Measurement of Transmission Losses of Superconducting Coplanar Waveguide and Microstrip Line with On-chip Resonators at 2 mm Wavelength

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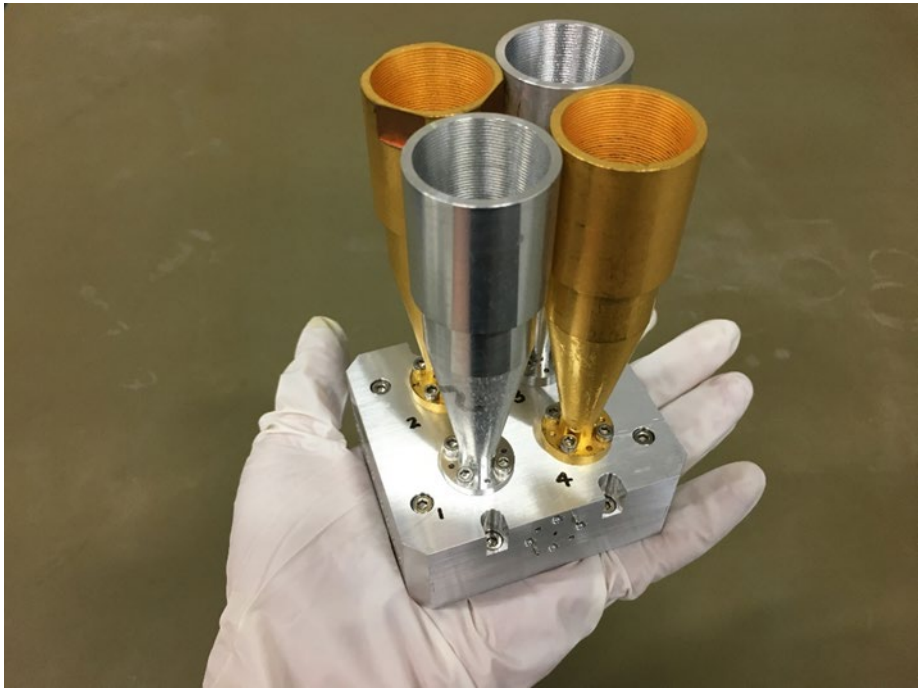
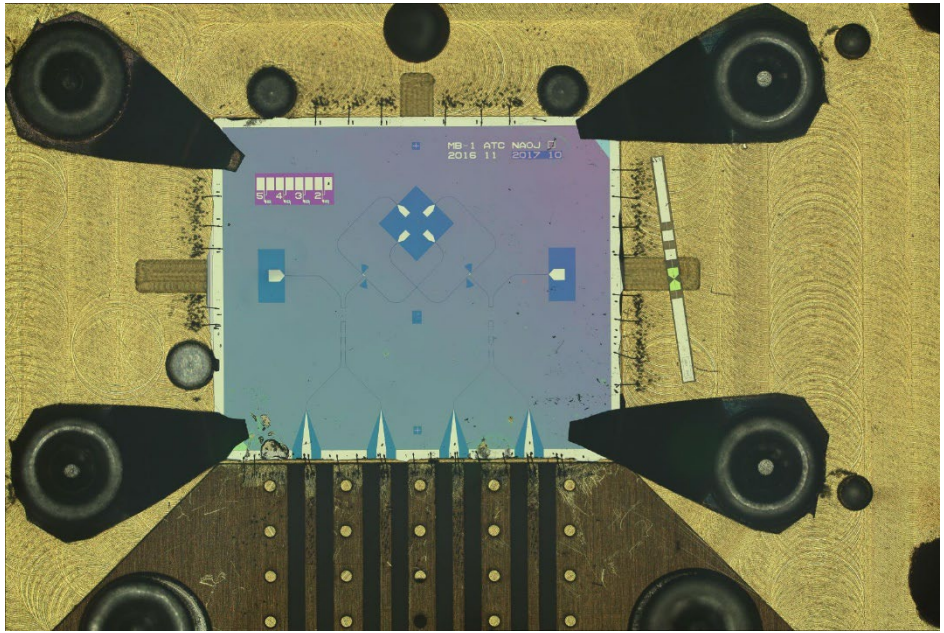
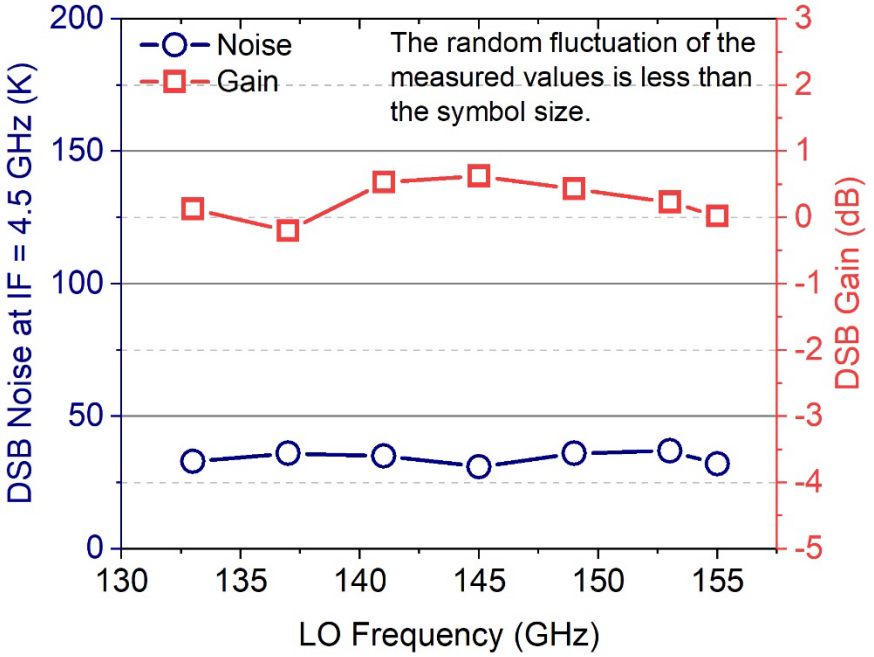
Demonstration of a Millimeter-wave Multibeam Receiver Implemented with Superconducting MMICs



