Mechanical characterization of SLID bonded Au-Sn and Cu-Sn interconnections for MEMS packaging

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- **Outline**
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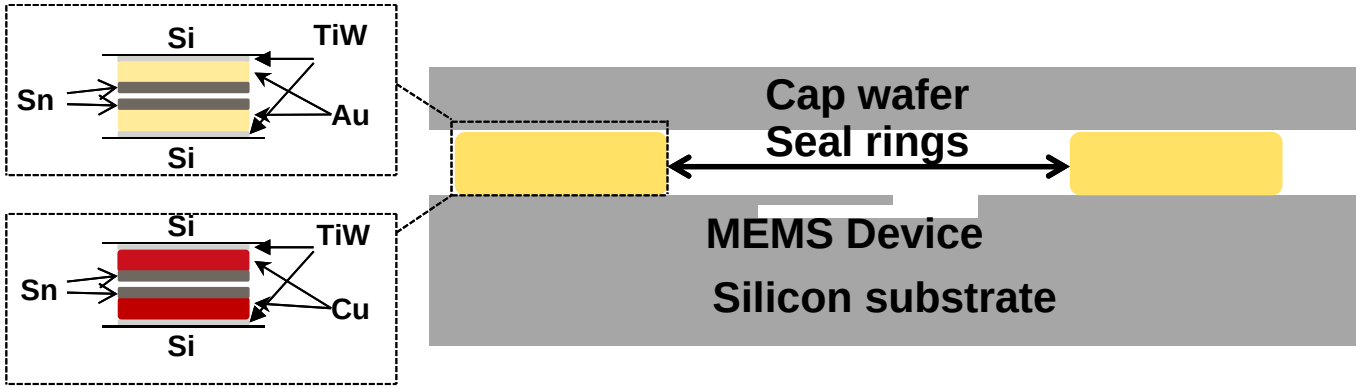
  - Bonding parameters and test structures
  - Shear and tensile test setups
  - Mixed Flow Gas (MFG) test
  - Results
    - *Microstructural analysis results*
    - *Results from mechanical tests of As bonded samples*
    - *Mechanical strength after MFG test*
  - Conclusions

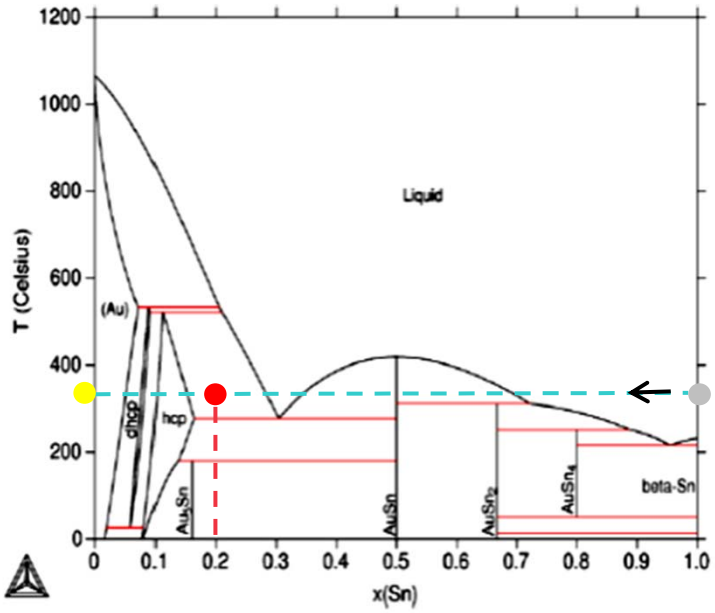
Objectives and methods

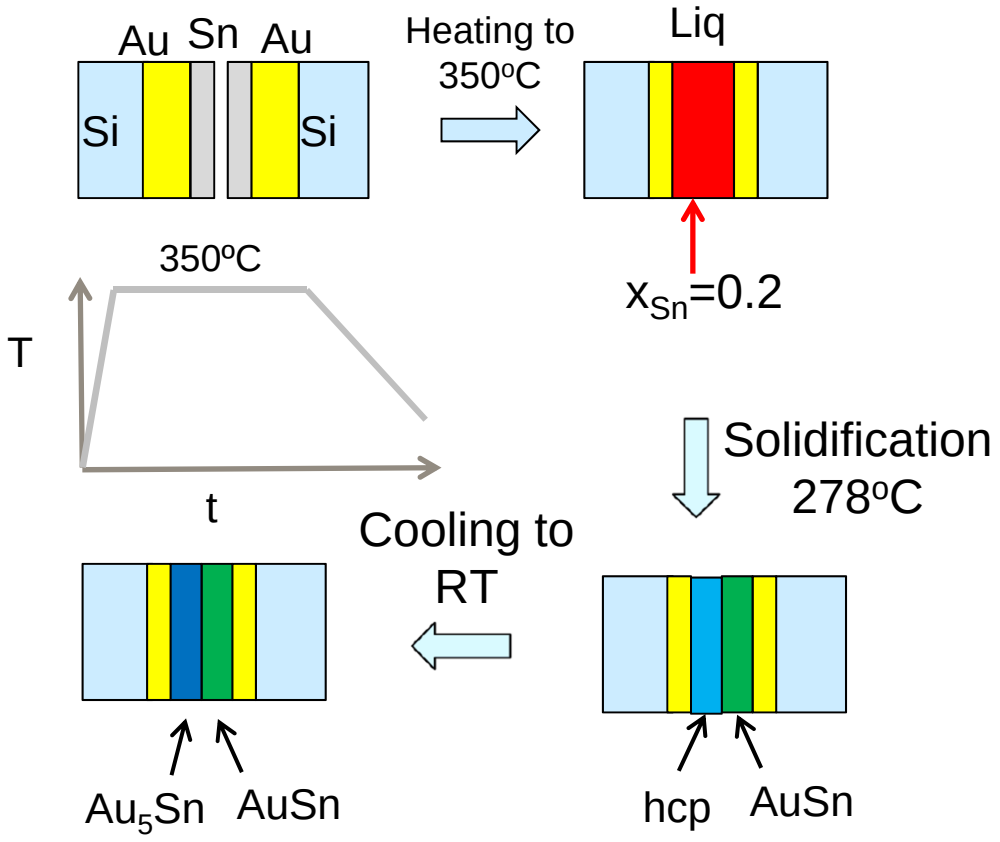
- The objective of this communication is to investigate mechanical properties of Au-Sn and Cu-Sn SLID bonded seal rings for hermetic MEMS packaging with shear and tensile tests



