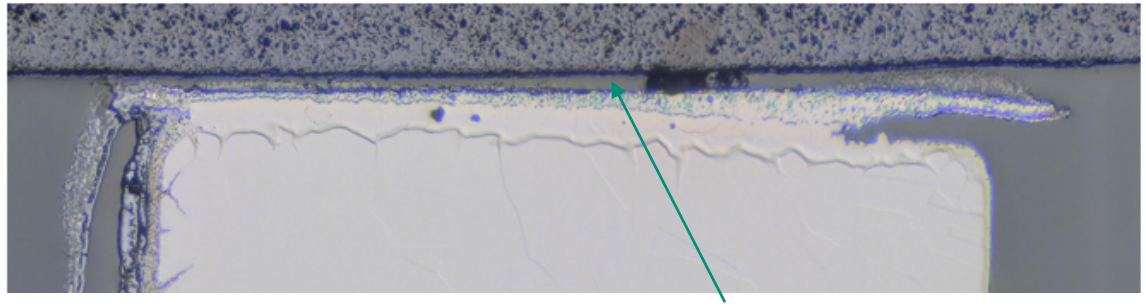
All sample still NDL after exposure.

Heavy oxidation seen on Ni plated Kovar flange.





Incomplete braze fill



Oxidation side

Failure at metallization/alumina interface

Conclusions – Suggestions for future improvements

Brazed Pins

- Brazes fail due to oxidation: Focus on better braze fit up on pin brazes - thinner brazes.
  - Oxidation appears slower when brazes are thin. Flange braze is thin enough.
- Ni pins better for oxidation than Ni-plated Kovar.
  - 2x Ni plating. Kovar flange before and after brazing.
- Metallization has good adhesion.
- Investigation of Au-based braze alloys to increase oxidation resistance.

Cermet Vias

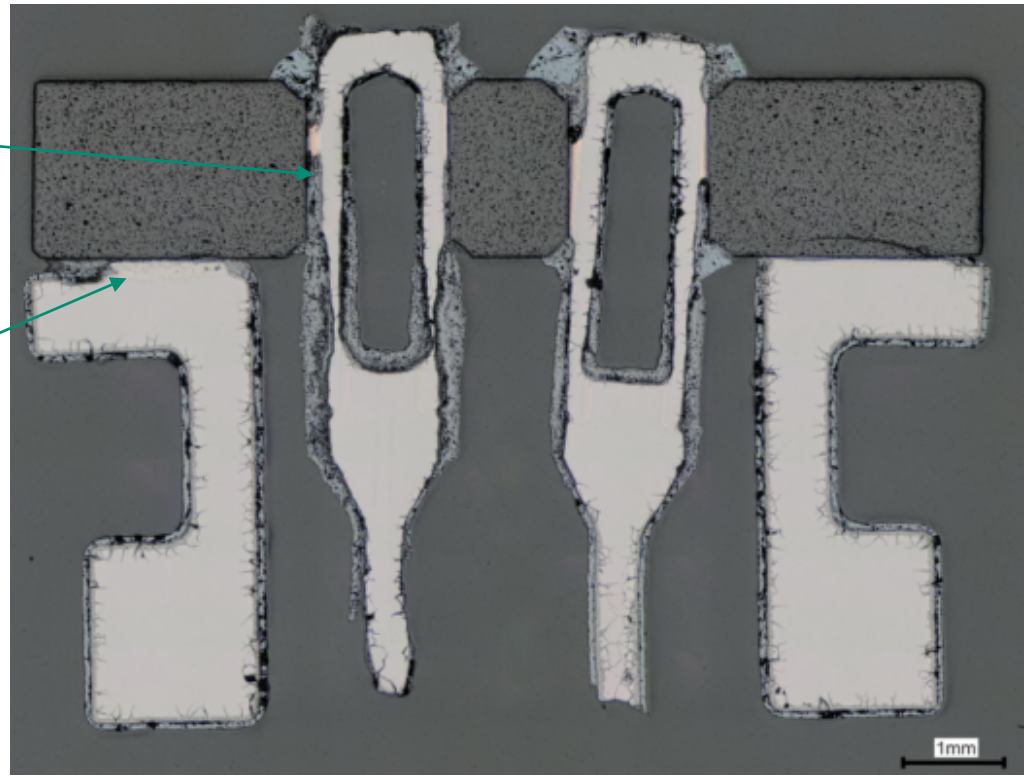
- Brazes fail due to cracking of metallization/ceramic interface: Focus on metallization strength.
- Vias are hermetic after high-temperature exposure.
- Improvement needed on lead braze strength.
  - Geometry change to larger lead head in a metallized ceramic blind hole.
- 2x Ni plating. Kovar flange before and after brazing.

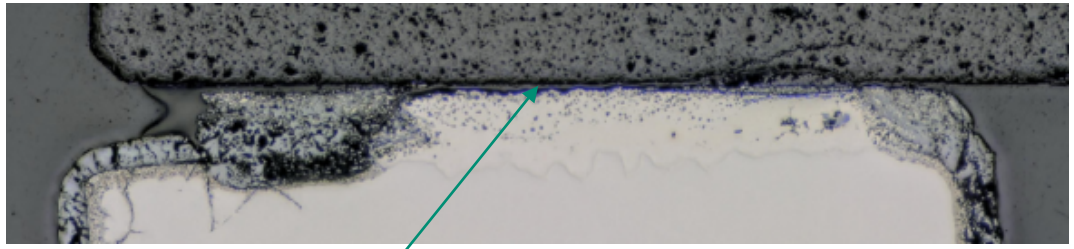
Pressure test housing redesign and test

Palniro – air fired both sides exposed

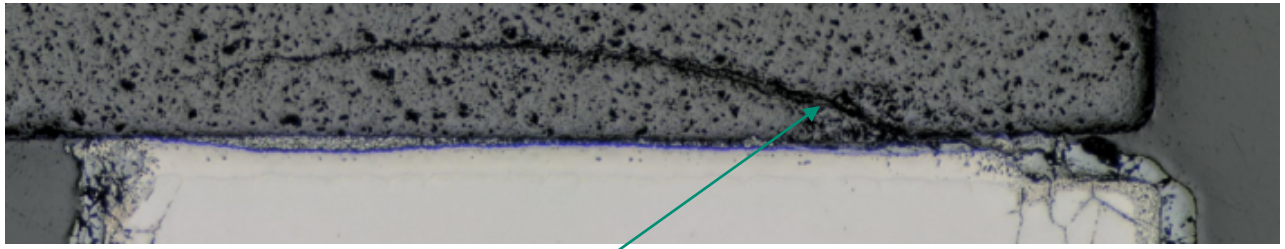
Cu pin brazes
- Heavily oxidized

Palniro flange braze
- Au25Ni25Pd
- Minimal oxidation





Metallization/Alumina interface failure



Bulk Alumina failure