Wenlei Shan, Shohei Ezaki, et al., “A Compact Superconducting Heterodyne Focal-Plane Array Implemented with HPI (Hybrid Planar Integration) Scheme,” IEEE Transactions on Terahertz Science and Technology, vol. 10, no. 6, pp. 677-689, Nov. 2020.

Compact SIS Mixer MMIC

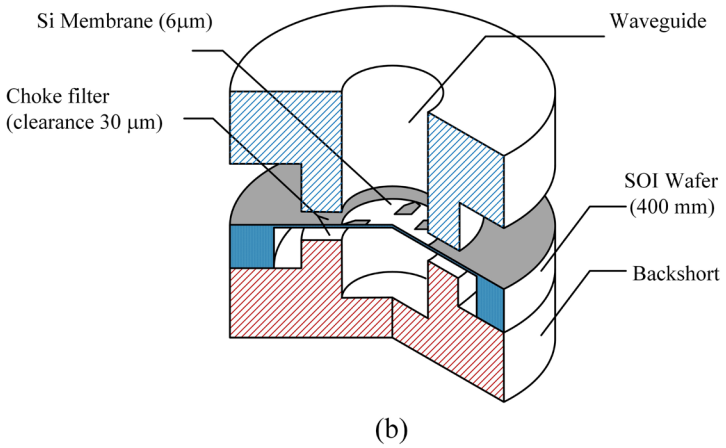




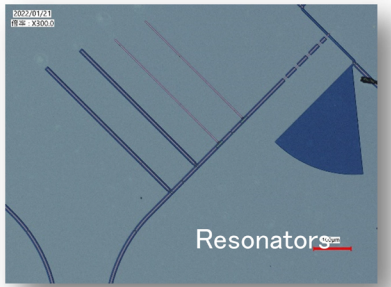
This work will answer the following question:
What is the loss (noise contribution) from the CPW and MS transmission lines on this MMIC?