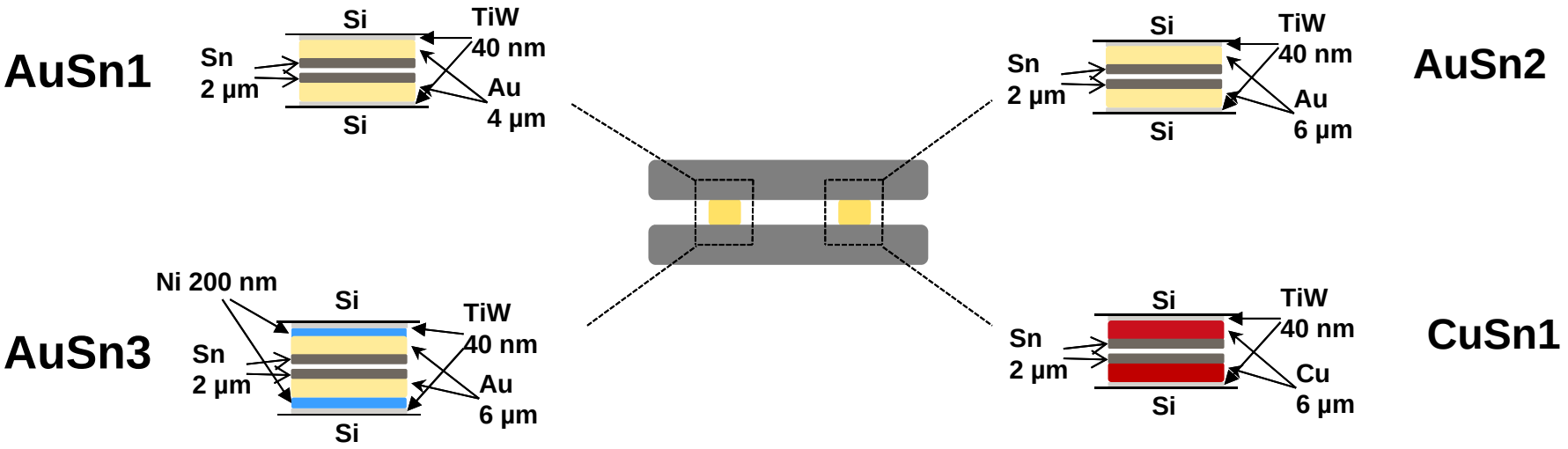
- Another objective is to study corrosion resistance of these bonds with Mixed Flow Gas test

