Ver0.1 2024/10/09

Ver0.2 2024/10/13

Ver0.3 2024/11/07

Ver0.4 2025/04/08

Ver0.5 2025/06/10

Ver0.6 2026/01/26

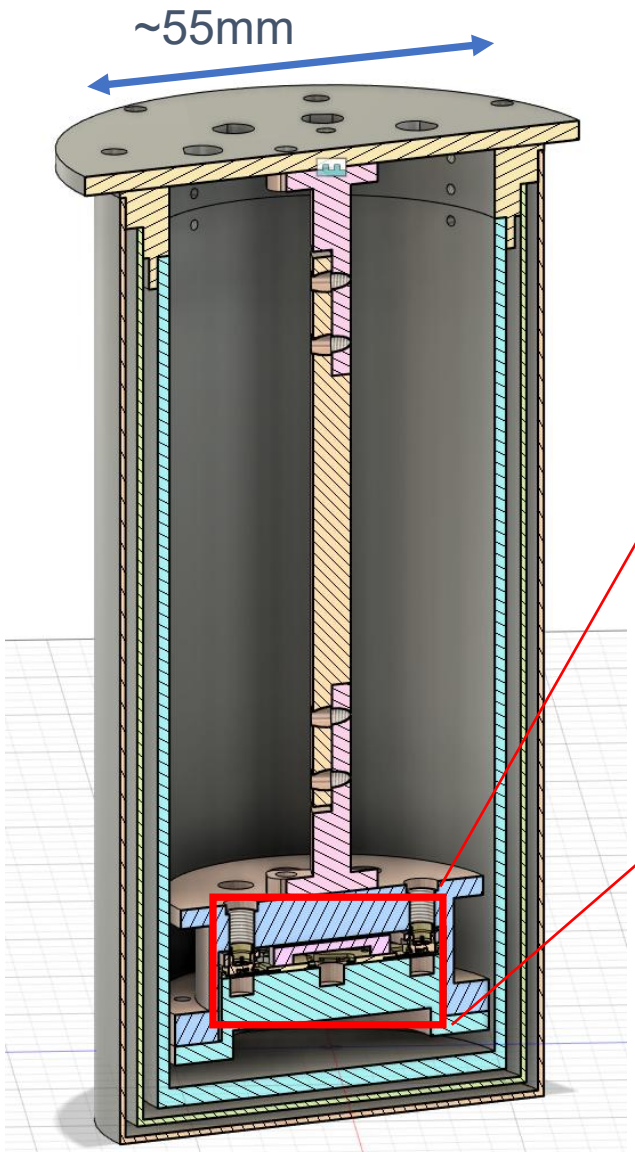
Small scale sample holder and PCB

Shotaro Shirai, Atsushi Noguchi

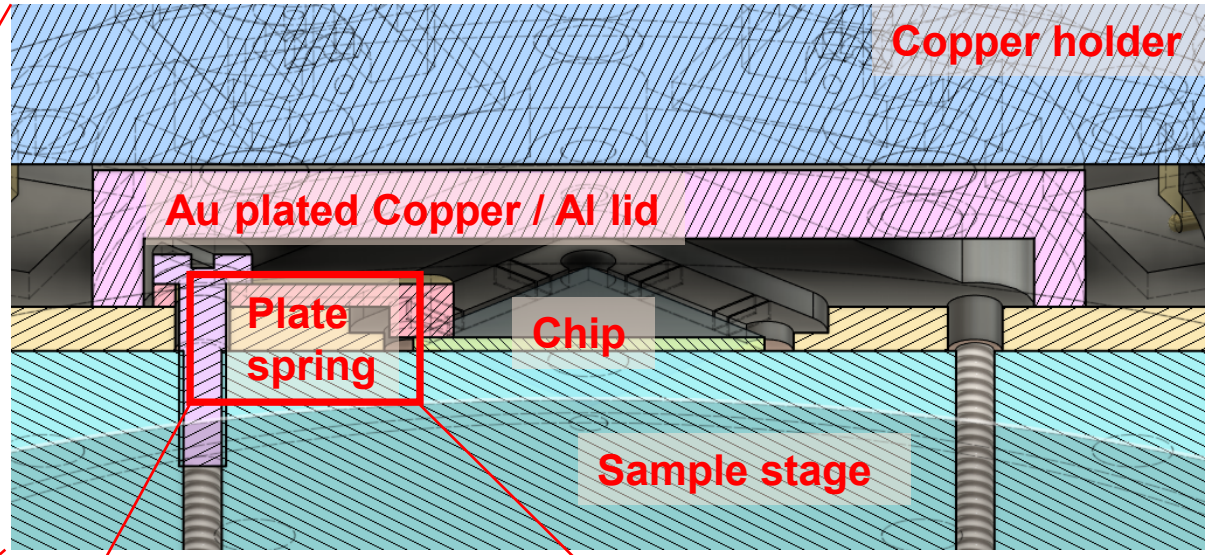
RIKEN Center for Quantum Computing

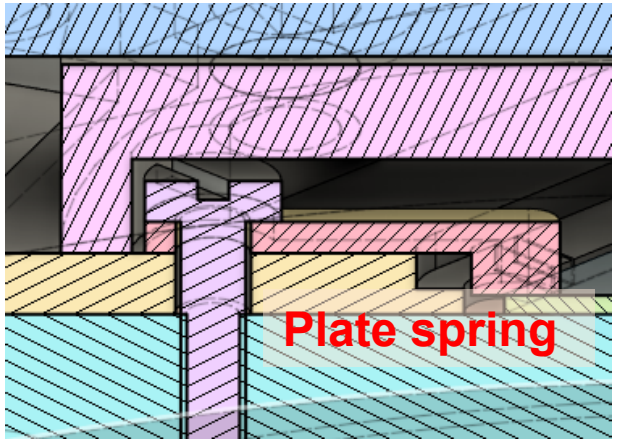
Komaba Institute for Science, UTokyo

Sample holder design



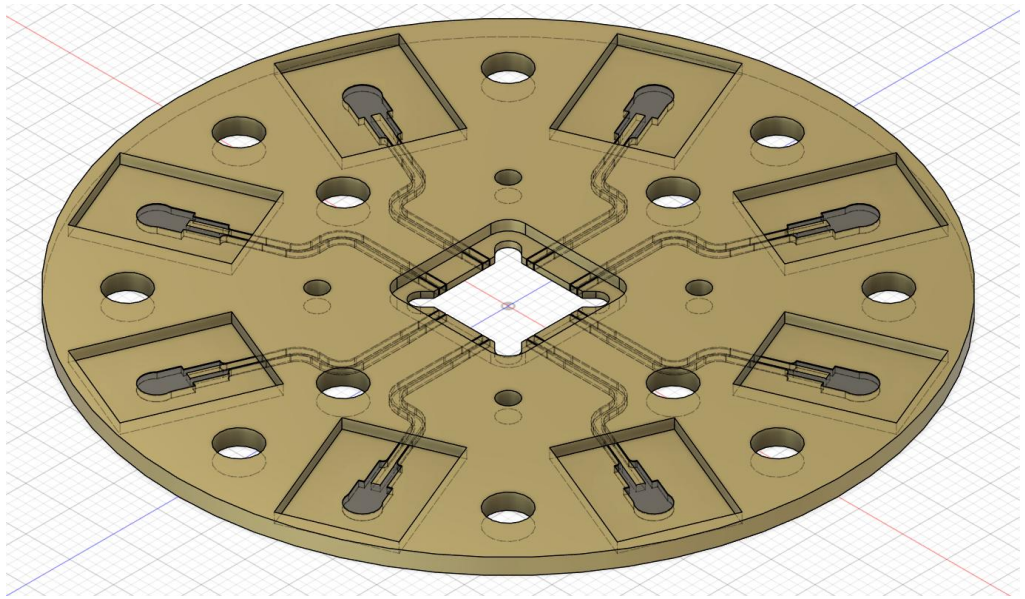
(A slim version is also available, if you don't want to change your magnetic shield.)



