Analysis, design and optimization of Stripline and Microstrip for Cryogenic applications

Huiqin Yu*, Shuna Wang, Pusheng Yuan, Lingyun Li, Lixing You

State Key Laboratory of Functional Materials for Informatics, Shanghai Institution of Microsystem and Information Technology (SIMIT),Chinese Academy of Sciences, Shanghai 200050,China

*E-mail: yuhuiqin@mail.sim.ac.cn

Motivations

- As the increasing complexity of superconducting system, the on-demand increasing number of semi-rigid cables are difficult to configured.
- Stripline and Microstrip with the characteristics of high flexibility, low-cost and easy installing are more suitable for the cryogenic applications.
- According to Wiedemann-Franz law, a trade-off between the heat load and signal insertion is necessary.

Simulation and Experiment

LCP Stripline

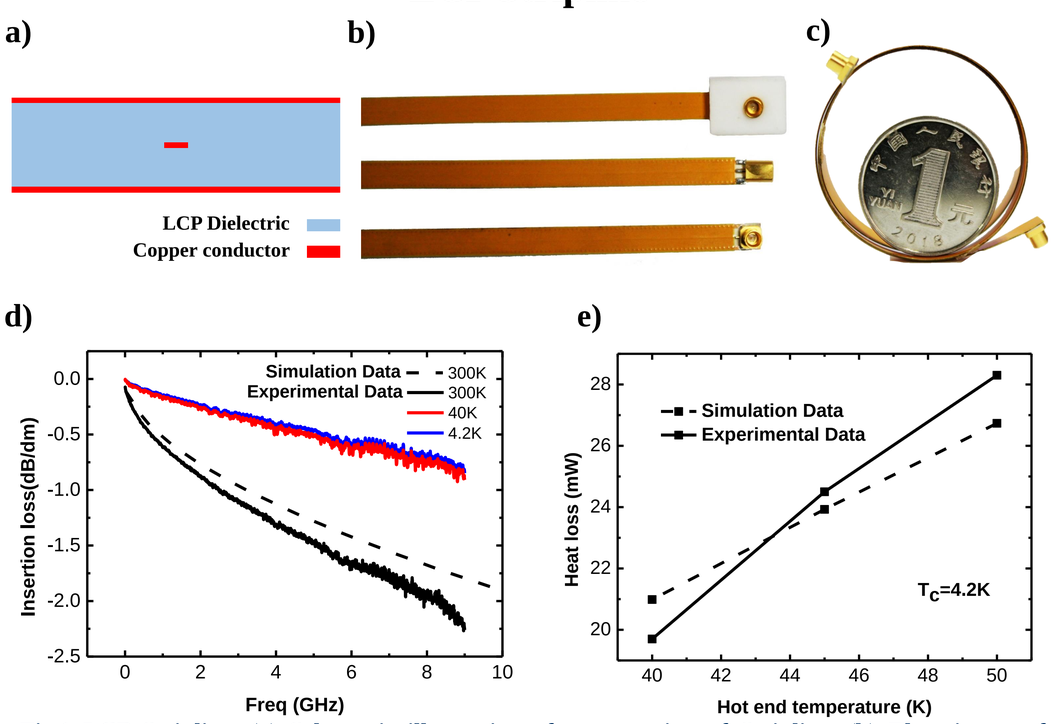

Fig.1 LCP Stripline. (a) Schematic illustration of cross-section of Stripline. (b) The picture of Stripline. (c) Flexibility of Stripline taking a Chinese coin as reference. (d) Insertion losses versus frequencies with different temperature. The dash line and the solid lines represent the simulation and experimental result, respectively. (e) Simulation and experiment results of heat loss versus different hot end temperature with 30 cm length of Stripline, where cold end temperature is 4.2 K.