Principles of SLID bonding



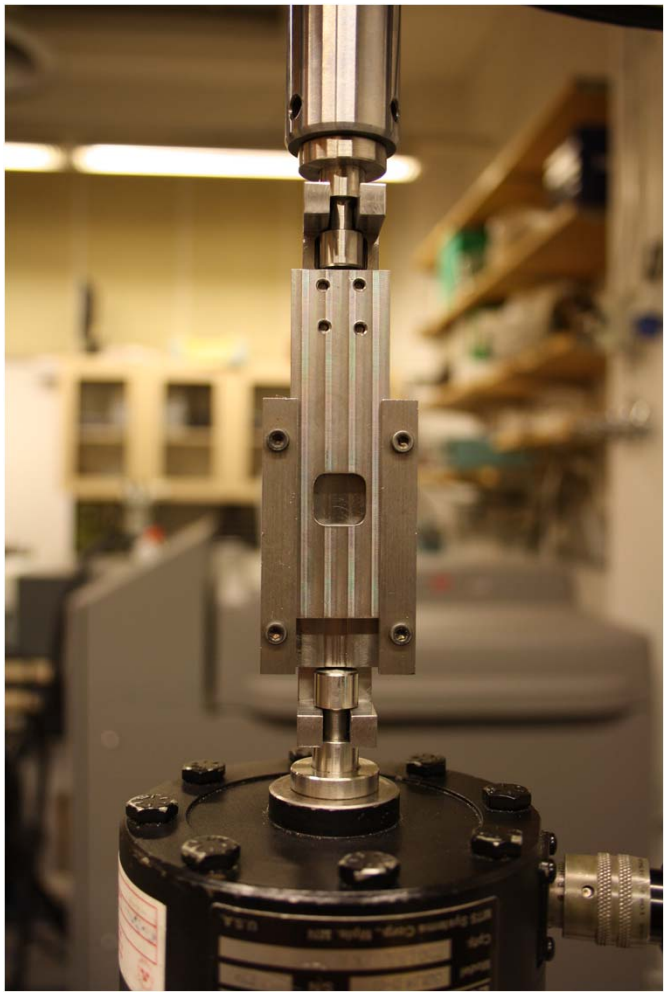


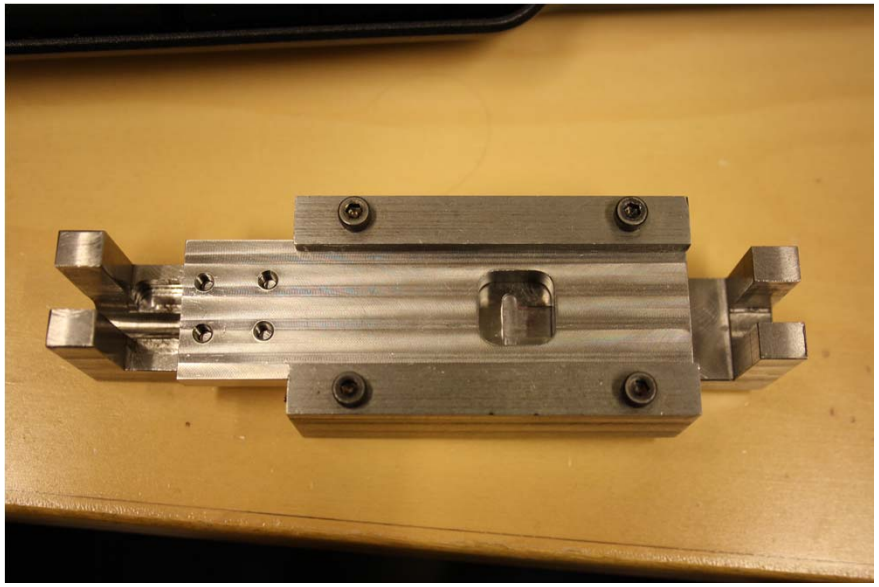
Bonding parameters and test structures

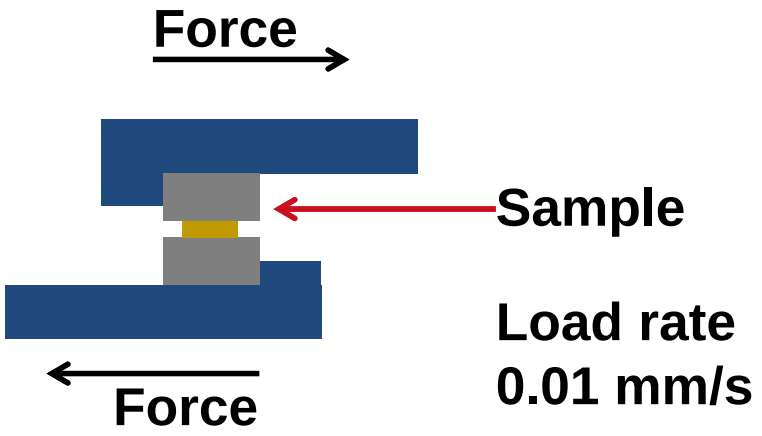


Group	Temperature (K)	Bonding pressure (MPa)	Bonding time (min)
AuSn1	593	2.4	60
AuSn2	593	2.4	60
AuSn3	623	14.4	60
CuSn1	623	14.4	60