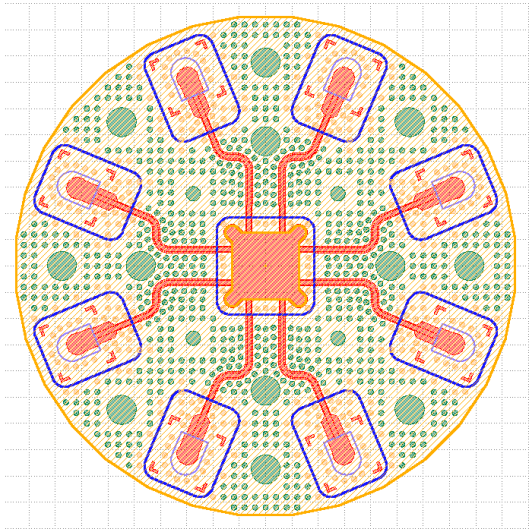


- ✓ No varnish required (you can still use it)
- ✓ Fast sample loading

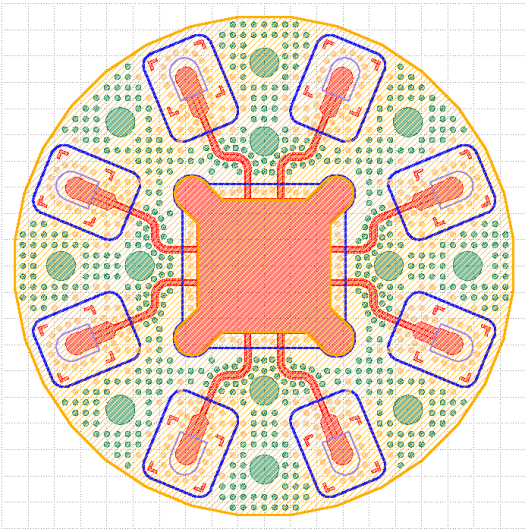
PCB design



For 5x5mm chip

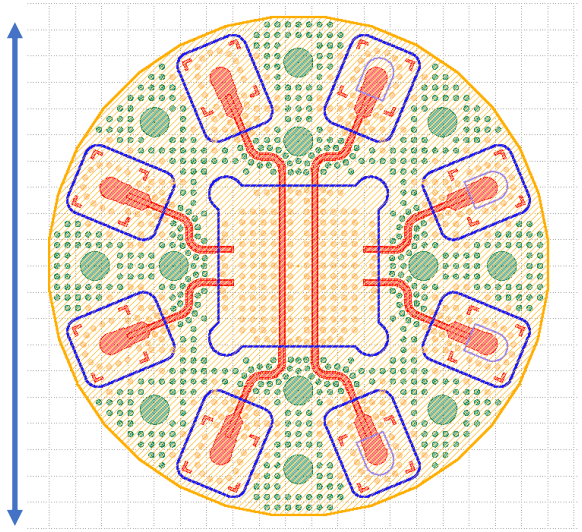


For 10x10mm chip



- SMP connectors are soldered directly to the 2nd layer
- No interlayer connection of signal lines required
- Use with electromagnetically tight lids

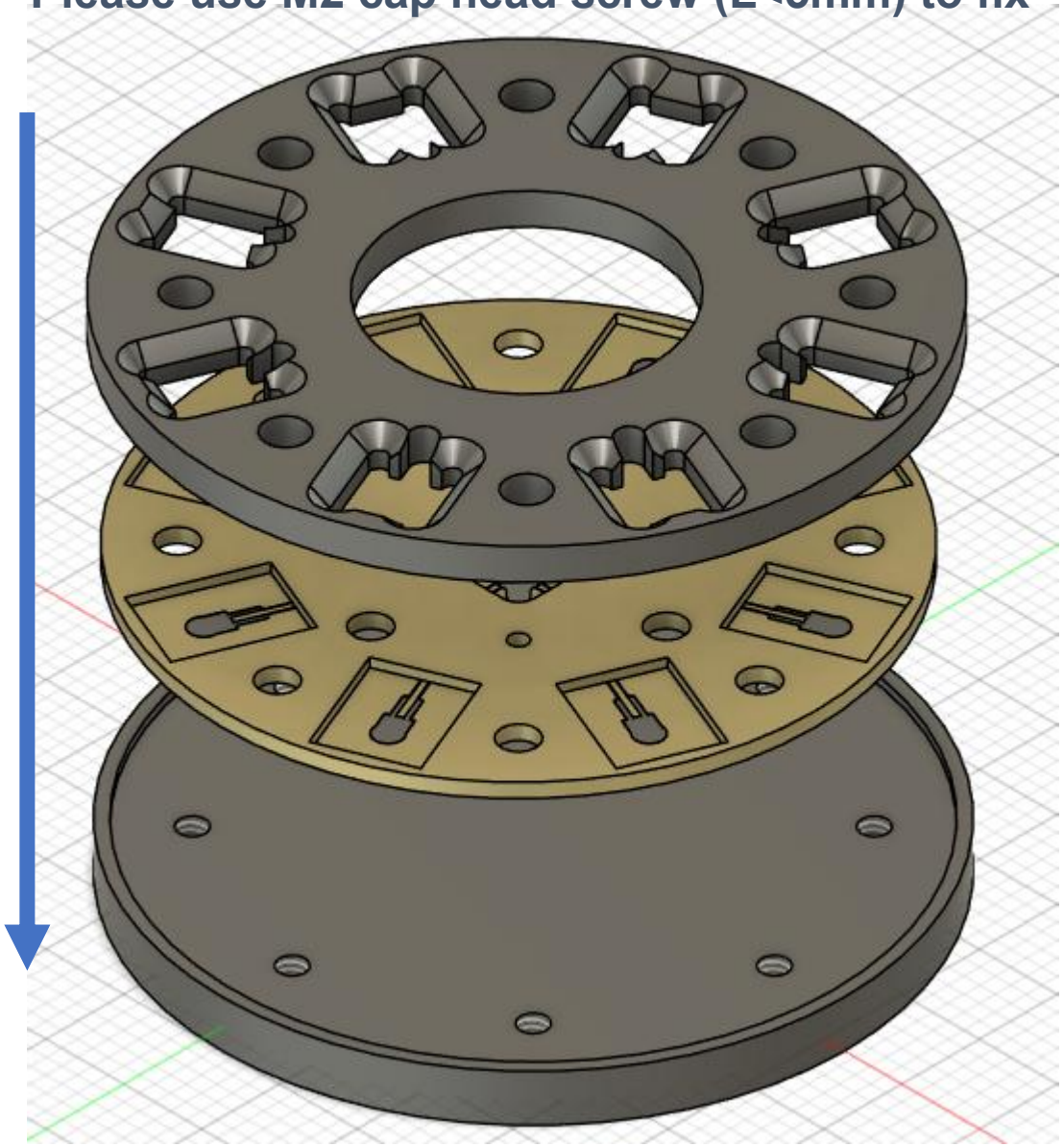
Φ~39mm



For SMP connector test

Assembling PCB

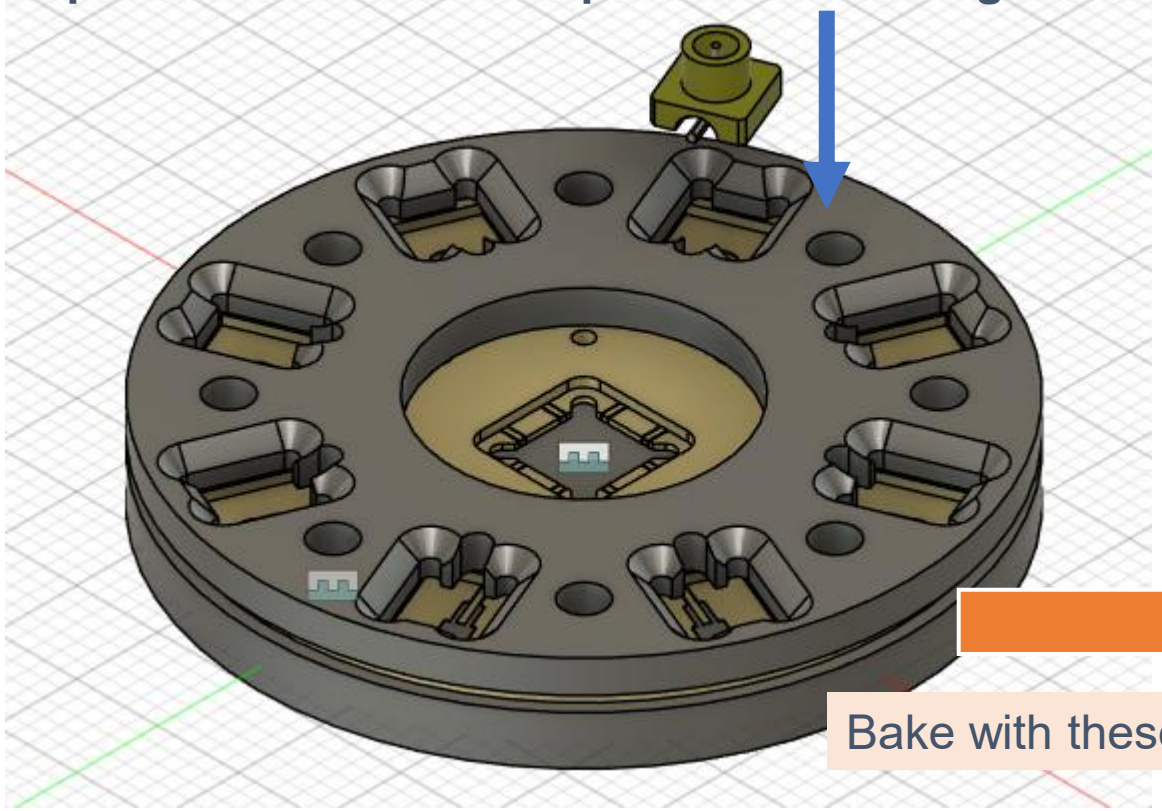
Please use M2 cap head screw (L<5mm) to fix



