SAND2013-4121C

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Diffusion bonding of Cu to Nb

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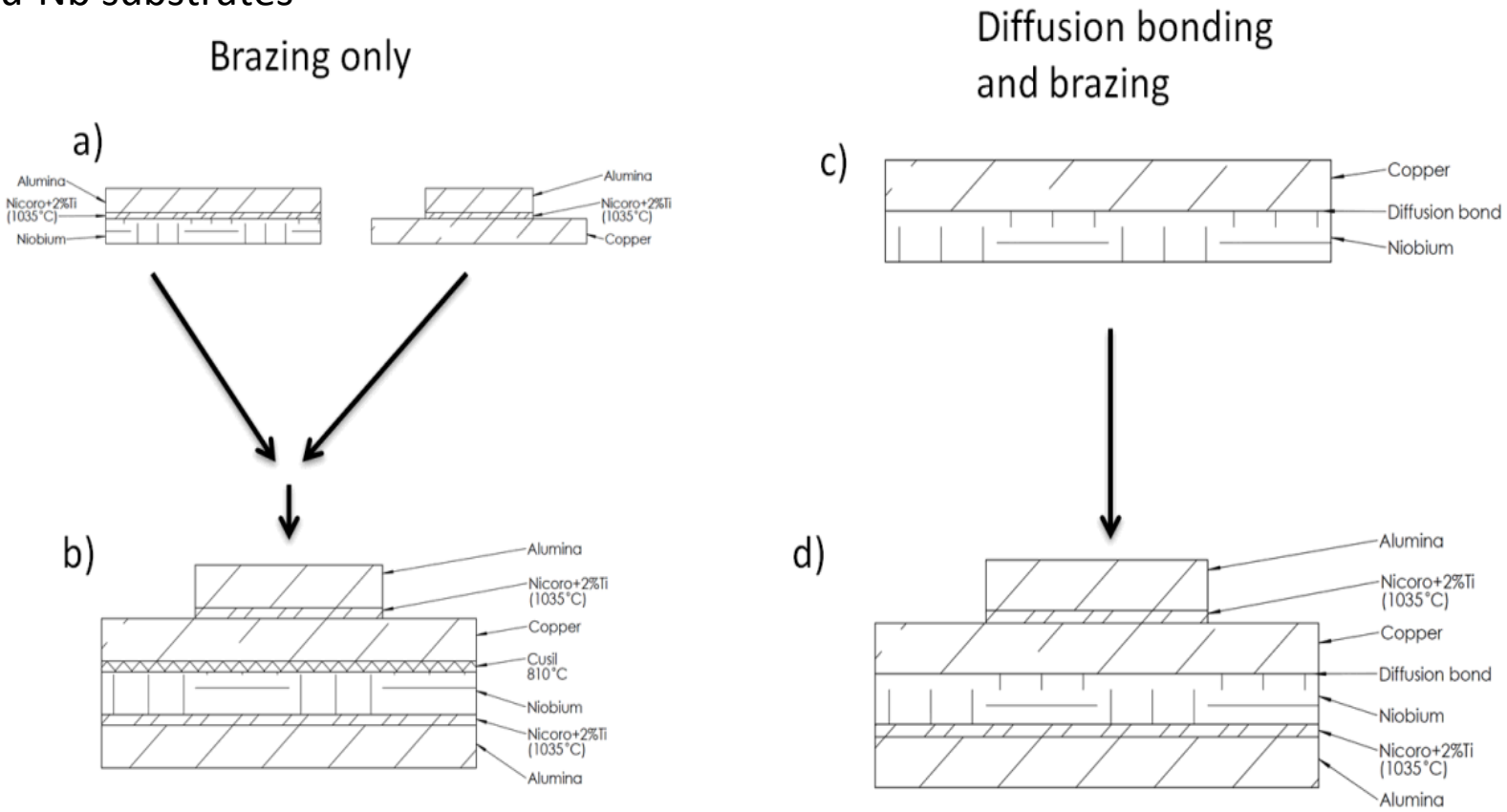
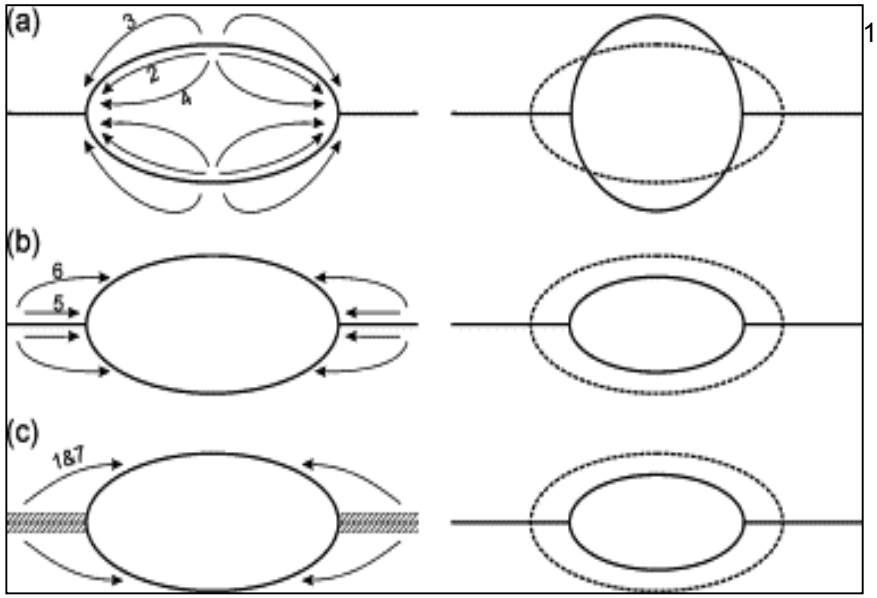
Introduction