PTFE Microstrip

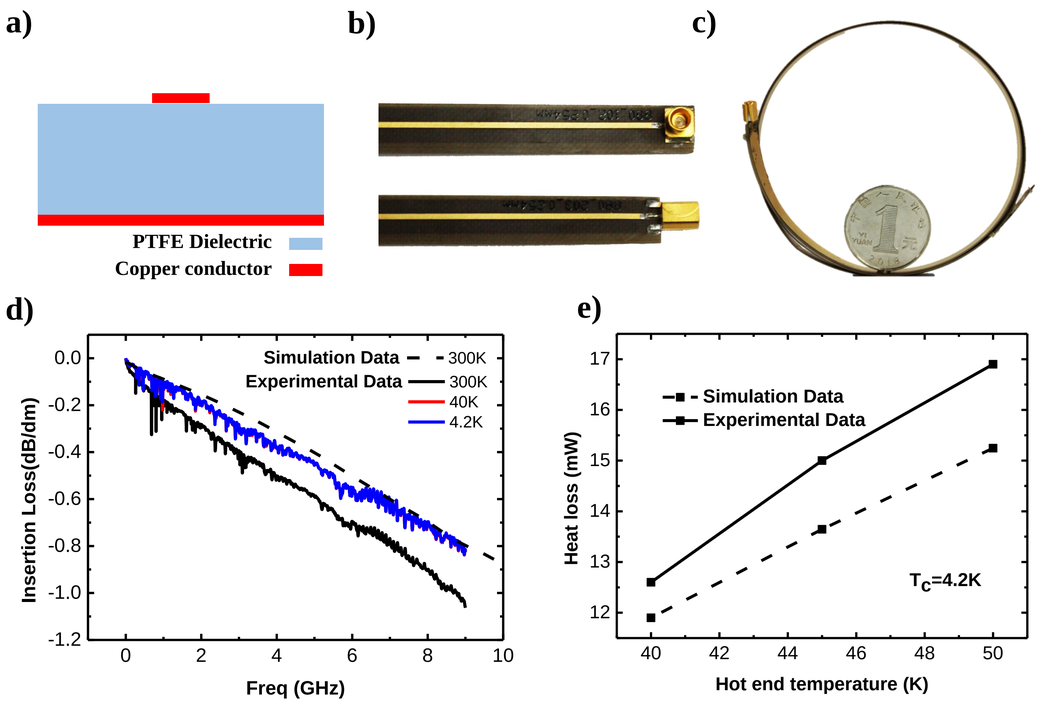

Fig.2 PTFE Microstrip. (a) Schematic illustration of cross-section of Microstrip. (b) The picture of Microstrip. (c) Flexibility of Microstrip taking a Chinese coin as reference. (d) Insertion losses versus frequencies with different temperature. The dash line and the solid lines represent the simulation and experimental result, respectively. (e) Simulation and experiment results of heat loss versus different hot end temperature with 30 cm length of Microstrip, where cold end temperature is 4.2 K.

- The insertion loss of PTFE Microstrip is less than that of LCP Stripline.
- The heat loss of Stripline is 22 mW, where the heat loss of Microstrip is 11.9 mW (ΔT:4.2~40 K, L=30 cm).
- The insertion losses of Stripline and Microstrip are not sensitive to the temperature from 4.2 K to 40 K.
- LCP Stripline is more flexible than PTFE Microstrip.

Discussion

PTFE Microstrip exhibits both less heat loss and insertion loss than that of LCP Stripline, which is the promising candidate of transmission line in superconducting system. Such microstrip can be further developed for obtaining better performance in signal transmission and heat transfer.