https://shop.sunhayato.co.jp/products/SMX-H05A

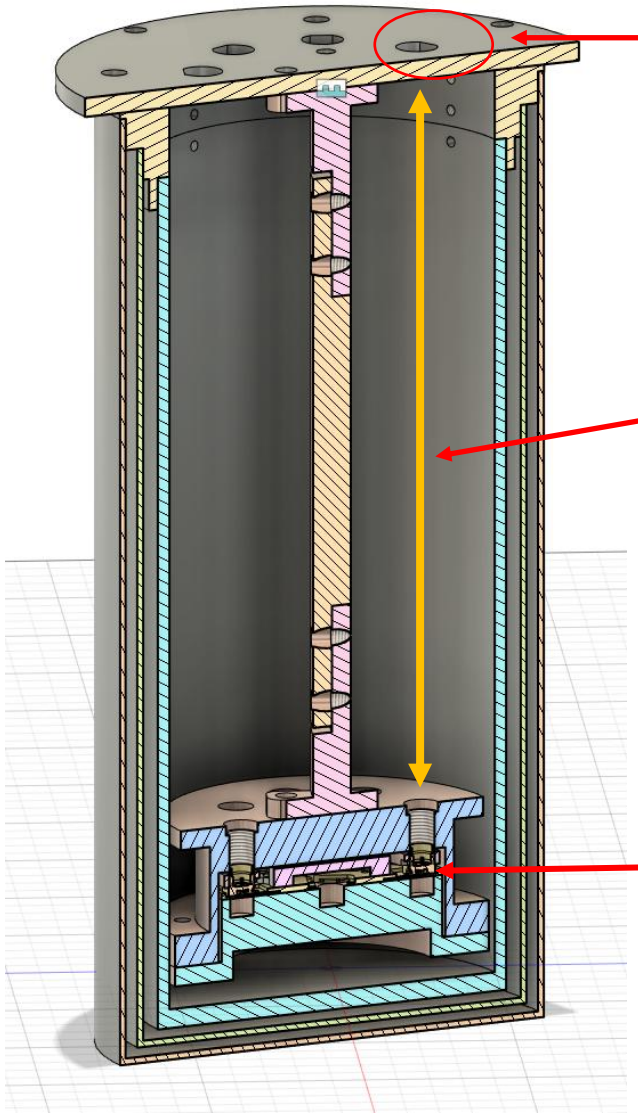
We use this (left) solder paste (Sn 63%, Pb 37%)
Hot plate temp. must be in 220--250℃ for soldering and baking time is ~5min

Drop SMP connector with paste solder along the frame



Bake with these jigs

Assembling PCB: cable and connectors



Amphenol SV Microwave PN: 1129-4004

SFC-219/50-SC-135-SMPBHPNM/SMAPNM
(SMP feedthrough: 19S641-271L5-NM)
***Above is the product code in Coax.**

SMT SMP connector:
19S102-40ML5-NM

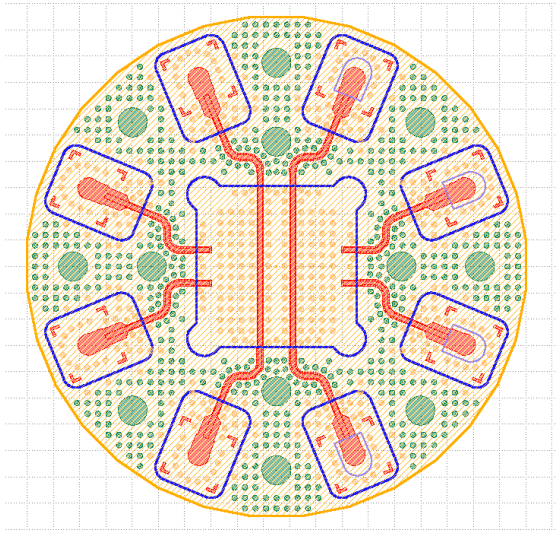
In addition, fixing the sample holder and lid requires four M2 hex socket screws of 5 mm length, four M2 screws of 8 mm length, and sixteen M3 screws of 8 mm length.

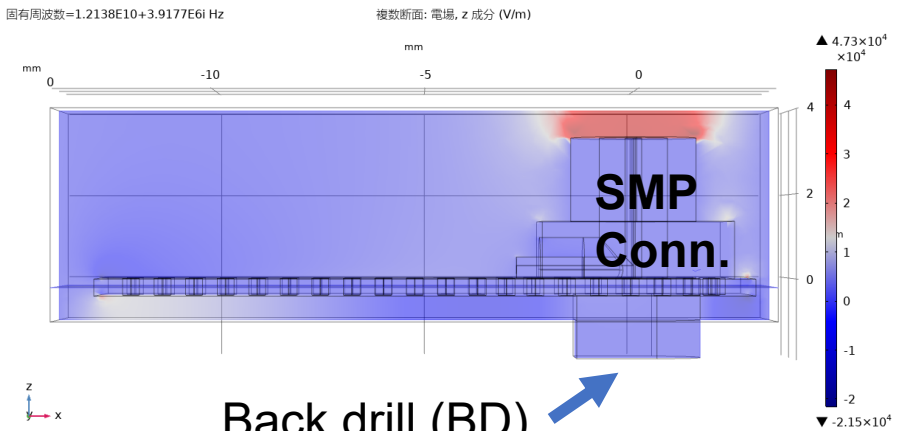
Chip assembling

The chip can be fixed either by using varnish or mechanically, as shown in the photo, by fastening a fixture with M1 screws (4 mm long). We recommend fixing with varnish.