- Join two ceramic components
- Current method multiple braze cycles
  - Alumina to Nb, Cu to Nb
- Goal: Join two ceramic components with optimized diffusion bonded Cu-Nb substrates



Diffusion bonding

- Solid state joining of similar or dissimilar components
- 2 sets of mechanisms during diffusion bonding
  - Deformation mechanisms
  - Diffusion mechanisms



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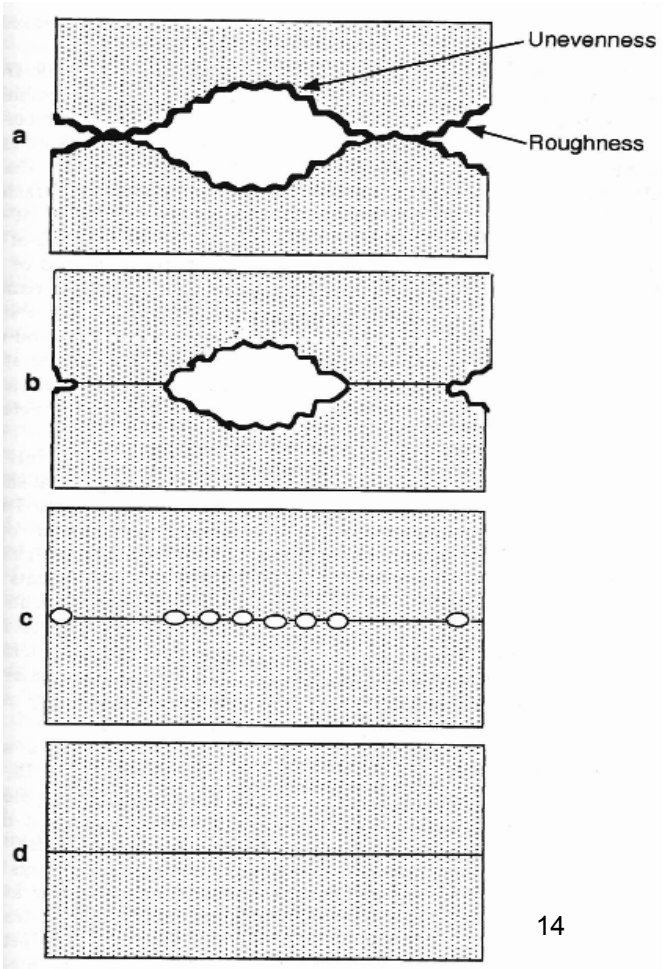

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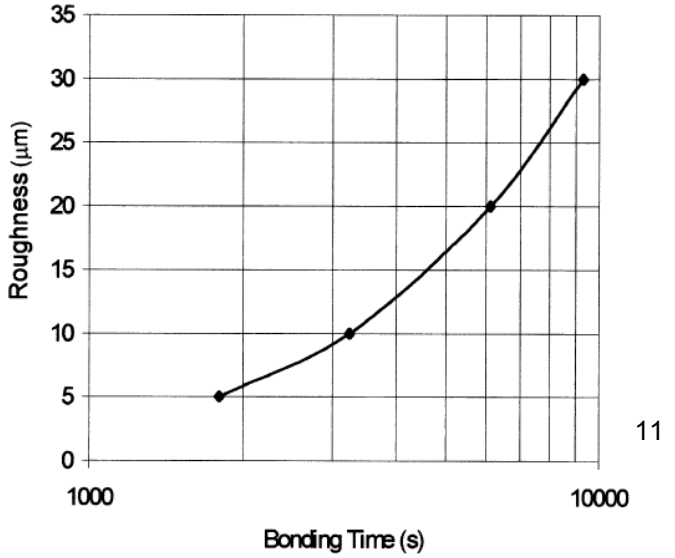
Literature review