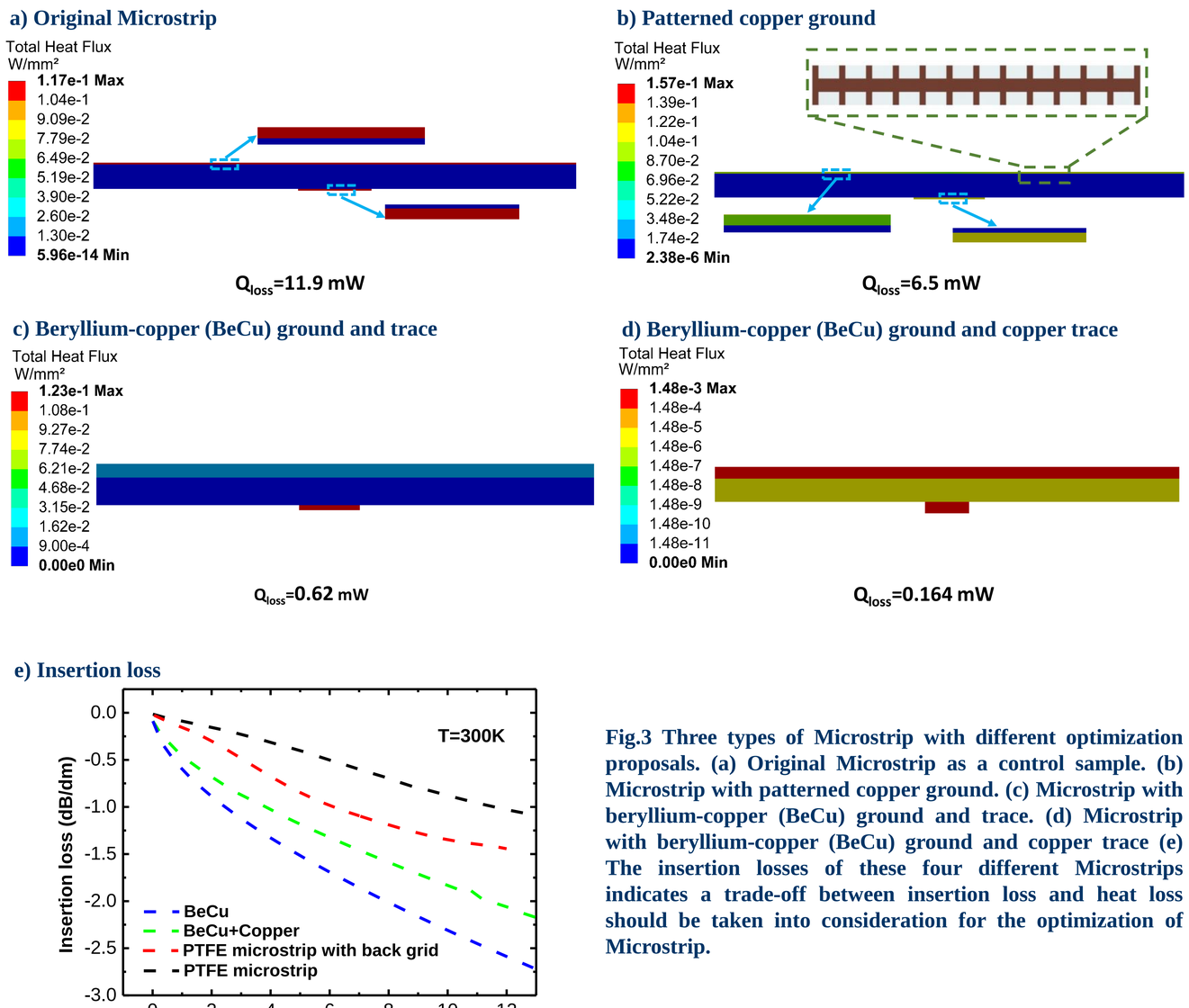

Fig.3 Three types of Microstrip with different optimization proposals. (a) Original Microstrip as a control sample. (b) Microstrip with patterned copper ground. (c) Microstrip with beryllium-copper (BeCu) ground and trace. (d) Microstrip with beryllium-copper (BeCu) ground and copper trace (e) The insertion losses of these four different Microstrips indicates a trade-off between insertion loss and heat loss should be taken into consideration for the optimization of Microstrip.