SMP connector's reflection and PCB loss

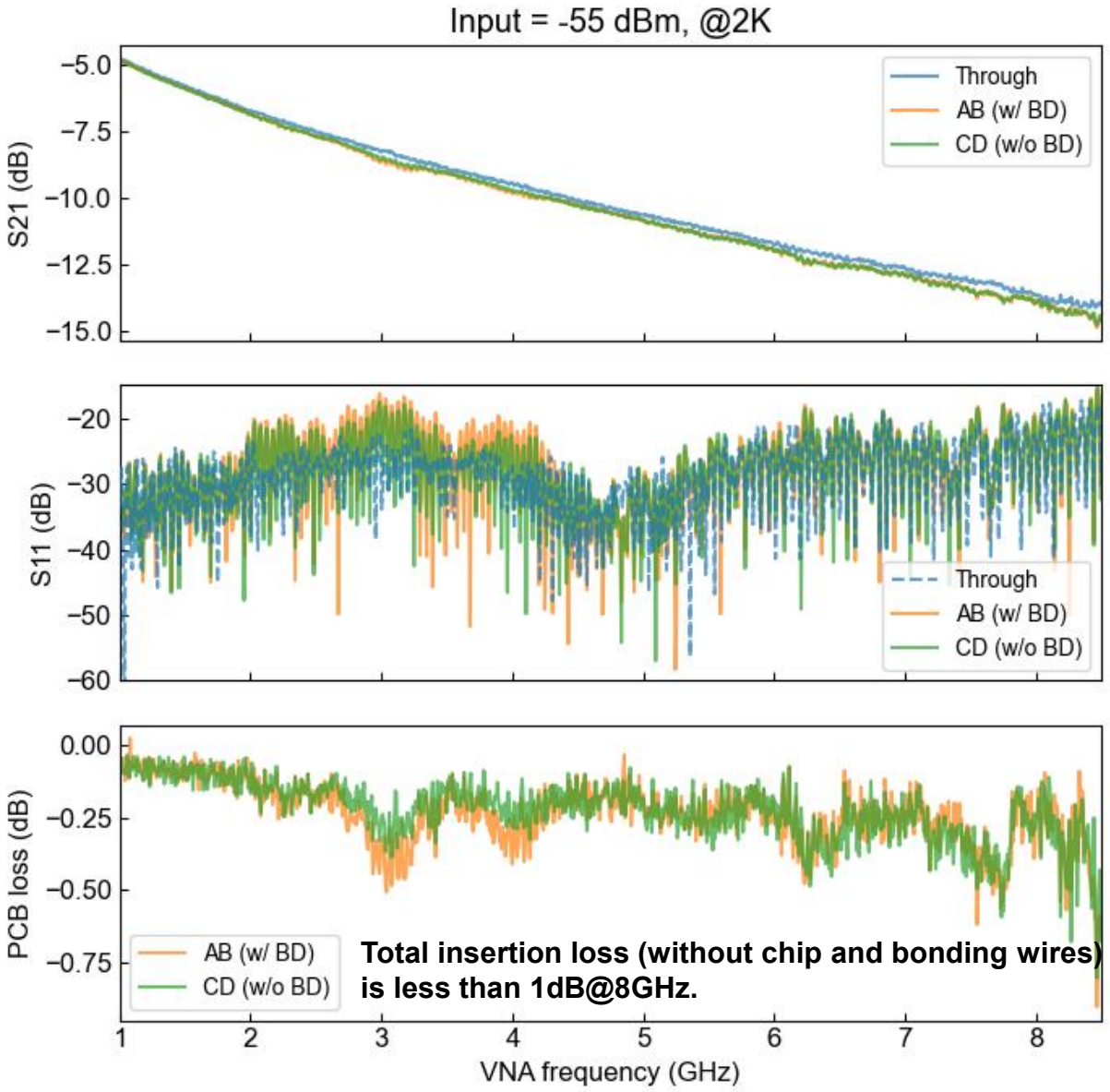
Test PCB pattern



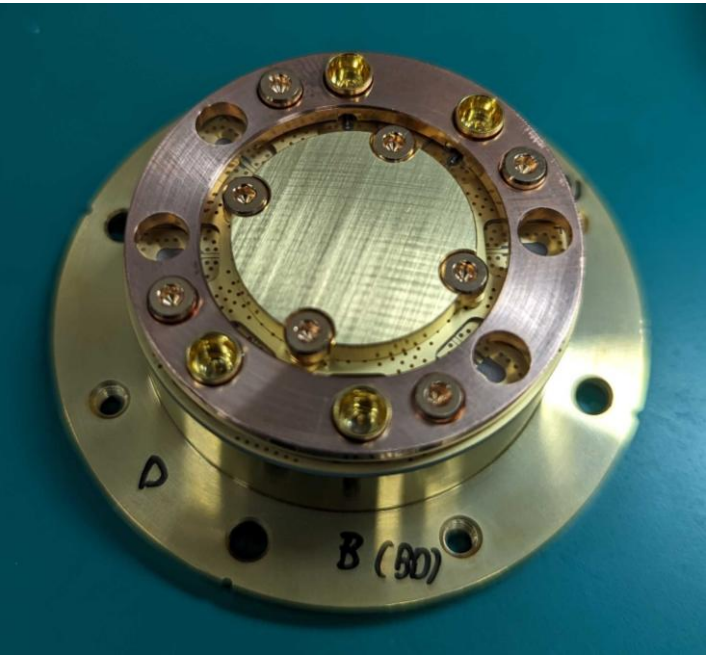


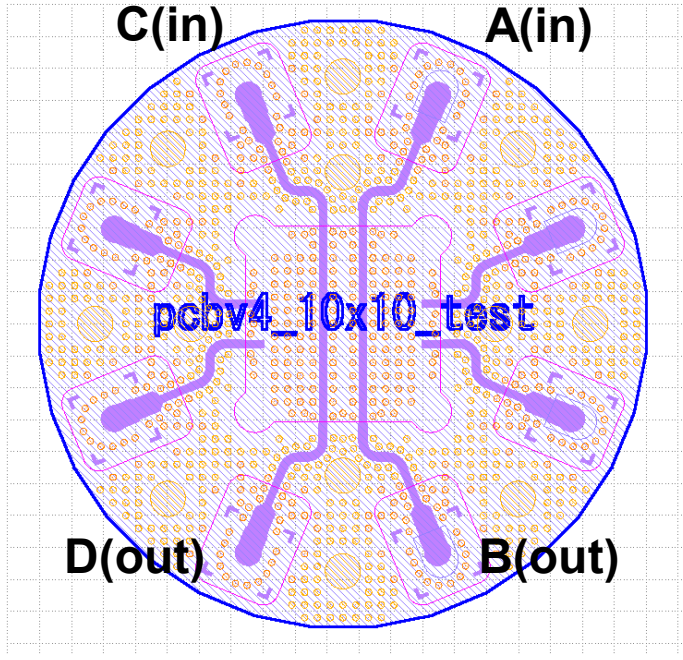
Back drill (BD)