- Diffusion bonding of Cu to Nb research is insufficient
- Research has been conducted on:
  - Cu-W with bond aid[1,2]
  - Cu-Alumina[3,4,5,6,7]
  - Nb-Alumina[3]
  - Cu to 304L stainless steel[8]

Diffusion bonding parameters

- Surface preparation
  - Surface roughness
  - Cleanliness
- Temperature
- Pressure
- Time



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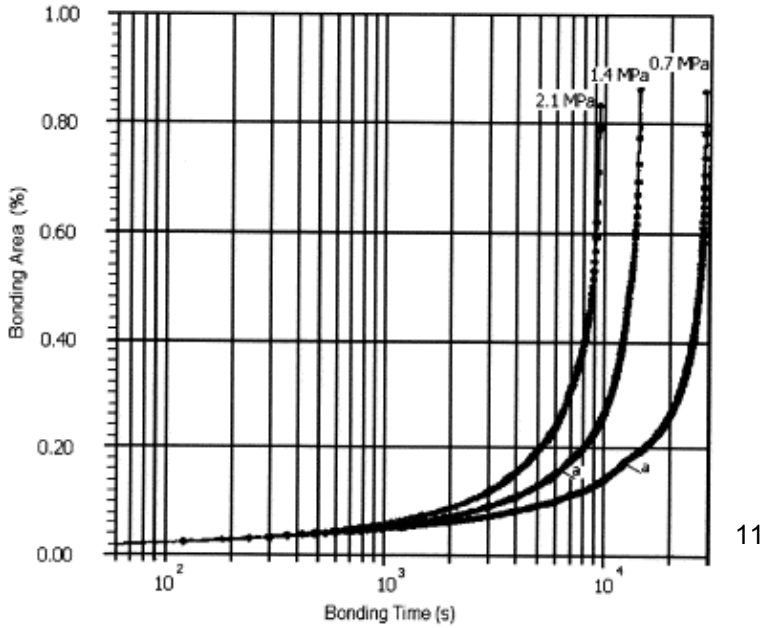

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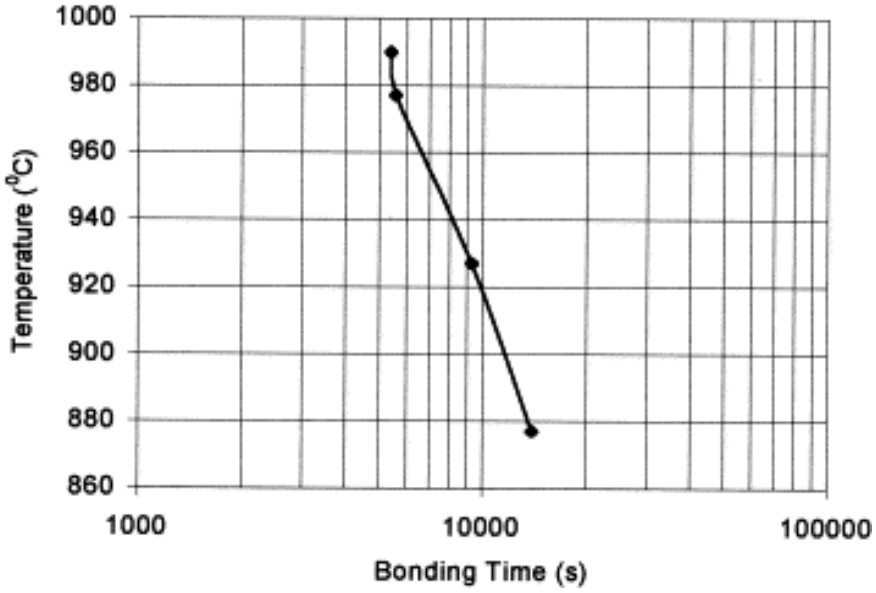

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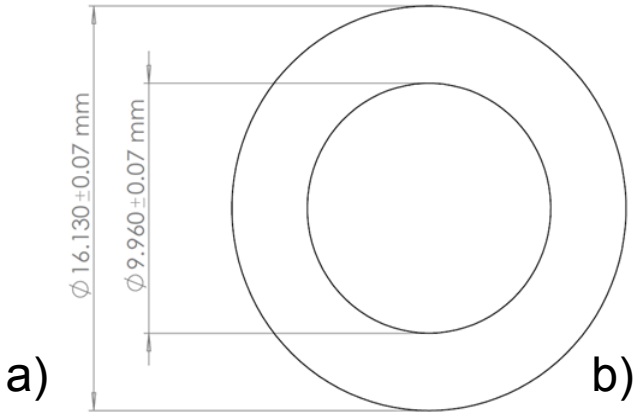
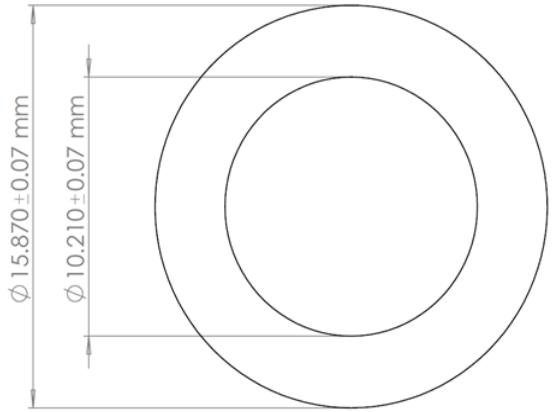
Sample preparation