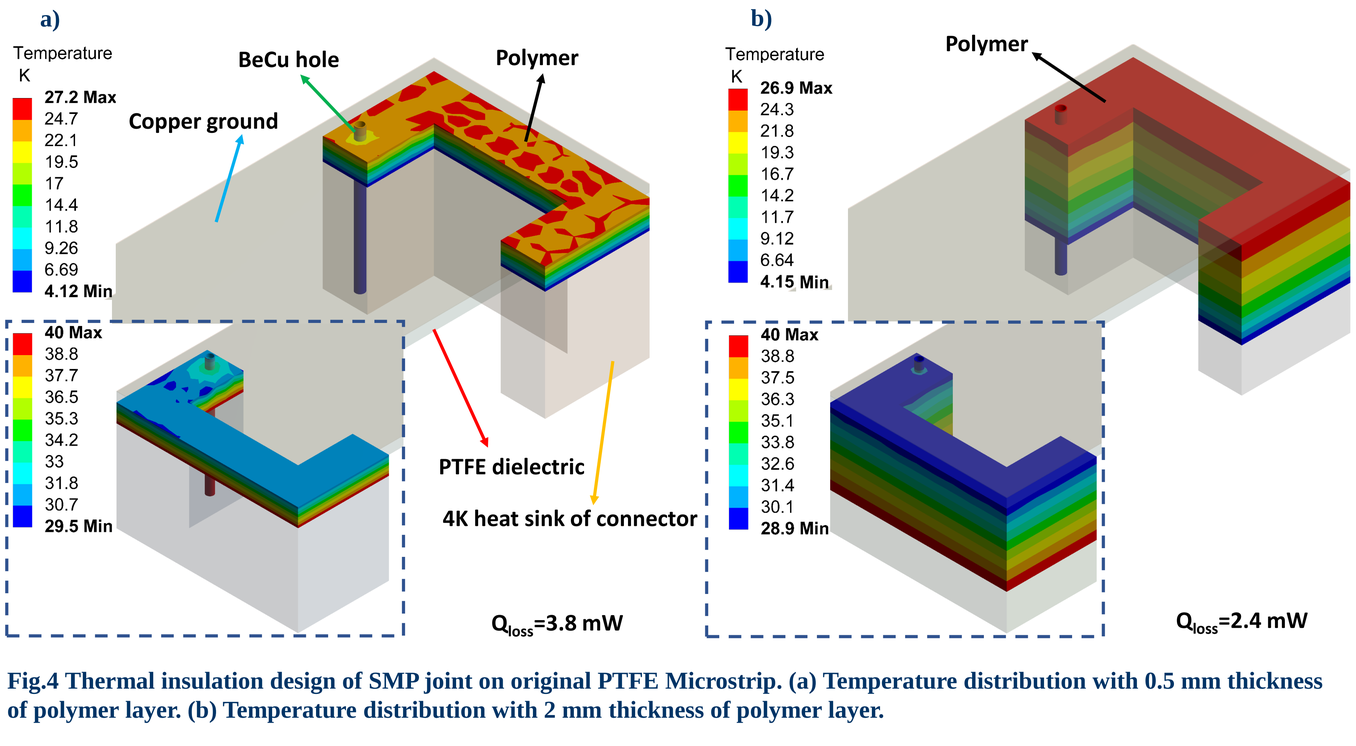

Fig.4 Thermal insulation design of SMP joint on original PTFE Microstrip. (a) Temperature distribution with 0.5 mm thickness of polymer layer. (b) Temperature distribution with 2 mm thickness of polymer layer.

- Four different types of Microstrip are showed to reduce heat loss via introducing different materials and structures. Nevertheless, there is a trade-off between heat loss and insertion loss.
- A more considerable way for reducing the heat loss is the thermal insulation design of joint, which heat loss reduced from 11.9 mW to 2.4 mW. In addition, the influence of this design on insertion loss is not obvious.

Conclusion

- ✓ **Stripline and Microstrip for superconducting system were designed and tested in our laboratory. The insertion loss can be -0.8 dB/dm with 9 GHz bandwidth at 4.2 K.**
- ✓ **To reduce the heat loss of Microstrip, four optimization proposals were discussed here, which the heat loss can be reduced to 2.4 mW without obvious influence on insertion loss.**