Cross-section SMP connector part@COMSOL

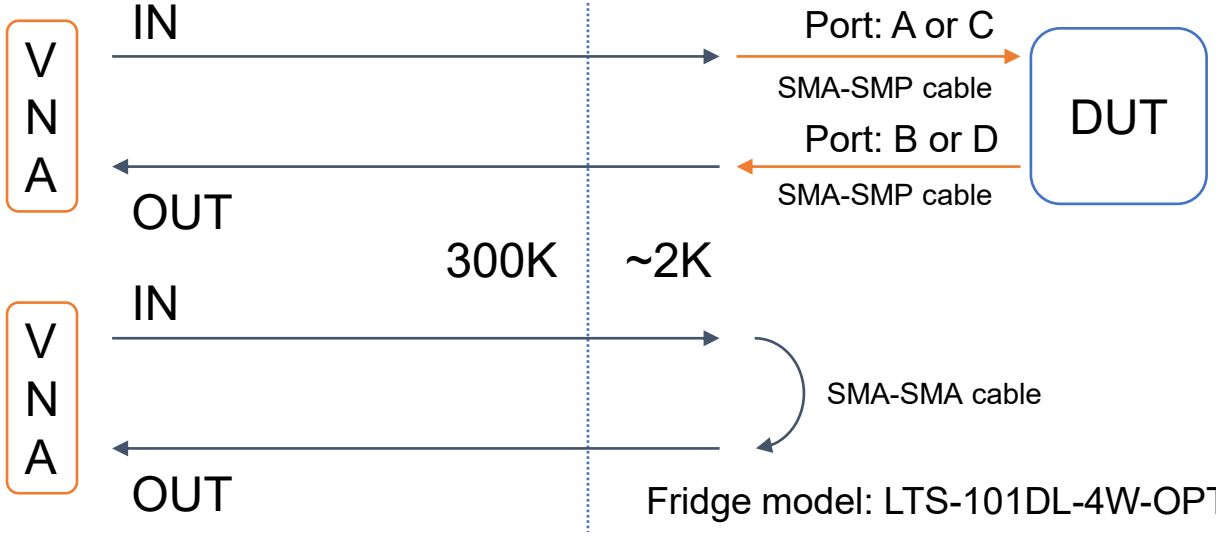


SMP connector's reflection and PCB loss



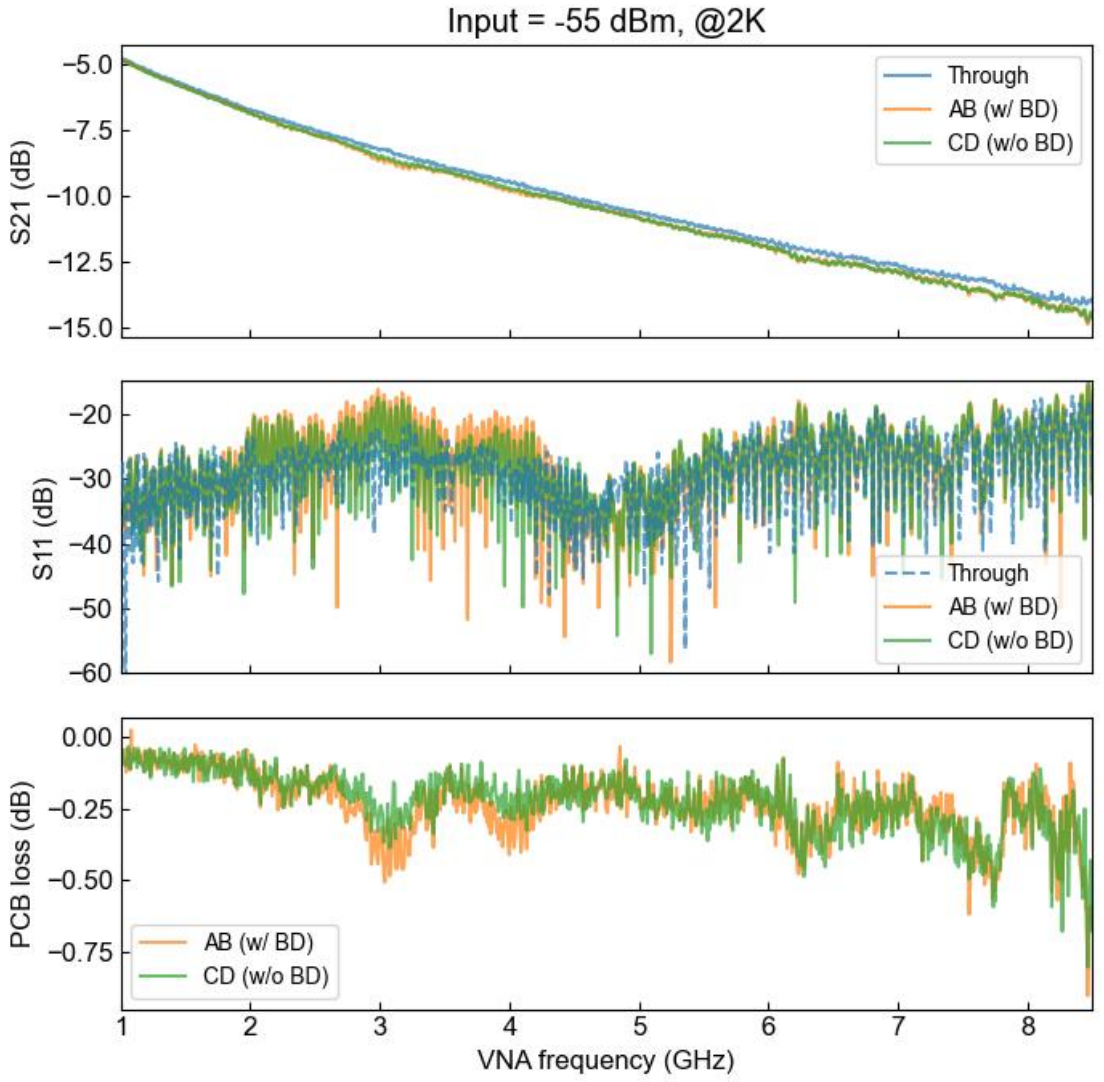


Measurement setup for AB (top), CD (top), and Through (bottom)



Fridge model: LTS-101DL-4W-OPT-Q

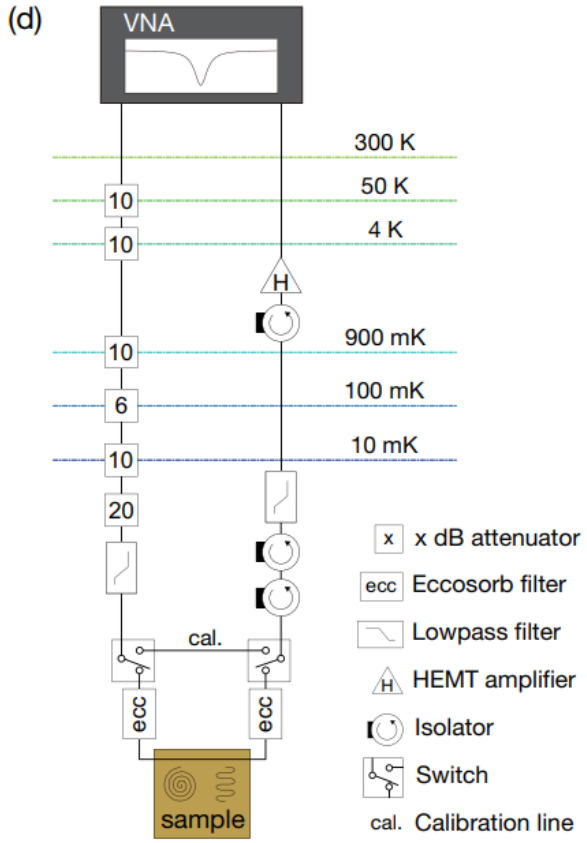
Measurement results using a VNA in a 2K environment

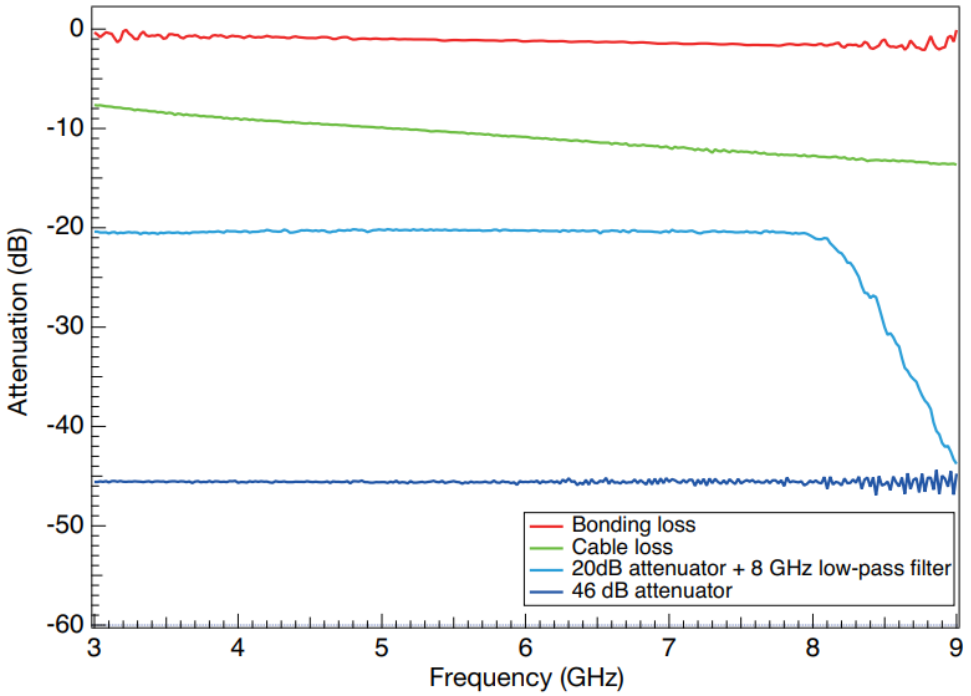


PCB loss including a chip and bonding wires

The total loss of the SMP connectors, PCB, bonding wires, and a chip after calibration in the 10 mK environment is approximately 1 dB, and when following the appropriate sample loading procedure (described below), no significant resonant structures have been observed in the 3–8 GHz range.

Using this PCB and sample holder, internal Q-factors exceeding 10^7 at the single-photon level have been observed for microwave resonators, and in the high-power regime, the internal Q-factor approaches 10^8. For these results and detailed calibration procedures, please refer to Ref. [1].





[1] Y. Tominaga, *et al.*, "Intrinsic quality factors approaching 10 million in superconducting planar resonators enabled by spiral geometry." *EPJ Quantum Technology* 12.1 (2025).