Measurement Scheme

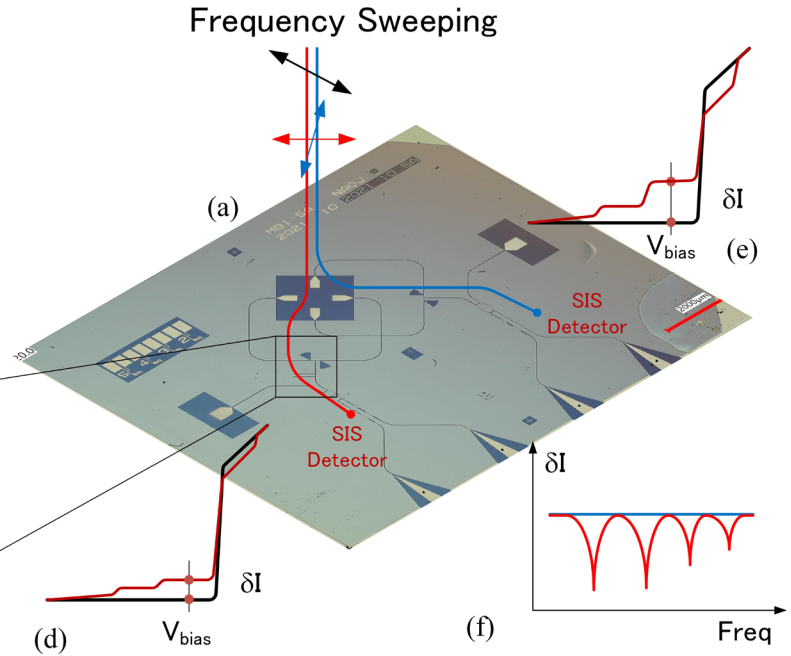
Membrane-based Planar OMT



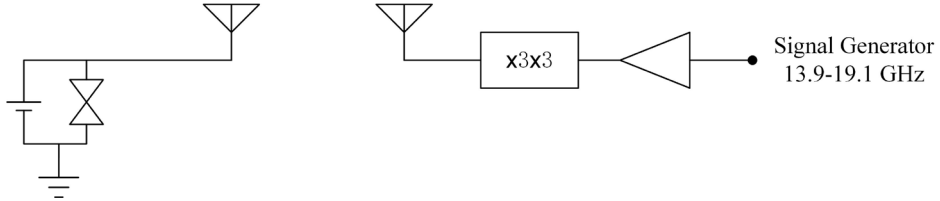
(b)



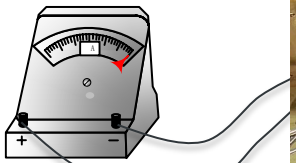
(c)



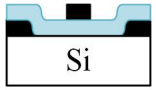
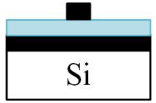
Measurement Setup