- Diffusion bonding
  - Cut samples
  - Vacuum bake Nb
  - Manually polish
  - Electropolish Cu and Nb
- Brazing
  - a) EDM Cu-Nb substrates
  - Bake Cu-Nb substrates
  - b) Punch Nicoro™+2%Ti



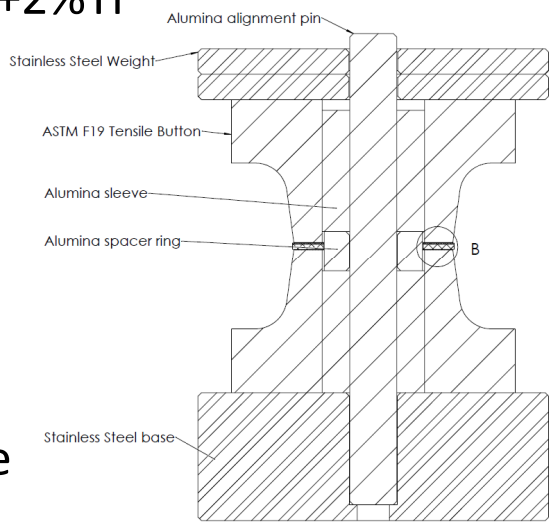
a)

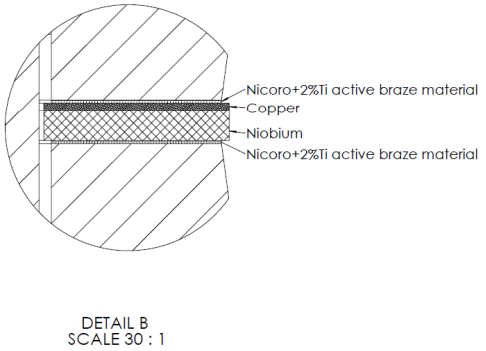


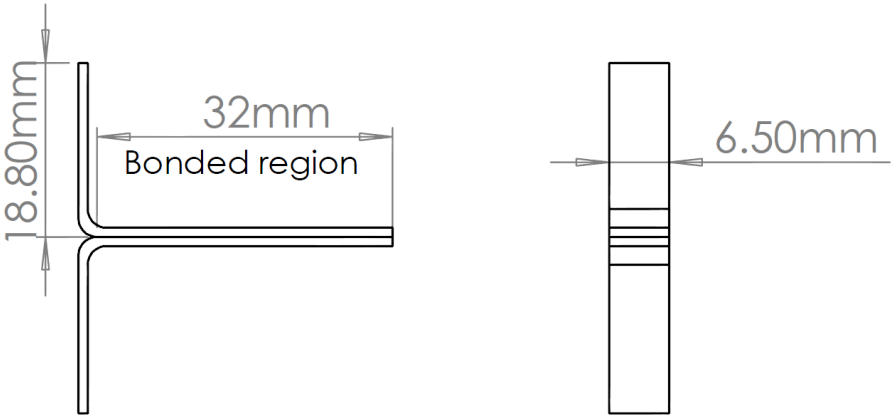
b)

