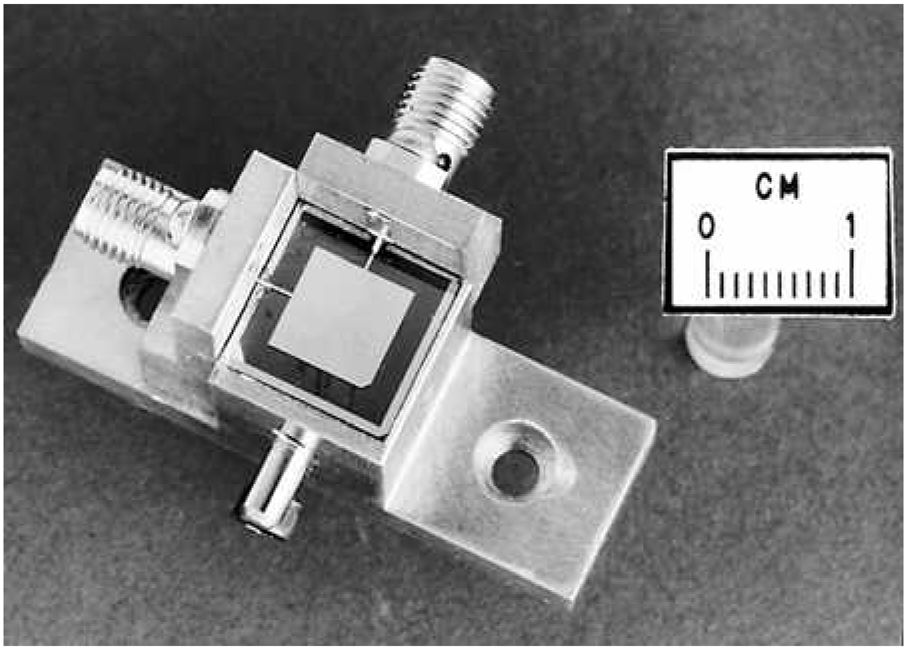
Miniaturized High-Temperature Superconducting/Dielectric Multilayer Filters for Satellite Communications

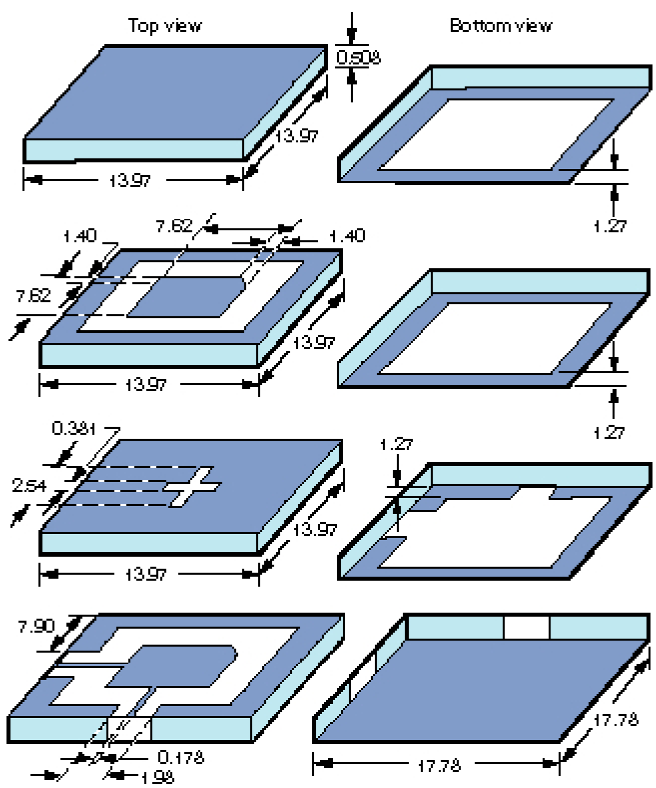


Dual-mode proof-of-concept gold resonator with corner-cut.

Most communication satellites contain well over a hundred filters in their payload. Current technology in typical satellite multiplexers use dual-mode cavity or dielectric resonator filters that are large (~25 to 125 $in.^3$) and heavy (up to 600 g). As the complexity of future advanced electronic systems for satellite communications increases, even more filters will be needed, requiring filter miniaturization without performance degradation. Such improvements in filter technology will enhance satellite performance. To reduce the size, weight, and cost of the multiplexers without compromising performance, the NASA Lewis Research Center is collaborating with industry to develop a new class of dual-mode multilayer filters consisting of $YBa_2Cu_3O_{7-\delta}$ high-temperature superconducting (HTS) thin films on $LaAlO_3$ substrates.

A major limiting factor in the continuing improvement of satellite communication systems is the unavailability of high-performance (i.e., high-Q) miniaturized filters that are compatible with monolithic microwave integrated circuits (MMIC) components. The poor Q factor of current miniature, planar components is due primarily to conductive loss, which can be significantly reduced by using HTS thin films (For example, at 77 K the surface resistance of $YBa_2Cu_3O_{7-\delta}$ thin films at 10 GHz is more than 2 orders of magnitude lower than that of copper at the same temperature and frequency). Therefore, it will be advantageous to replace dual-mode cavity and dielectric resonator filters with HTS thin-film-coated printed circuits that are dramatically smaller, lighter, and potentially less costly.

In this work, a new class of miniaturized filters based on a multilayered stack of dual-mode stripline or microstrip resonators coupled through irises, is being developed. These filters, which are extremely small in size and mass, can be fabricated of thin-film superconductors such as $YBa_2Cu_3O_{7-\delta}$. All current filter types that have dual-mode cavities or dielectric resonators can be replaced with those having this novel filter structure. For example, in the C-band this configuration will occupy only 1 percent of the volume of its dielectric resonator counterpart. Also, the multilayer configuration is smaller and lighter than the previously introduced dual-mode microstrip filters (ref. 1). The $YBa_2Cu_3O_{7-\delta}/LaAlO_3$ multilayer filters being pursued in this work can be based on a variety of dual-mode, planar resonator structures similar to those used in dual-mode microstrip filters. These include square patches, circular disks, and rings (ref. 2). Coupling between the dual orthogonal modes supported by these resonators is achieved by introducing a perturbation to the symmetry of the previously single-mode resonator at a location that is offset 45° from the axes of coupling to and from the resonator. Proof-of-concept of these miniaturized multilayer filters has already been demonstrated in our laboratory (ref. 3), and work is underway to optimize their performance through more detailed analysis, fabrication, and testing.



Physical layout of a four-pole dual-mode multilayer filter. (Dimensions are in millimeters.)

References

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2. Fiedziuszko, S.J., et al.: Low Loss Multiplexers With Planar Dual Mode HTS Resonators. IEEE Trans. Microwave Theory Tech., vol. 44, July 1996, pp. 1248-1257.

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