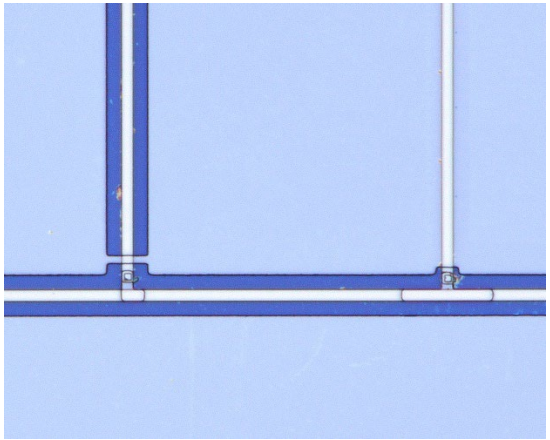
DC measurement



Resonator and Transmission Line Parameters

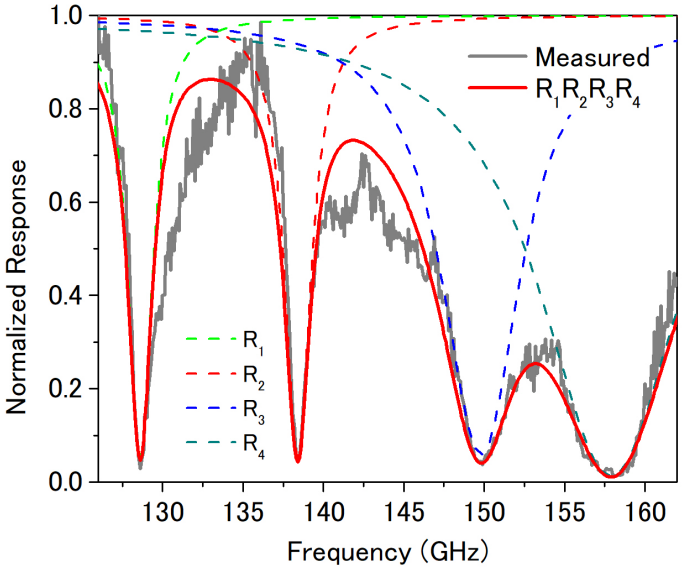
	Strip	Gap	Z_0	v_g	Structure
CPW	3 μm	4 μm	69 Ω	0.428 c	
MS	3 μm		20 Ω	0.436 c	

Insulator layer: SiO_2 300 nm



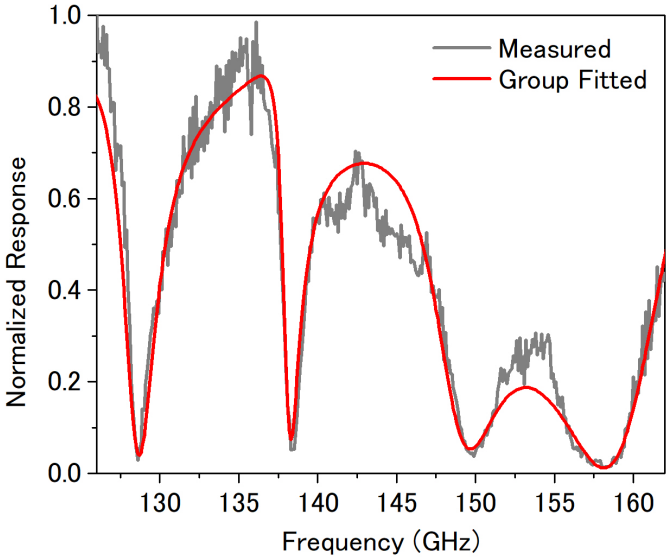
Coupling Q's for CPW and MS are about 150 and 30 respectively.