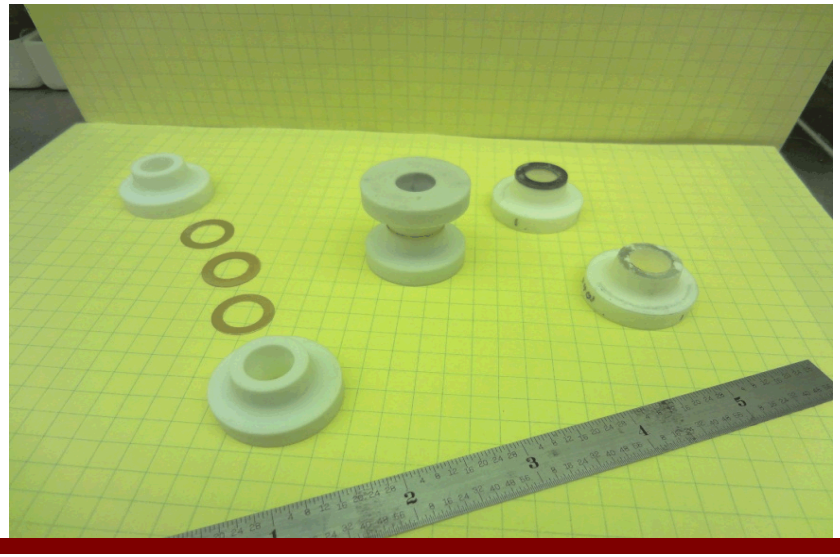
Characterization

- Braze samples with Nicoro™+2%Ti
- Helium leak check with
  He mass spec leak detector
- SEM
- Mechanical testing
  - Tensile test: braze joint
  - Peel test: Cu-Nb interface



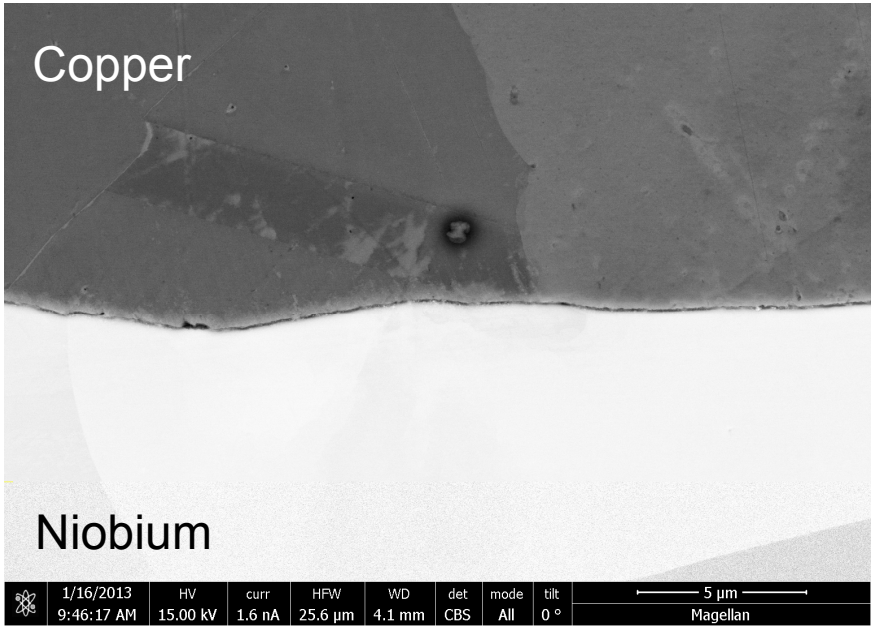


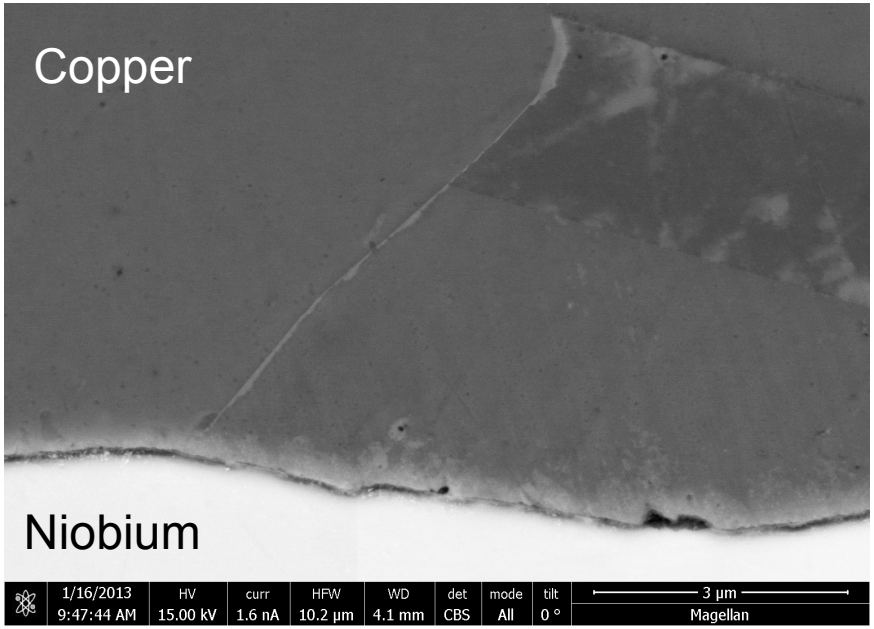




Results: Sample 1

- Cu-Nb bonded interface.
- Bonding parameters: 1035^{o}C, 3 hours, 4MPa (0.6 KSI), <2x10^{-6}Torr





Results

- Tensile button test
  - Diffusion bonding parameters: 1035°C, 3 hours, 4MPa (0.6 KSI)
  - Brazing profile: 15°C/min to 900°C, hold 10.0 mins; 10°C/min to 1035°C, hold 5.0m mins; 25C/min to RT.