Sampler holder assembling

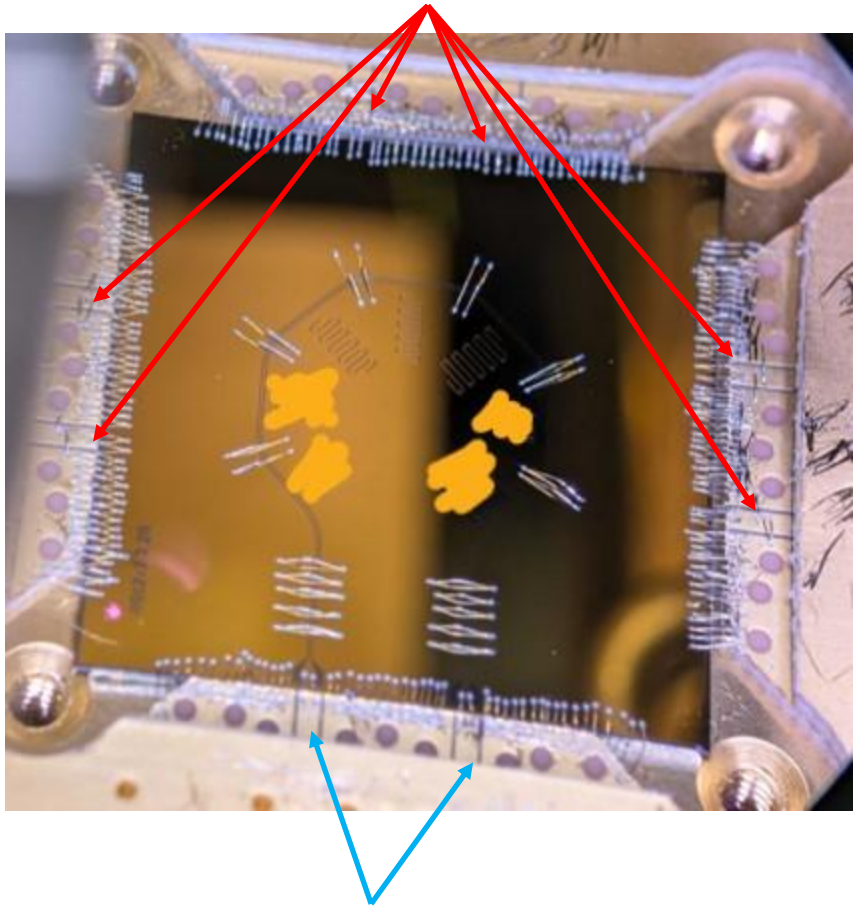
Note

- One known issue at present, as explained below, is crosstalk between SMP connectors mediated by modes in the space between the central lid of the sample holder and the surrounding copper ring.
  This can be mitigated by grounding unused ports or sealing the gap with metallic tape. In the future, this issue can be addressed by designing a more tightly fitting lid.

Assembled sample stage and PCB

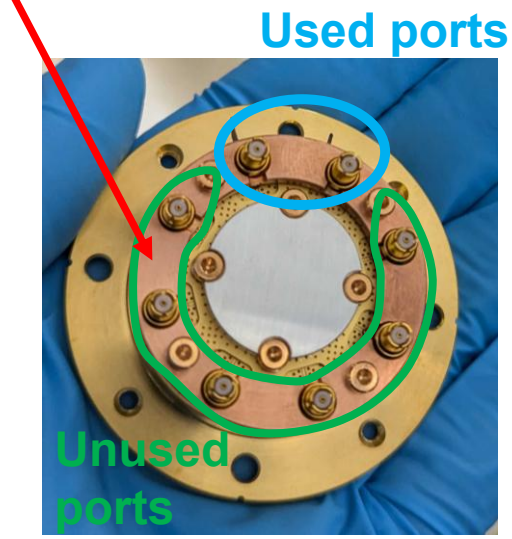
There is a proper way to assemble the sample holder that does not produce parasitic modes.

All unused lines should be connected to ground by bonding.



Used lines

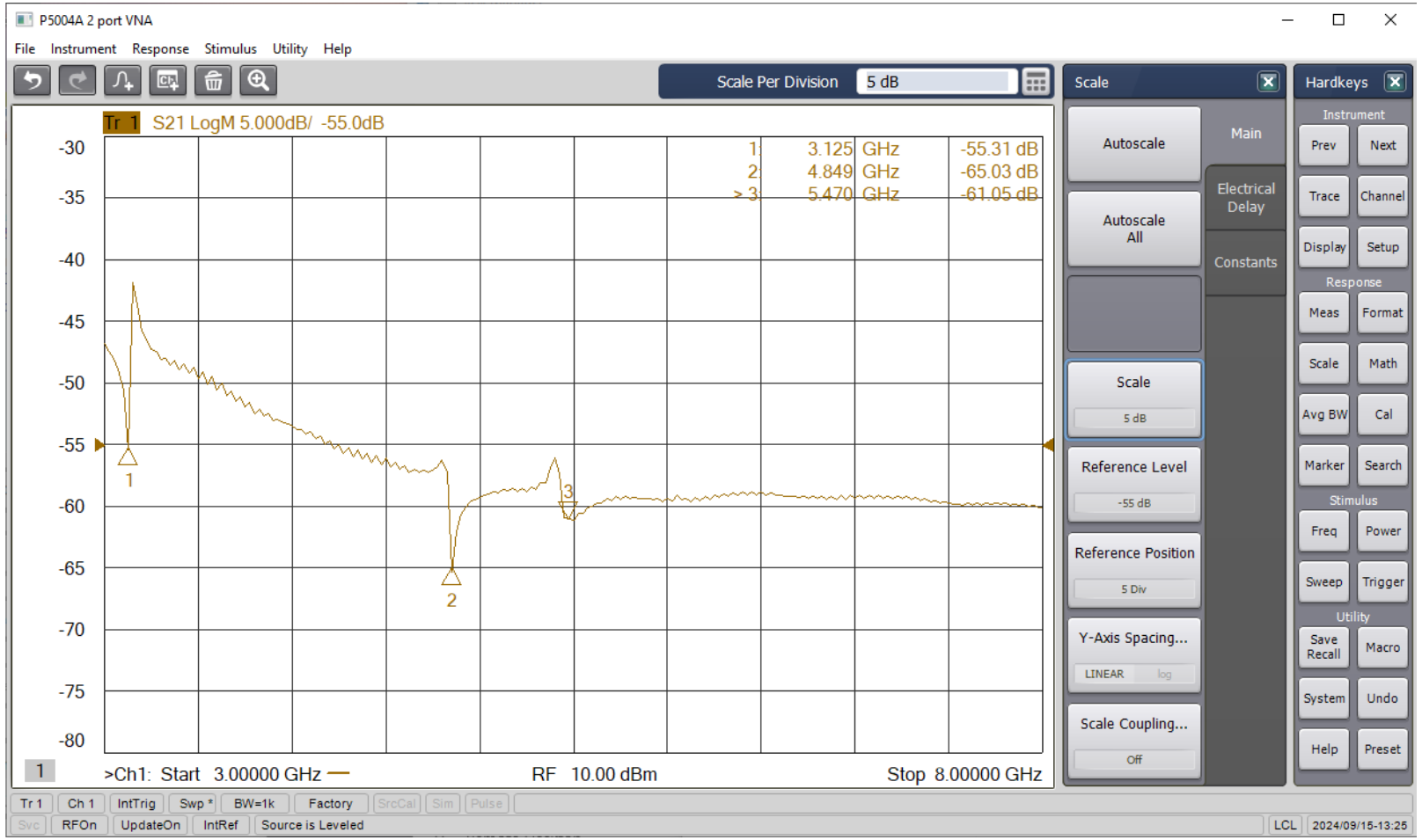
This ring is for fixing SMP connectors, and is to improve the lifetime of the PCB.