Resonance Curves and Fitting



Independent fitting for each resonator with Lorentzian function

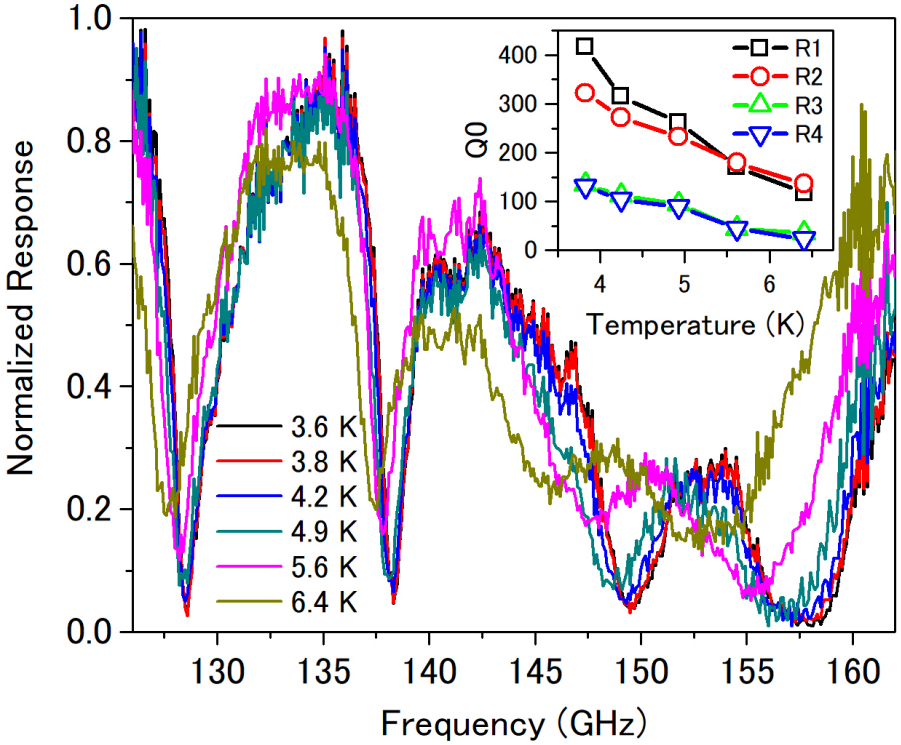
$$|S_{21}|^2 = f(\omega_i) = \left| 1 - \frac{\frac{Q_t}{Q_c}}{1 + jQ_t \frac{\omega - \omega_i}{\omega_i}} \right|^2$$



Fitting of all resonators simultaneously to count the interaction between resonators.

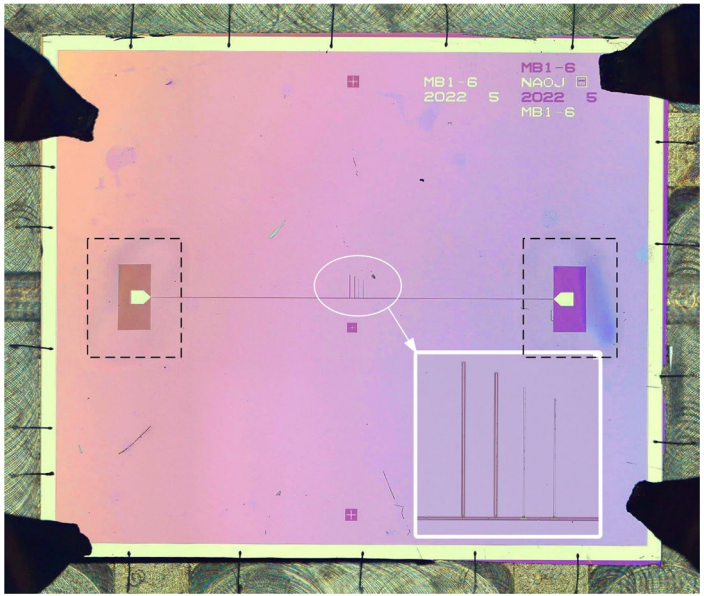
$$|S_{21}|^2 = f(\omega_1)f(\omega_2)f(\omega_3)f(\omega_4)$$