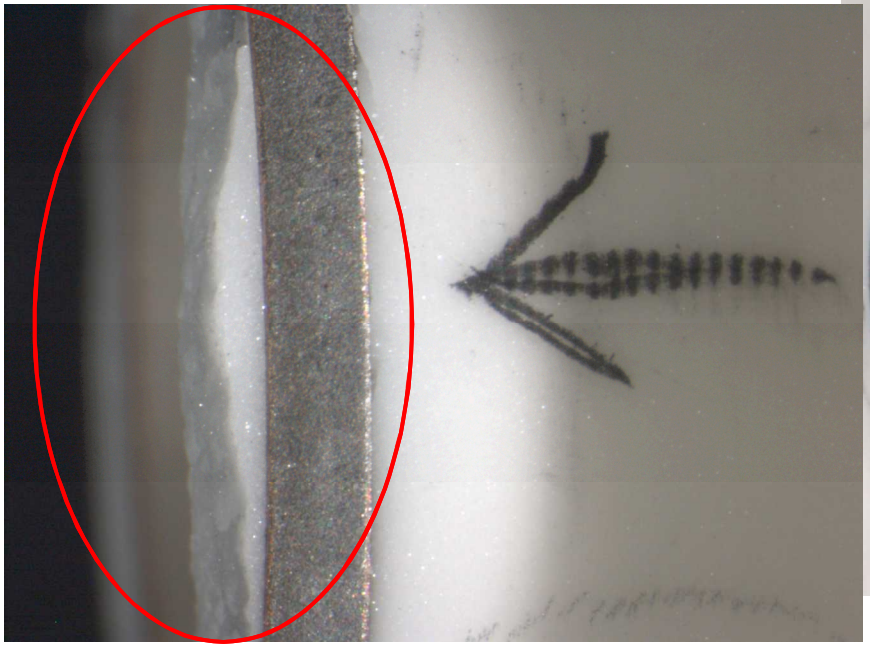
Sample	Leak rate [sccs]		Load [lbs]	KSI*	MPa		Failure Location
1	NDL		1602.40	8.91	61.42		Braze joint between ceramic and Nb
2	NDL		2797.00	15.55	107.21		Braze joint between ceramic and Cu
3	NDL		2142.10	11.91	82.11		Braze joint between ceramic and Cu