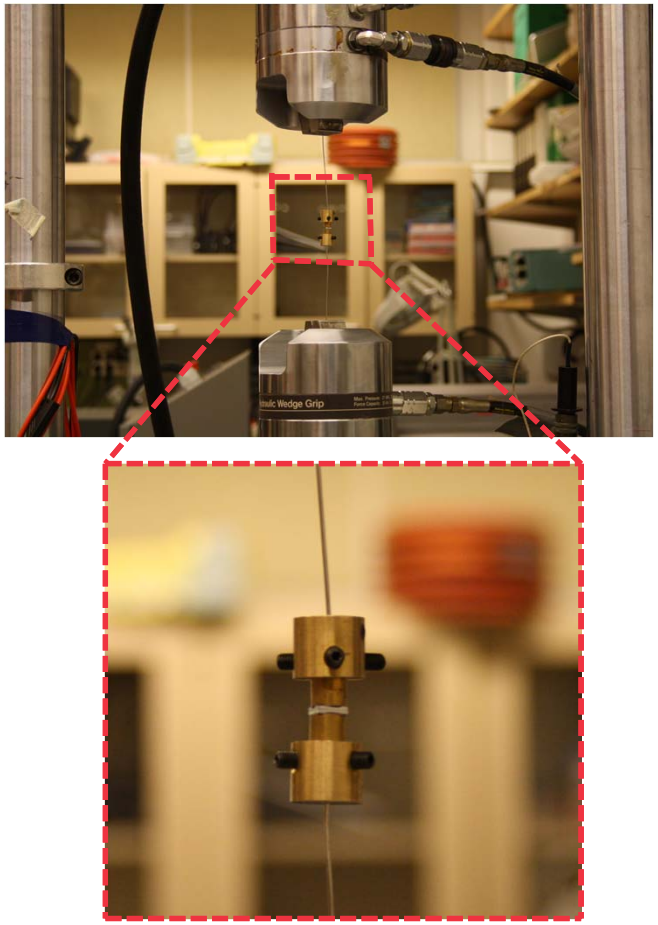
Shear test setup

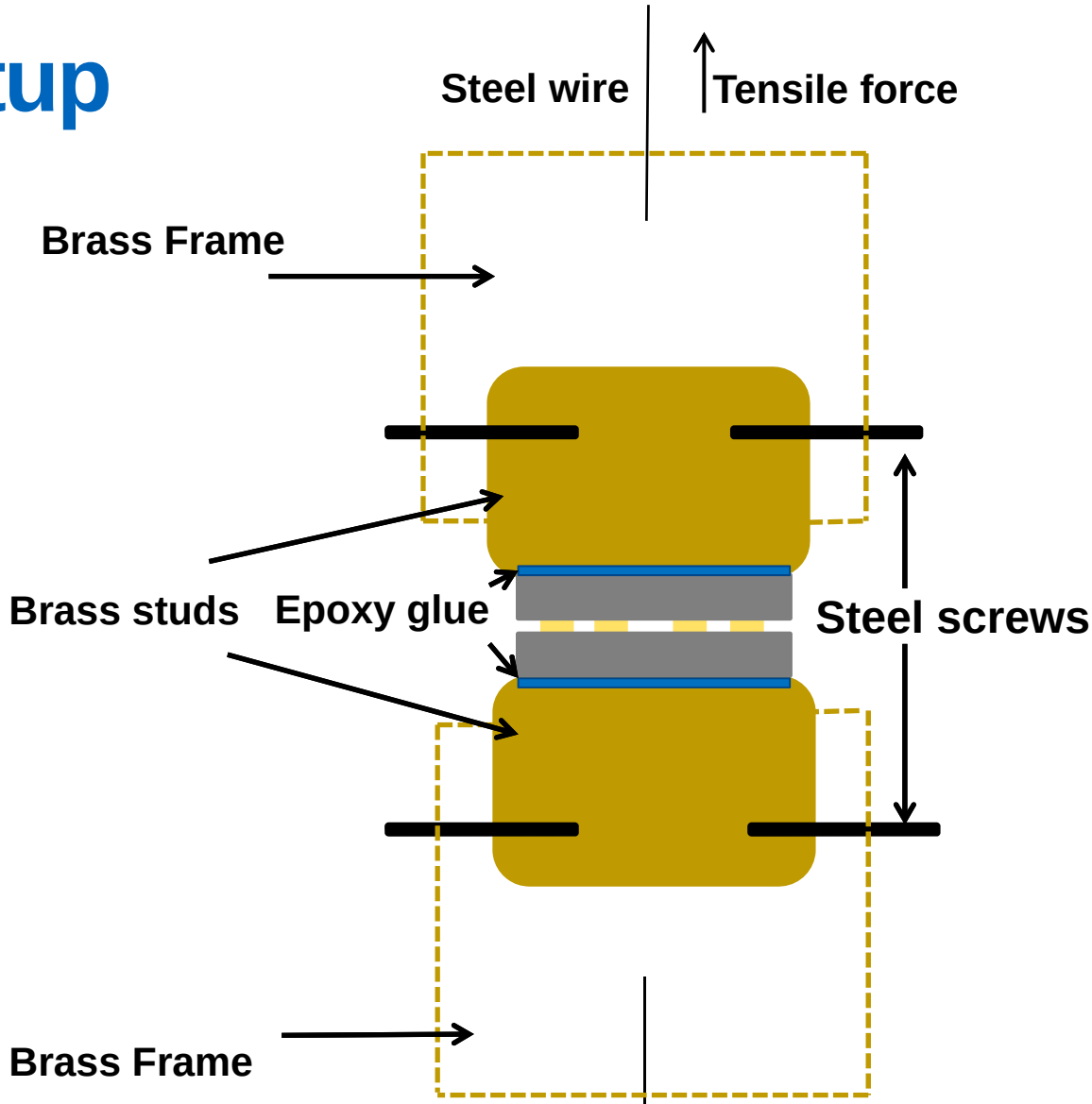






Tensile test setup





Load rate
0.1 mm/s

Mixed Flow Gas (MFG) test

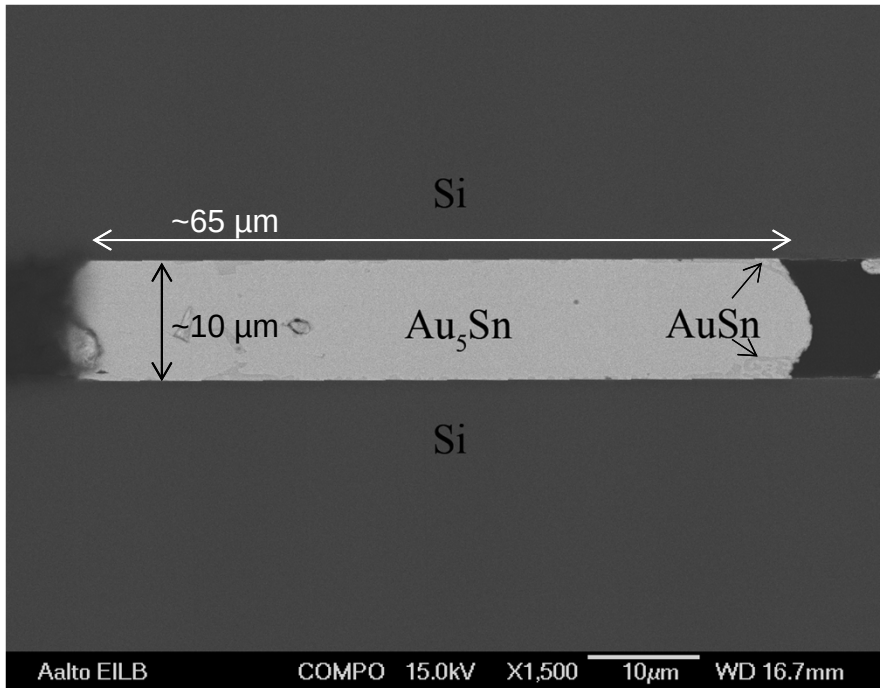
- **Corrosion properties of SLID bonds are rarely tested**
- **Pressure Cooking Test is used in some situations**
  - However, only pressure, temperature and humidity as a corrosive agents (lacks corrosive gases)

  -> Mixed Flow Gas test
- **Weiss WKI1 600/40 Environmental test chamber system**
  - Test based on Telcordia GR-63-CORE standard “Outdoor” conditions
  - Corrosion monitoring: ASTM-B810 with copper plate mass growth method
  - Vaisala HMT 333 for humidity/temperature measuring