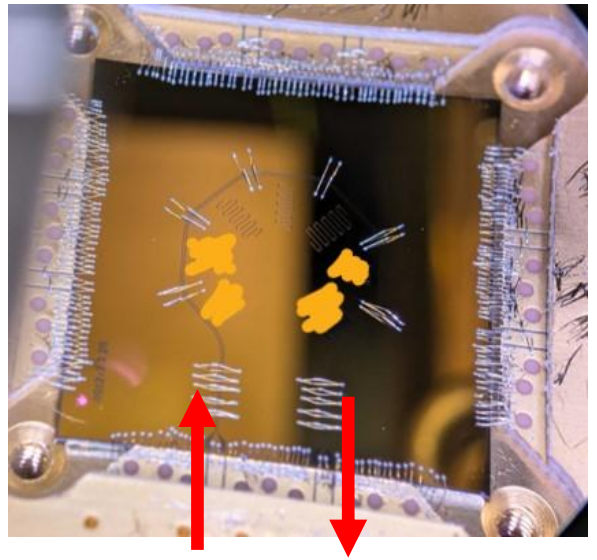
All unused ports must have SMP bullets too and be connected and terminated at the top of the sample holder(right fig.).

S21 measurement @ Room temperature

S21@RT **without** ground bonding and terminations.



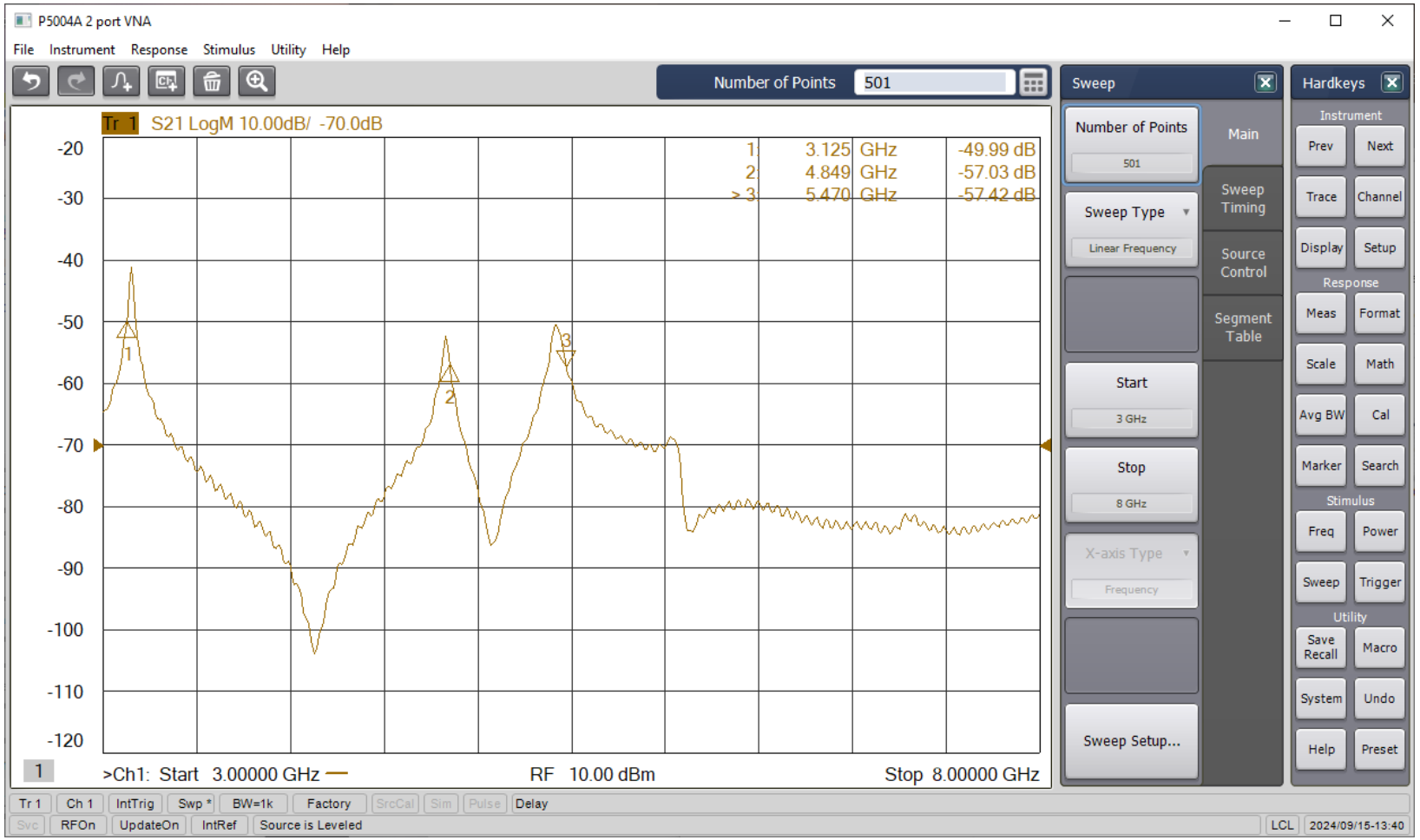
Port setup



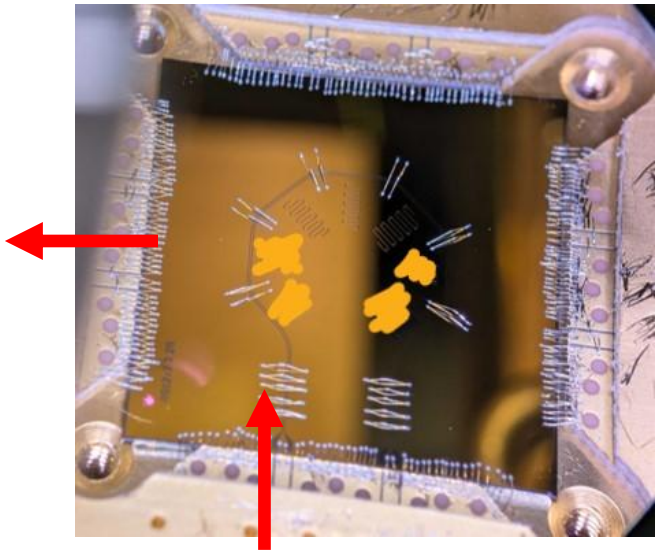
We see spurious modes at 3.1, 4.8 and 5.5 GHz.

S21 measurement (Crosstalk) @ Room temperature

S21(Crosstalk) @ RT **without** ground bonding and terminations.