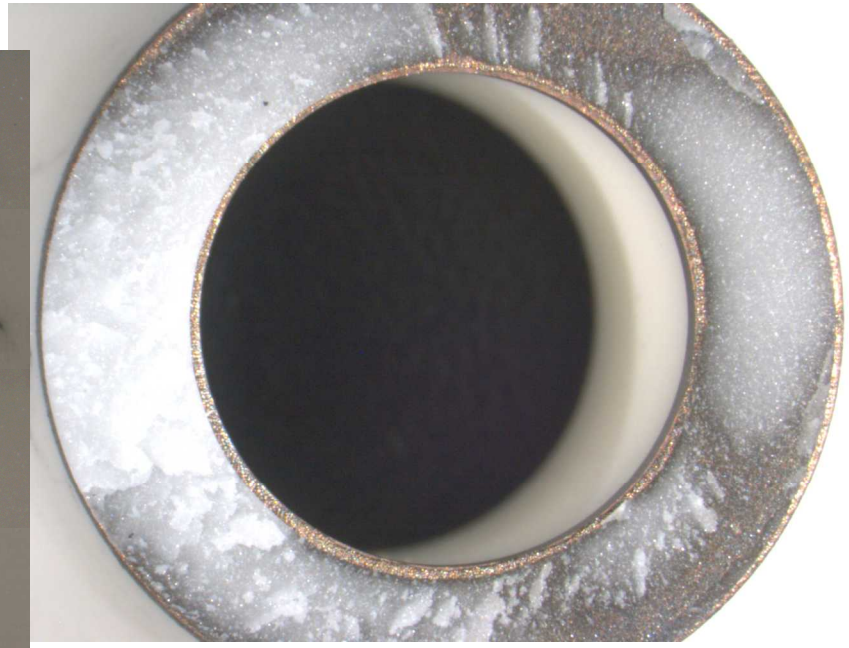
Avg.:	12.12	83.58

*Surface area: 0.179873 sqr in

Results: Fracture of tensile button

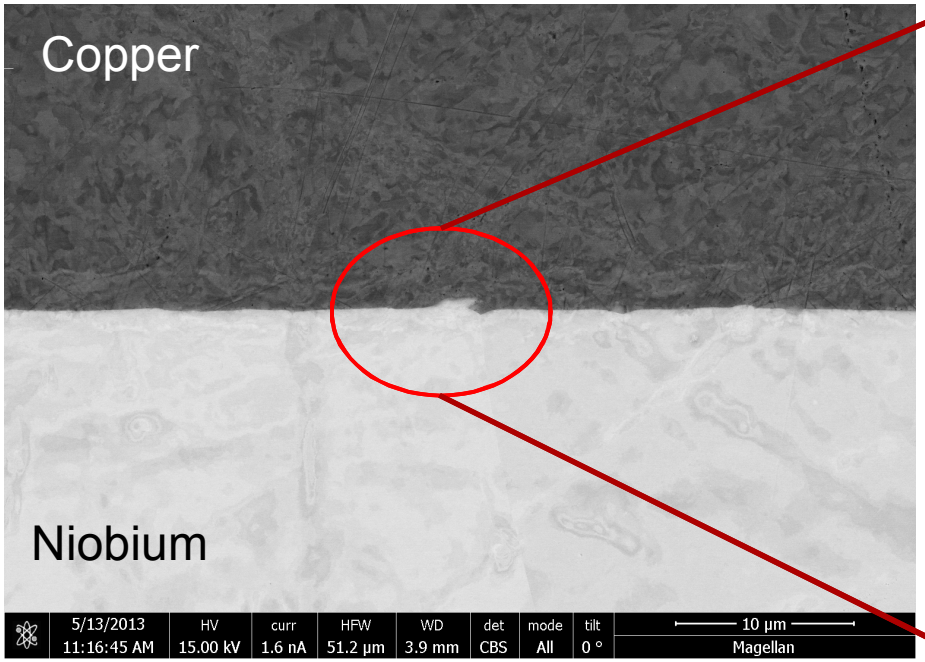
- Diffusion bonding parameters: 1035°C, 3 hours, 4MPa (0.6 KSI)
- Sample tensile strength 107.21 Mpa (15.5 KSI)