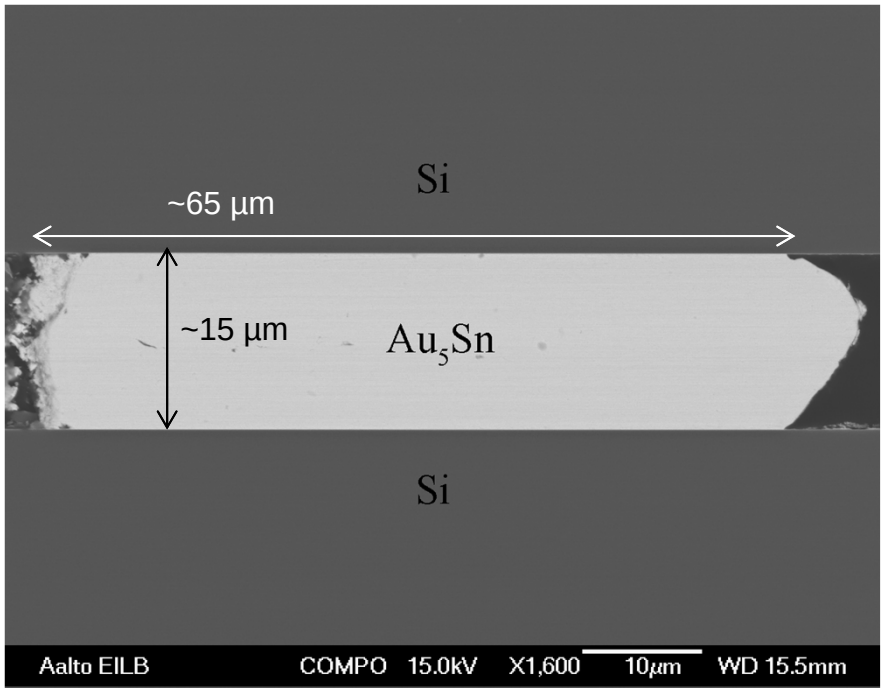
Humidity (%RH)	Temperature (°C)	H_2S (µg/m³)	NO_3 (µg/m³)	Cl_2 (µg/m³)	SO_2 (µg/m³)
70	30	262	188	19	136