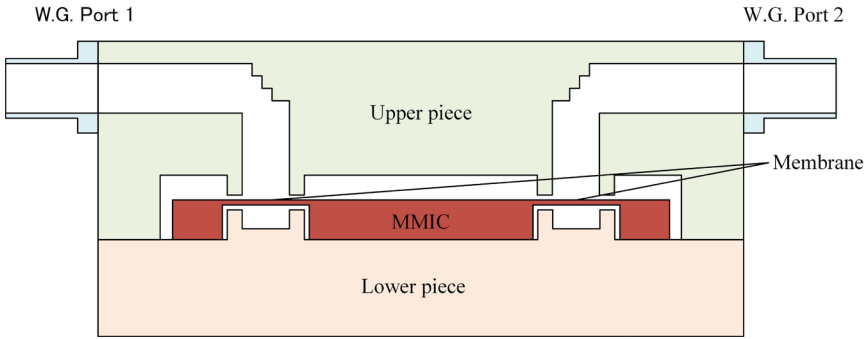
Q factors and Dependence on Temperature



A different method (Conventional)

Measurement with Network Analyzer

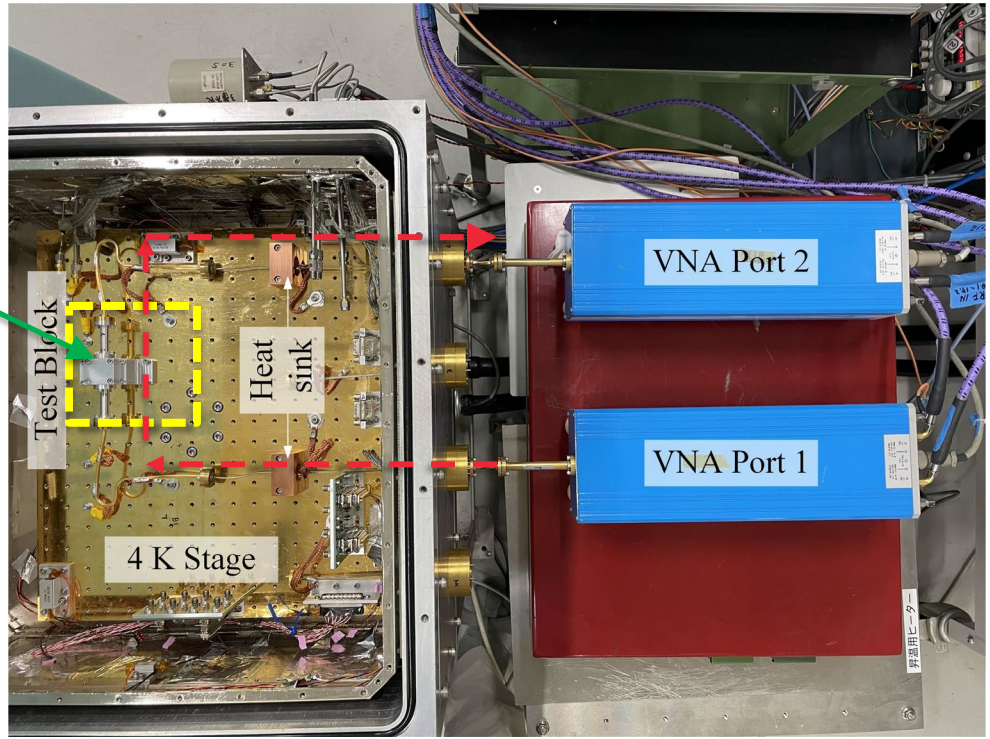




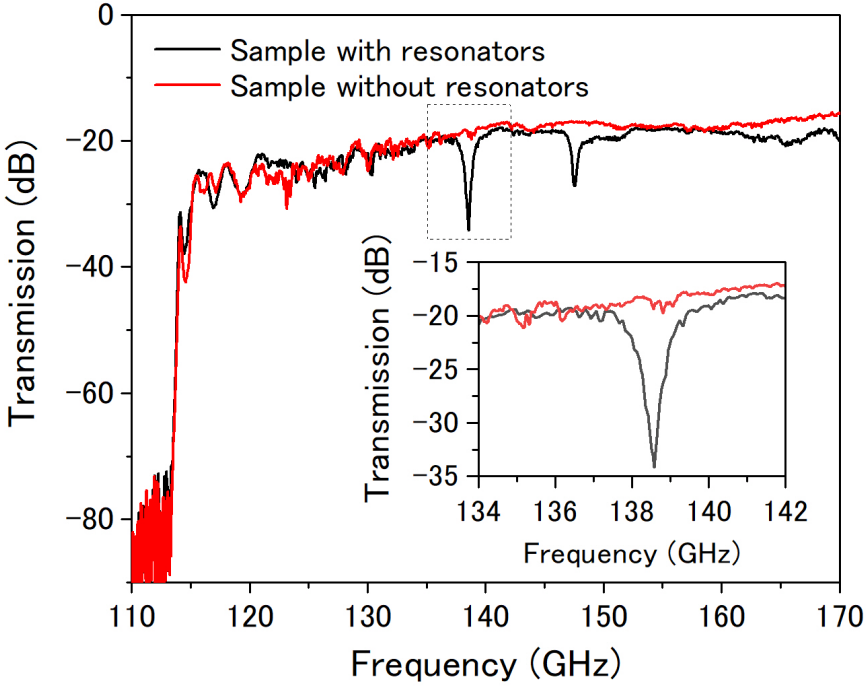
The Back-to-Back Probe will be presented in ASC2022. A. Masukura, W. Shan, S. Ezaki, et al., etc. “Silicon Membrane-based Superconducting Wave-guide-to-CPW Transitions at 2 mm Band”

Measurement Setup

DUT

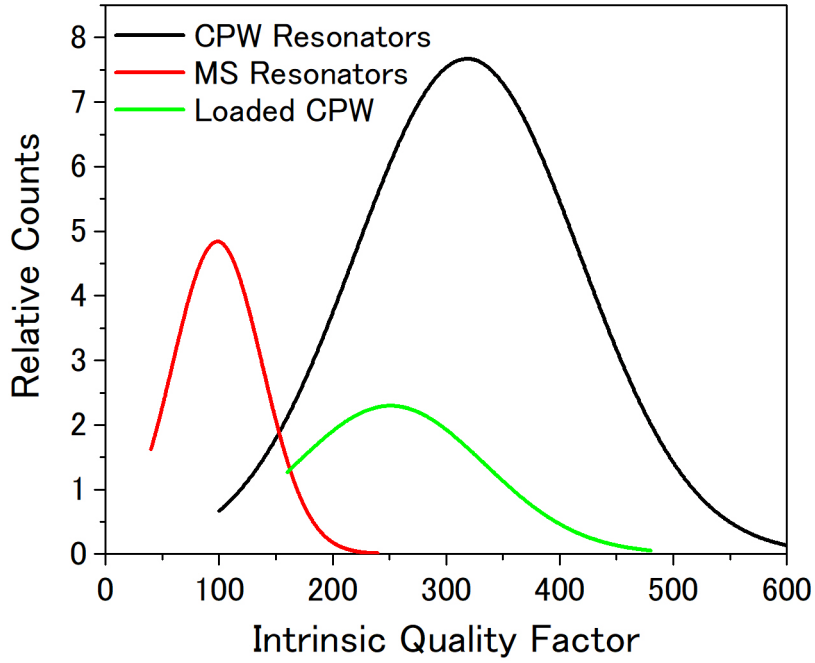


Resonance Curves



The measured transmission of resonator-loaded transmission line and a reference sample without resonators.

Conclusion of Q measurement



The distribution of all measured intrinsic Q factors. Three types of resonator: CPW, MS and capacitor-loaded CPW.

Conclusion

- An “in-situ” thin-film superconducting transmission line measurement method has been established for MMIC mixer development. This measurement uses SIS junctions as detectors and one of polarization as reference.
- The results were verified by measuring an resonator-loaded transmission line with network analyzer. This measurement platform is useful in transmission measurement of various 2-port superconducting thin film circuits.