High-temperature Superconducting Interconnects for Ultra-low Temperature High-field Environments

Vyacheslav Solovyov, **Hyunwoo Kim and Paul Farrell**

Brookhaven Technology Group, 1000 Innovation Road, Stony Brook, NY 11794, (slowa@brookhaventech.com).

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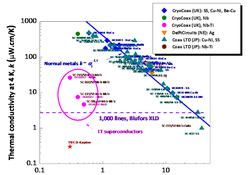
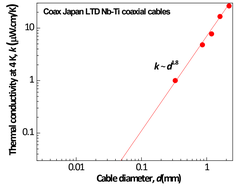
Introduction

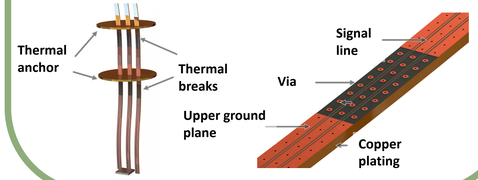


In normal metals thermal conductivity is proportional to electric conductivity Wiedemann-Franz (WF). Due to the limitations imposed by the WF law, the minimum loss is independent of the lead material and is 45mW for a conduction-cooled lead operating at 1 A

In superconductors, the WF law is violated by the formation of a coherent ground state and the opening of a gap in the excitation spectrum everywhere on the Fermi surface. However, Nb-based materials operate < 10 K.

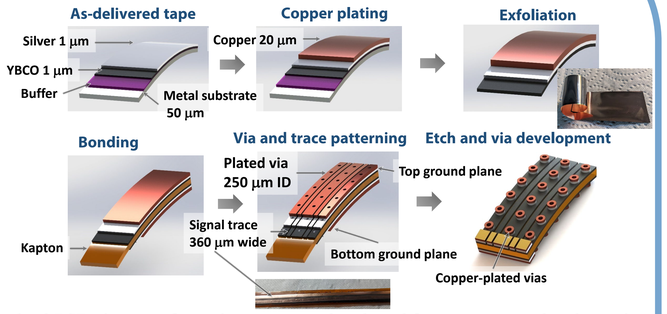


YBCO-Kapton RF cable with thermal breaks offers ultra-low thermal conductivity, low insertion loss and tolerance to magnetic field.



Experiment

Two-step exfoliation-bonding process, similar to Flexible PCB.



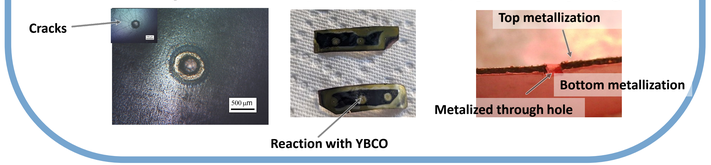
Standard PCB via manufacturing process, developed for copper, needs adaptation for YBCO

Drilling (CNC or laser) → Electroless Cu or Ni → Cu plating

✓ Drill hole etch to avoid cracking

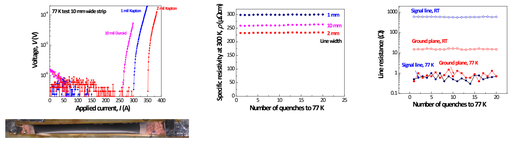
× Electroless deposition (Cu or Ni) is not compatible with YBCO,

✓ Carbon ink provides for YBCO-compatible treatment prior to Cu plating



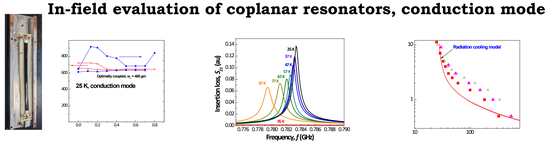
Results & discussion

Critical current and stability of YBCO-dielectric composites



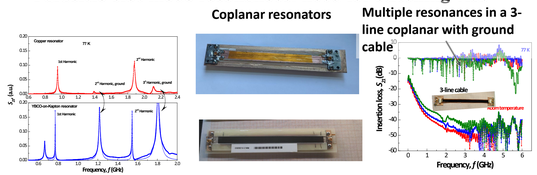
✓ Up to 80% Ic retention ✓ No degradation after quenching to 77 K

In-field evaluation of coplanar resonators, conduction mode



✓ No Q reduction up to 0.8 T ✓ Cooling mechanism is radiation

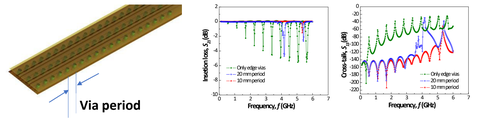
Parasitic slot mode resonances: need for stitching vias



✓ Superconducting lines are particularly prone to parasitic resonances

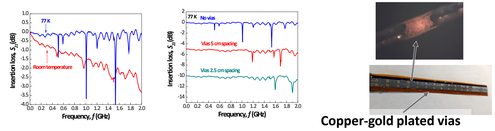
Results & discussion

Model: effect of stitching vias on S21 and cross-talk



✓ The model show that a via array with 10 mm period suppresses parasitic resonances

Effect of via period, experiment on a single coplanar line



✓ Via fences suppressed the first and the second harmonics

Conclusion

- We have demonstrated a two-step process for manufacturing HTS two-sided PCBs on popular dielectric materials: Kapton, FR4 and Duriod. Multi-line “coplanar with ground” transmission lines and coplanar resonators
- The processing step is compatible with the standard PCB manufacturing methods, except for electroless through-hole metallization. However, conducting carbon ink coating was successfully applied.
- Future work will focus on smaller vias and high line density

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