Microstructural analysis results

AuSn1

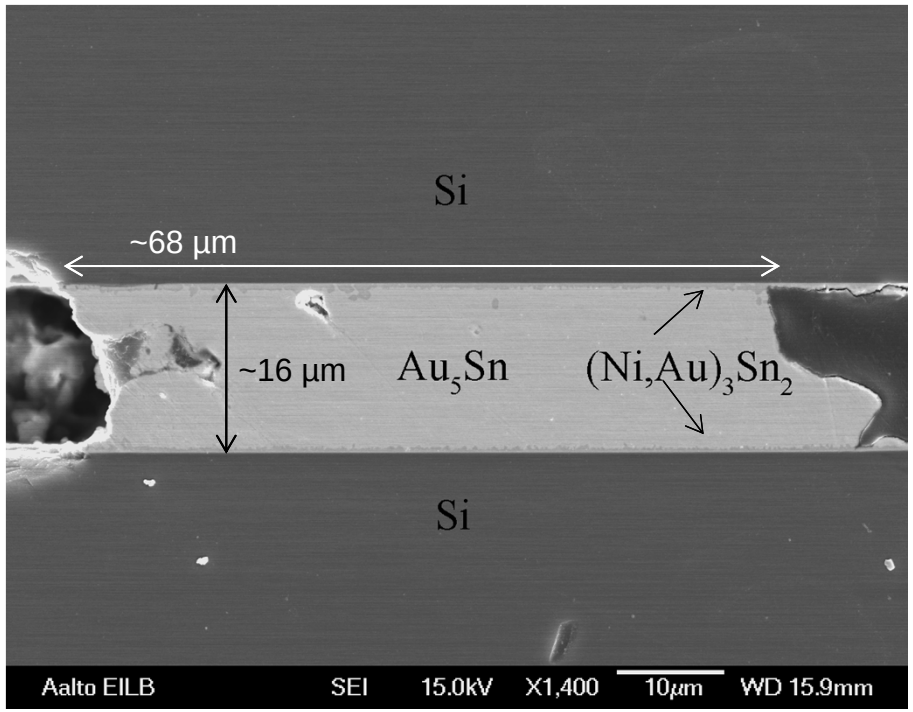


AuSn2

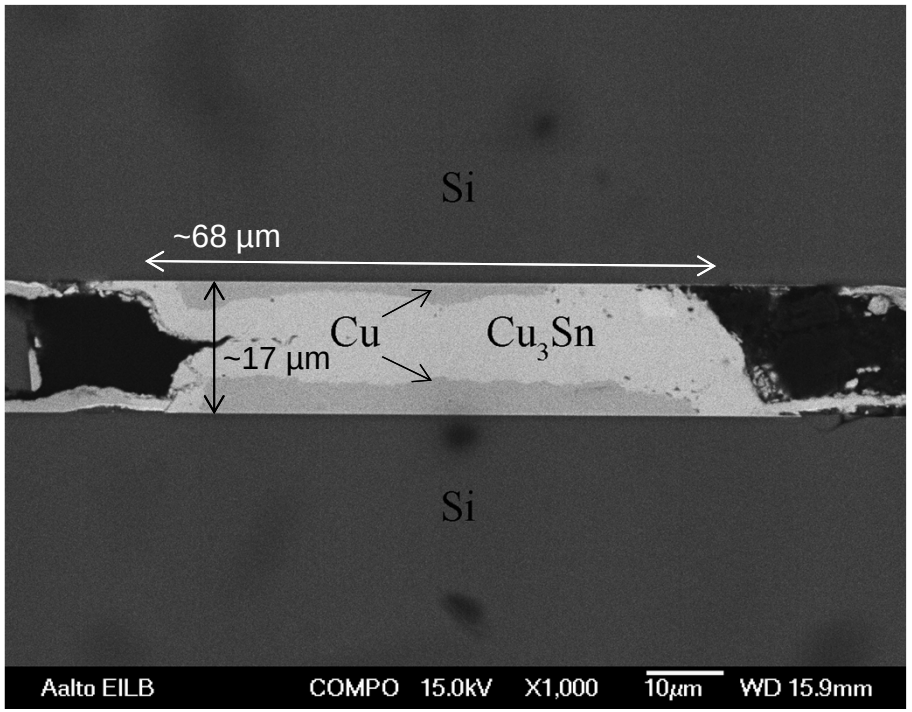


Microstructural analysis results

AuSn3



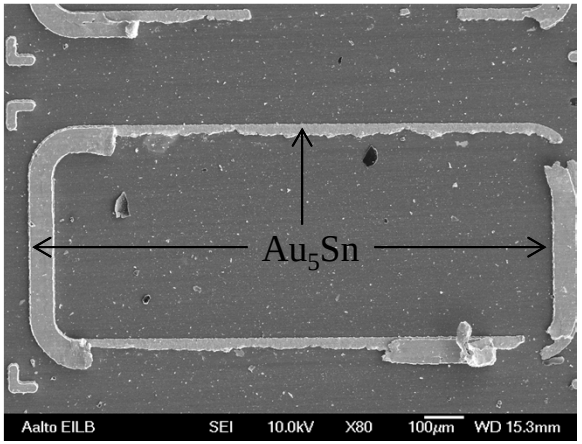
CuSn1



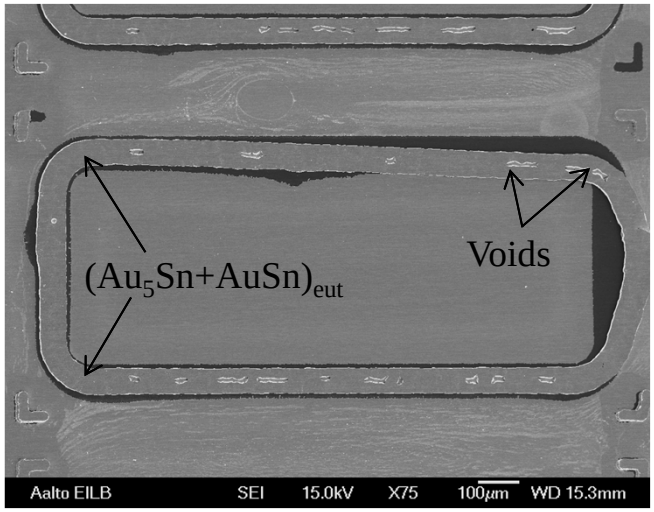
Results from mechanical tests of As Bonded samples

	Shear Strength (MPa)	StDev	Tensile Strength (MPa)	StDev