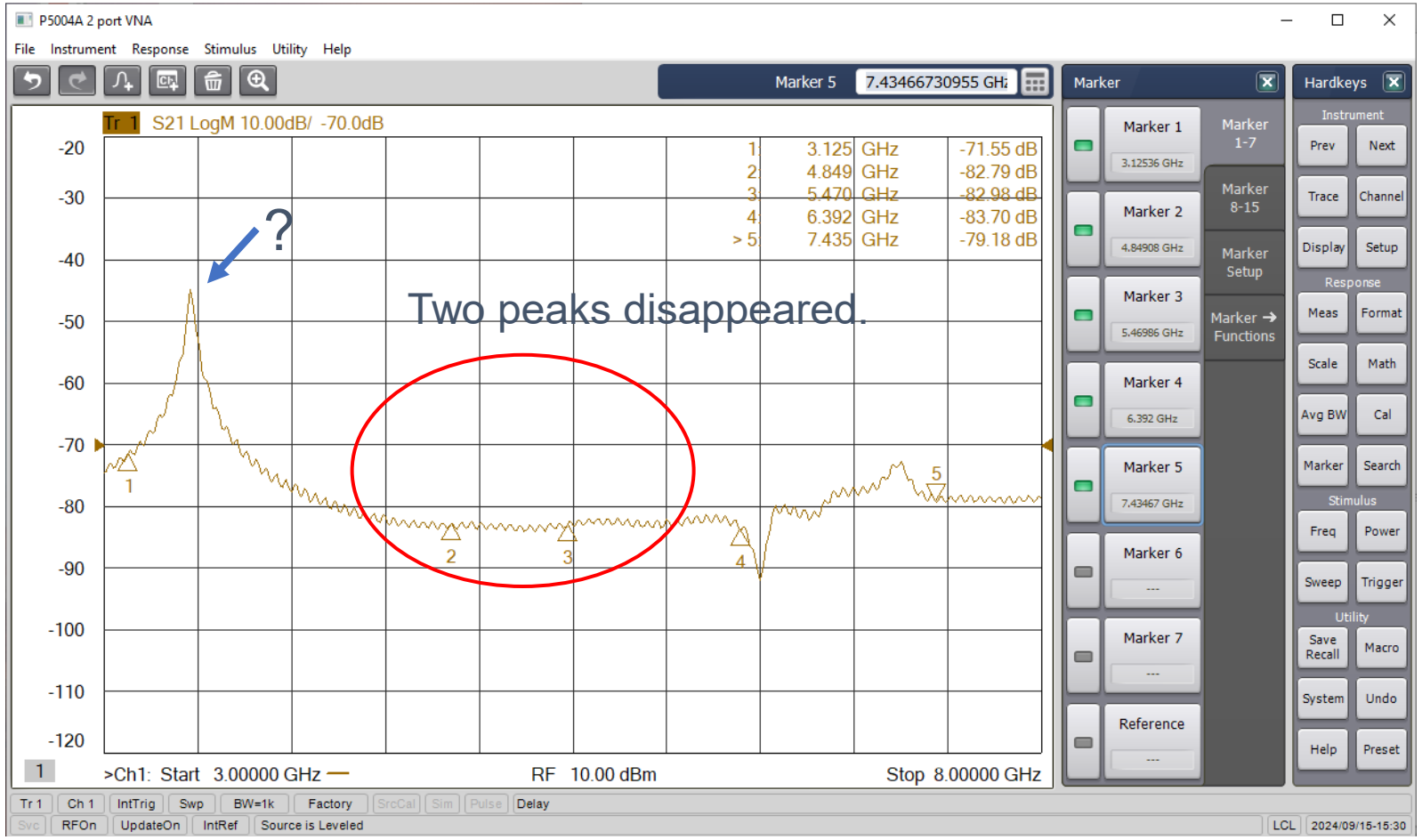
Port setup



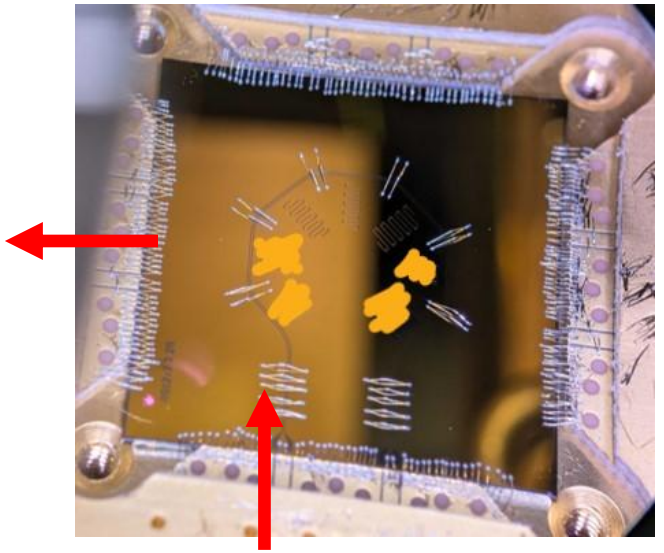
A resonance peak appeared at the same frequencies.

S21 measurement (Crosstalk) @ Room temperature

S21(Crosstalk) @ RT **with** ground bonding and terminations.

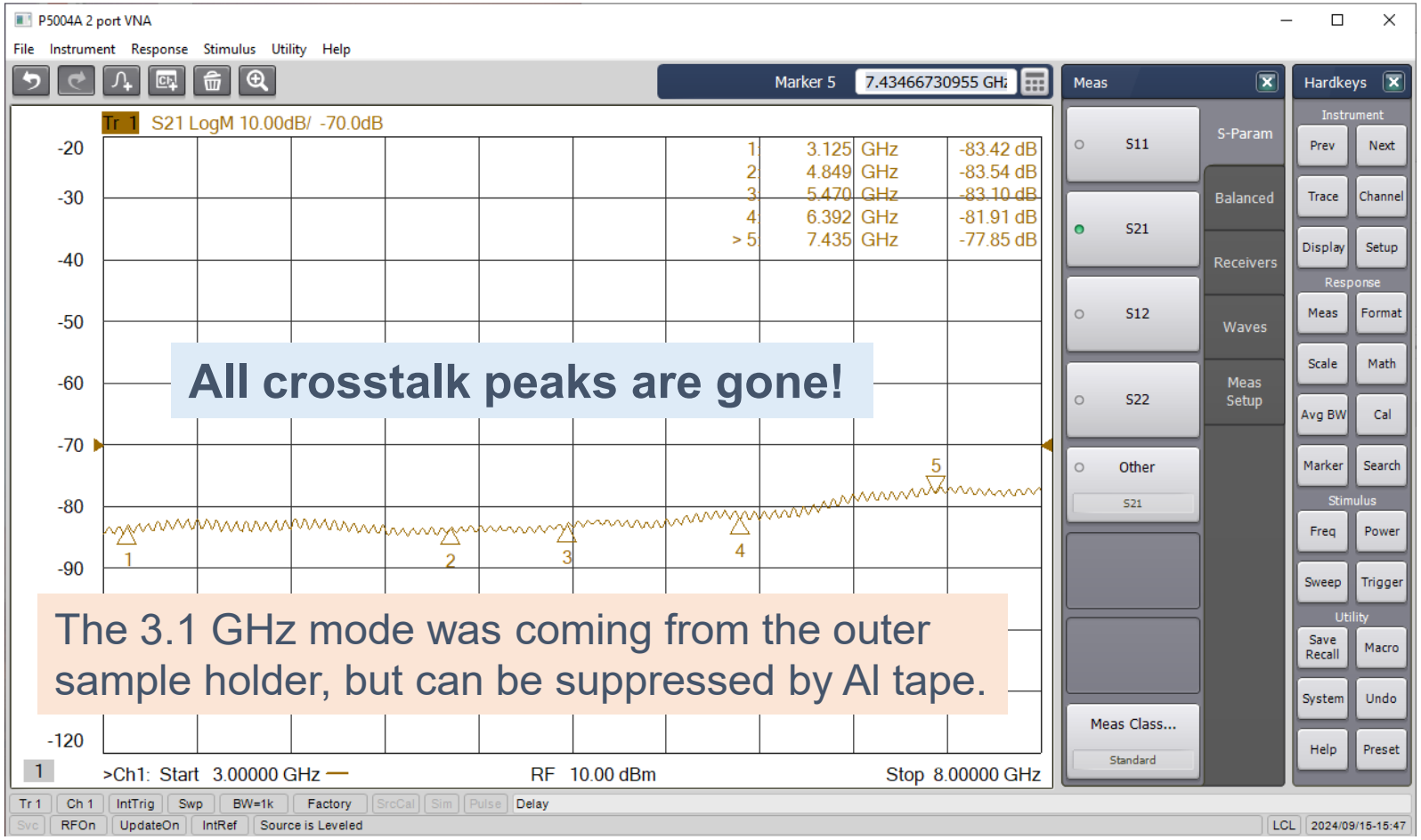


Port setup

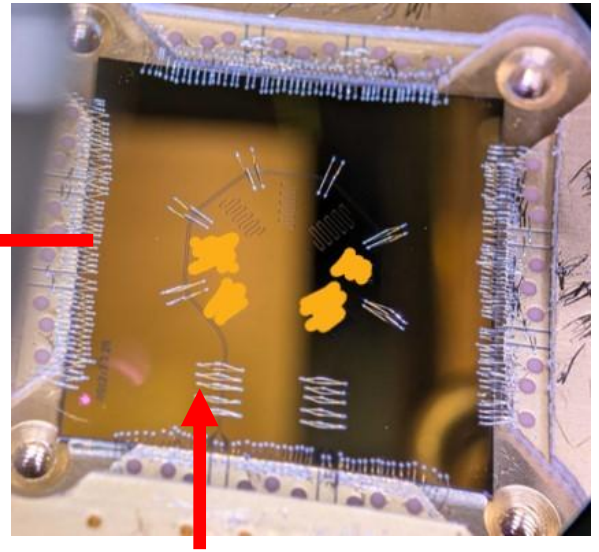


RT S21 measurement (Crosstalk)

S21(Crosstalk) @ RT **with** ground bonding and terminations.
+ Al tape



Port setup



PCB layer


Au/Pb 0.3um
Cu 15um
Cu 5um
FS300AS 500um
Au50KA 50um
Au/Pb 0.3um
Cu 15um
Cu 5um
Filled via
FS300AS 300um
Cu 5um
Cu 15um
Cu 15um