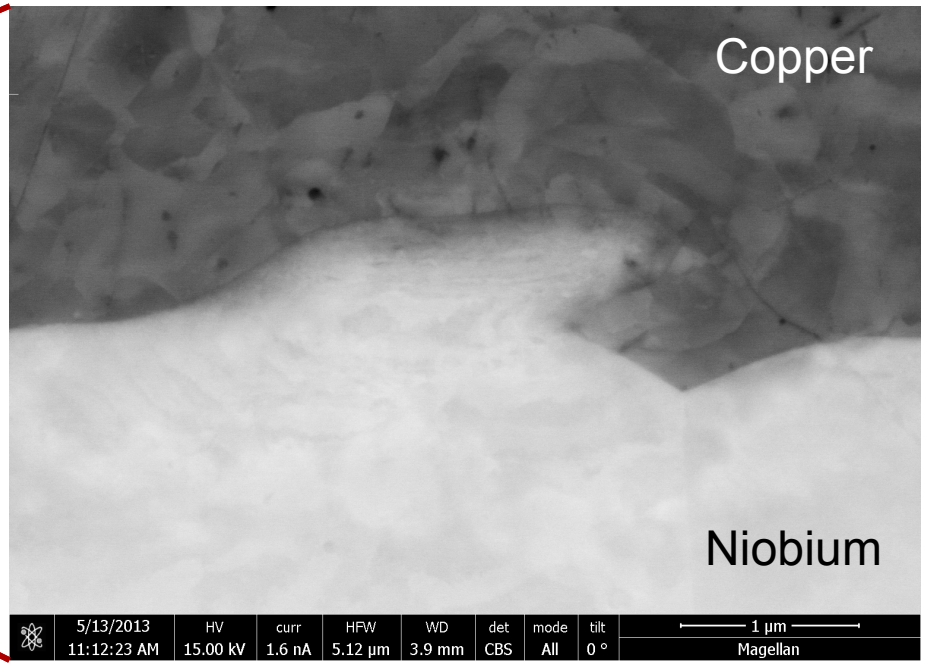




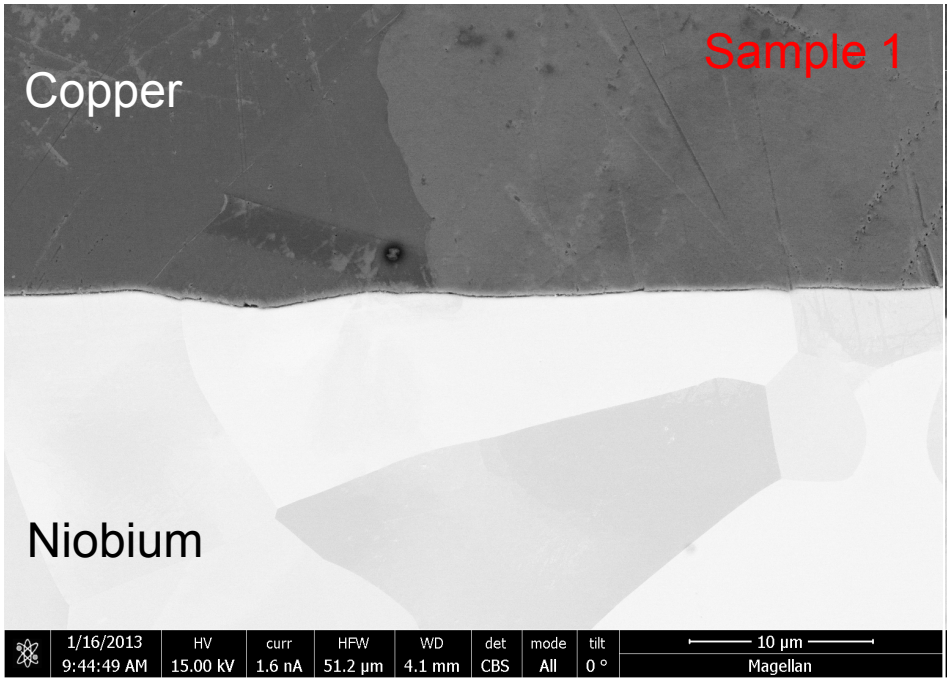
Results: Sample 2

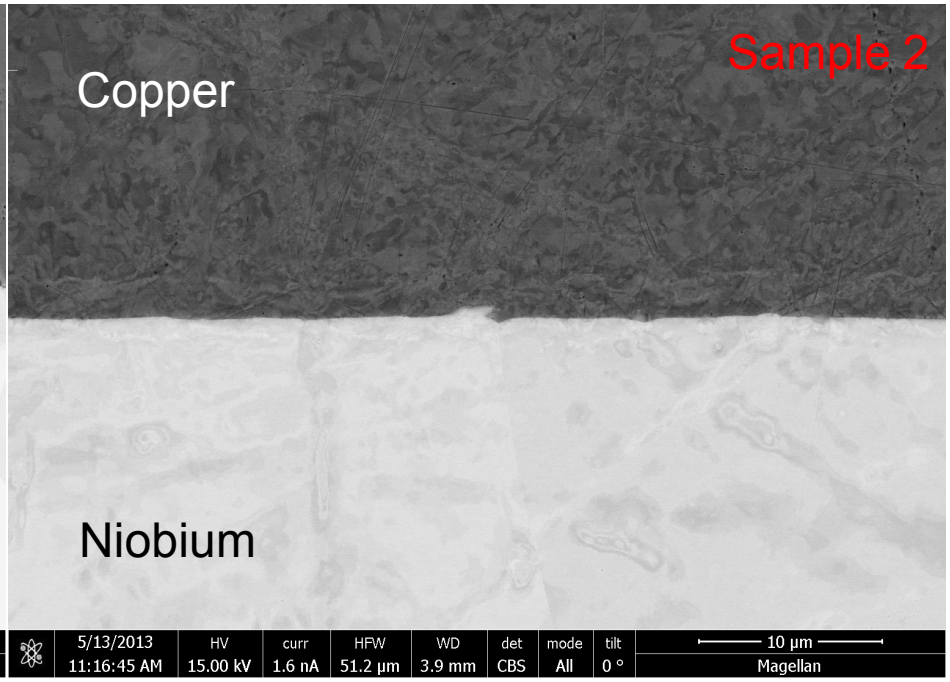
- Cu-Nb bonded interface.
- Bonding parameters: 1050^{o}C, 3 hours, 4MPa (0.6 KSI), <2x10^{-6}Torr





Results: Interface comparison





Future experiments

- 5 initial experiments
  - 950°C, 1.2 KSI, 0.5 hours
  - 1050°C, 0.6KSI, 3 hours
  - 1000°C, 0.9 KSI, 1.75 hours
  - 1050°C, 1.2 KSI, 0.5 hours
  - 950°C, 0.6 KSI, 3 hours
- 3 additional experiments to determine optimal parameters
- 2 final experiments to confirm optimal parameters

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Acknowledgments

- Deidre Hirschfeld, Sandia National Laboratories, Academic Advisor
- Aaron Wildberger, Vacuum process Engineering, California
- Chuck Walker, Sandia National Laboratories
- Greg Bishop, Sandia National Laboratories
- Don Susan, Sandia National Laboratories
- Alice Kilgo, Sandia National Laboratories
- Bonnie McKenzie, Sandia National Laboratories
- Tom Crenshaw, Sandia National Laboratories
- Mike Saavedra, Sandia National Laboratories
- Dick Grant, Sandia National Laboratories

Questions and Comments

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