AuSn 1	66	8	24	5
AuSn 2	112	26	41	9
AuSn 3	170	35	88	23
CuSn 1	275	42	91	27

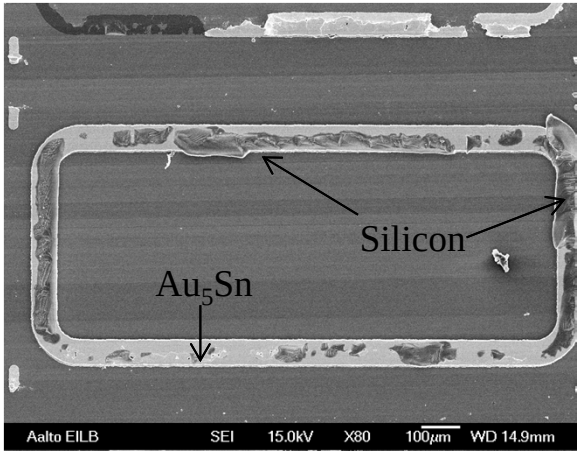
AuSn2 Shear

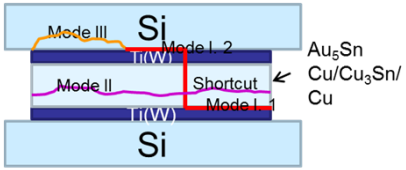


AuSn1 Shear

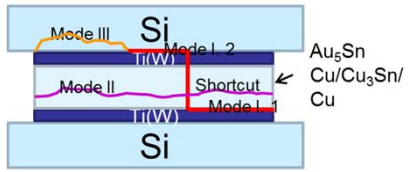


AuSn2 Tensile

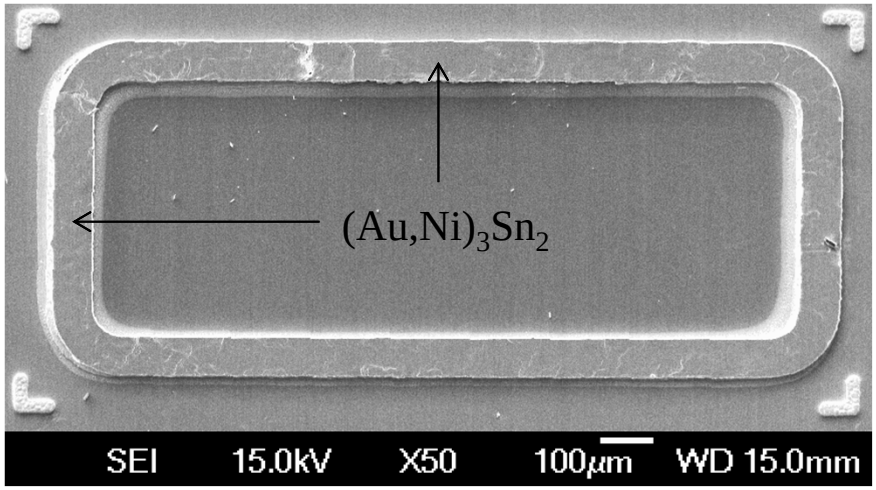




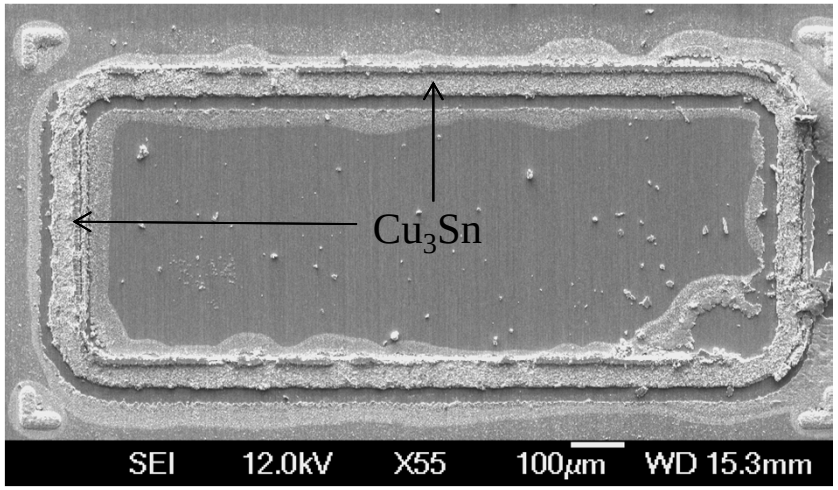
Results from mechanical tests of As Bonded samples



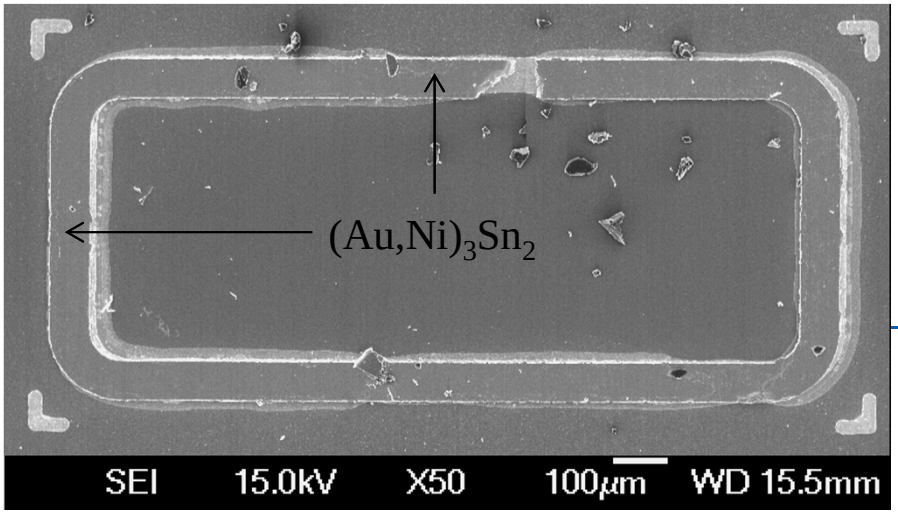
AuSn3 Shear



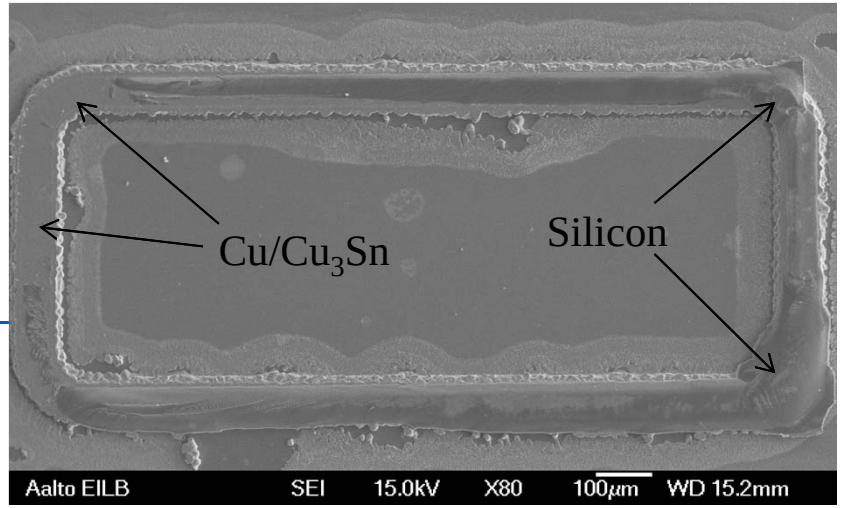
CuSn1 Shear



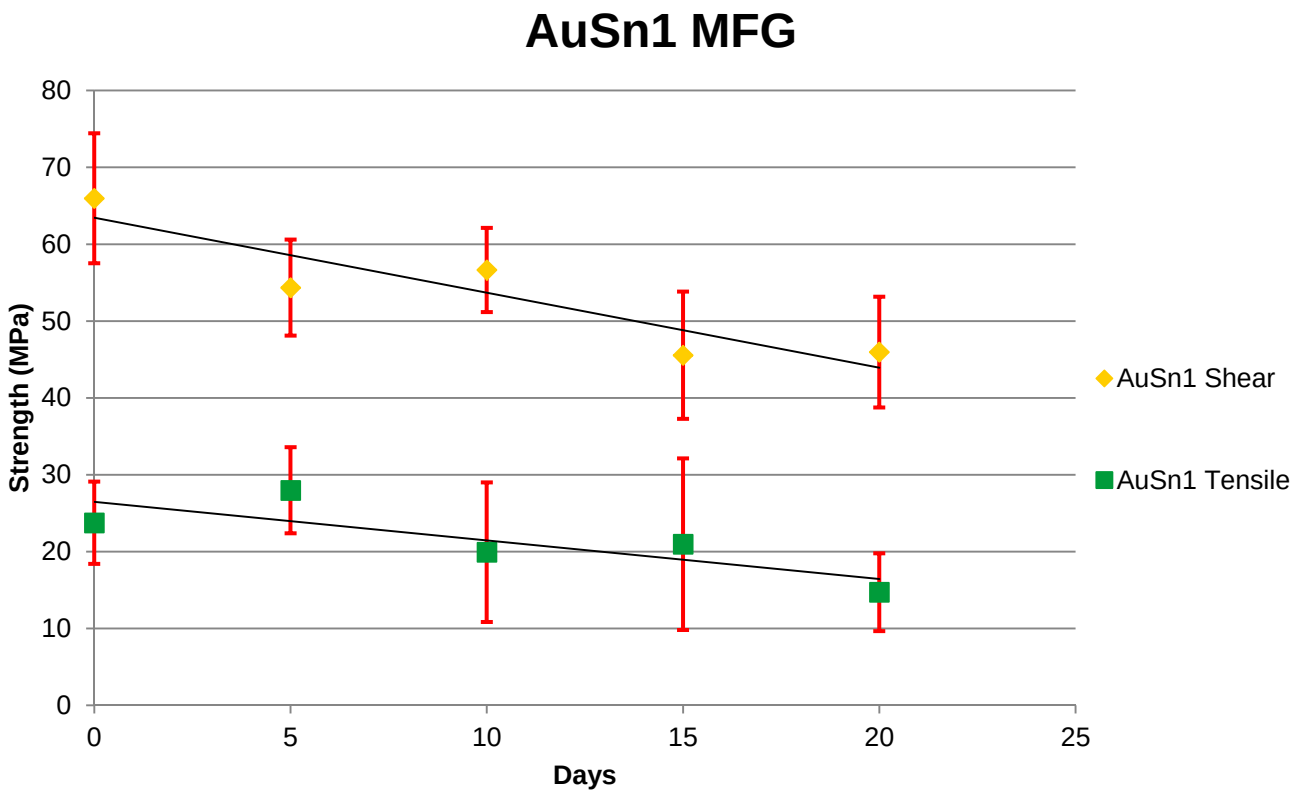
AuSn3 Tensile



CuSn1 Tensile



Mechanical strength after MFG test



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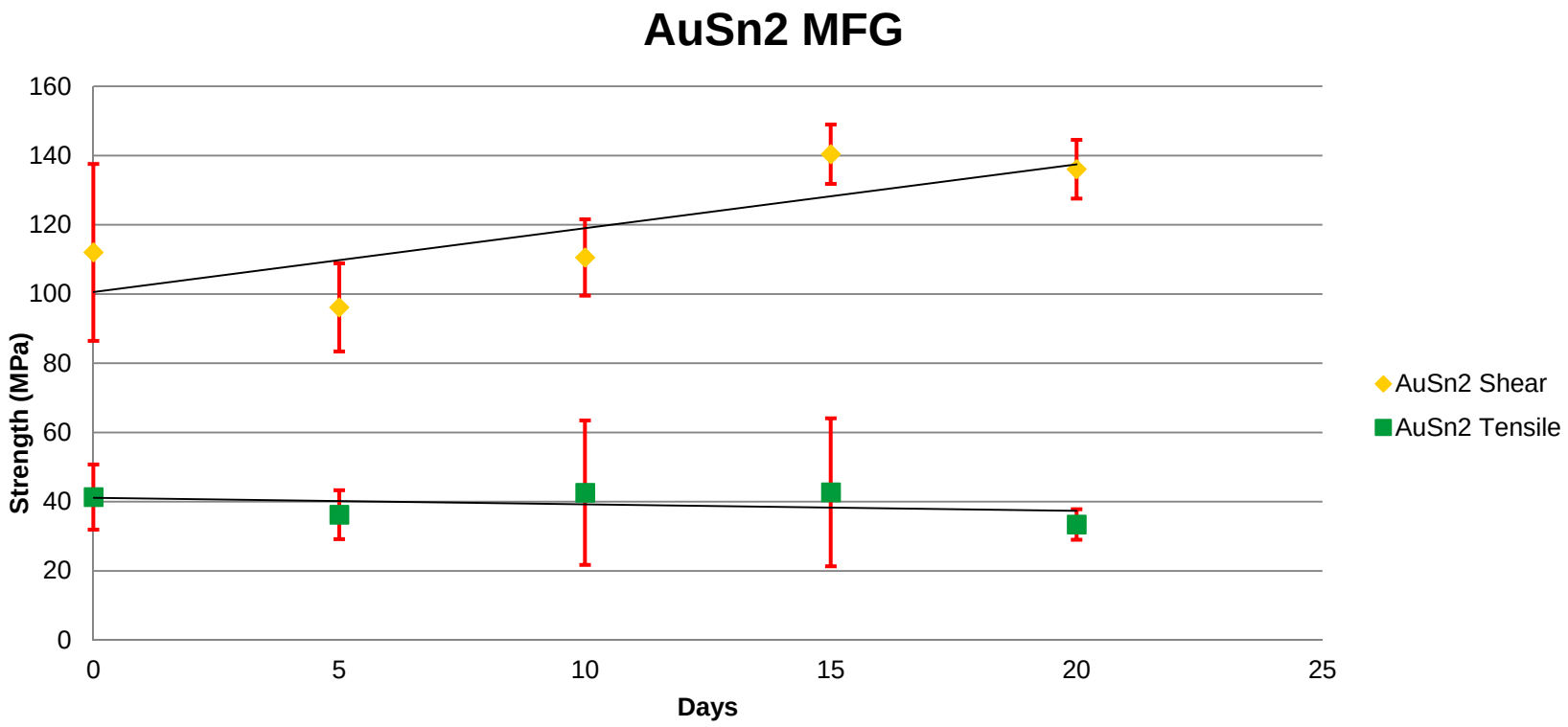

Conclusions

- **Cu-Sn bonding possess high shear and tensile strength**
- **Au-Sn bonding with Ni barrier demonstrates high shear and tensile strength**
- **Non-optimal interfaces, i.e. when $(Au_5Sn+AuSn)_{eut}$ is directly in contact with the TiW adhesion layer, are susceptible to corrosive environments**
- **The results highlight the need to carefully design the thicknesses of metallization layers with respect to the bonding parameters in order to avoid the formation of mechanically weak interfaces and voids**
- **Design rules: Control Au/Sn ratio, thin Ni barrier between AuSn and TiW, Amount of Sn vs. bonding parameters in Cu bonding**

Acknowledgments

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Questions please?