Rarefying Spectra of Whispering-Gallery-Mode Resonators

Undesired families of resonances are damped by a relatively simple technique.

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A method of cleaning the mode spectra of whispering-gallery-mode (WGM) optical resonators has been devised to make such resonators more suitable for use as narrow-band optical filters. The method applies, more specifically, to millimeter-sized whispering-gallery-mode optical resonators that are made of crystalline electro-optical materials and have ultrahigh values of the resonance quality factor (Q). The mode spectrum of such a resonator is typically dense, consisting of closely spaced families of modes; as such, the spectrum is not well suited for narrow-band filtering, in which there is a need for strong rejection of side modes. "Cleaning" as used here signifies rarefying the spectrum so that what remains consists mostly of a single desired family of modes or, at worst, a few mode families that are more widely spaced in frequency than are the mode families in the original, non-rarefied spectrum.

The spectrum-cleaning method exploits the fact that various WGM mode families occupy various positions near the equator at the rim of a resonator disk. In this method, a damper in the form of a prism or other polished piece of material having an index of refraction greater than that of the resonator material is placed in contact with the rim of the resonator at such a position that the Qs of most or all of the undesired mode families are greatly reduced while the Q of the desired mode family is reduced by only a tolerably small amount. In an alternative method that has been considered, the mode spectrum would be cleaned through special design of the shape of the rim, but fabrication of the rim in a special shape is a complicated task. The advantage of the present method, relative to the alternative method, is that special shaping of the rim is not necessary and the damping prism can be emplaced after the resonator has been fabricated.

This method was demonstrated in an experiment on a WGM resonator in the form of a 12-mm-diameter, 180-μm-thick lithium tantalite disk, the rim of which was polished to a spherical shape. The Q of

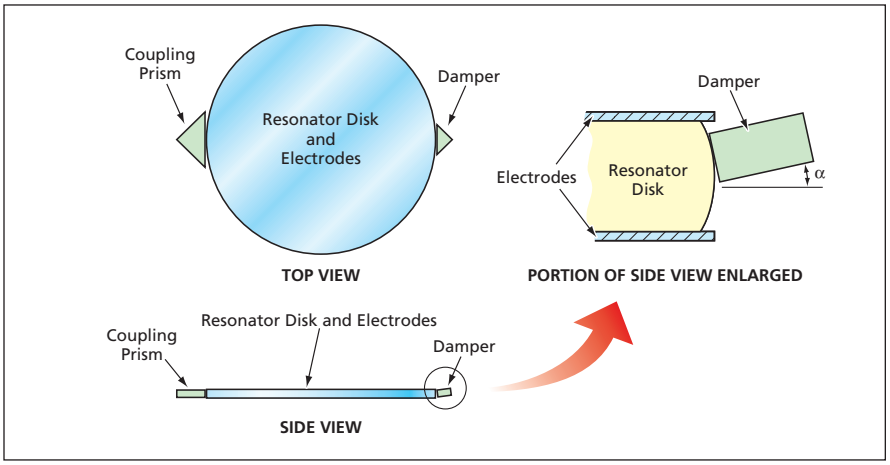

Figure 1. A **WGM Resonator Disk** is equipped with top and bottom tuning electrodes, a coupling prism, and a damper. The placement angle, α, of the damper is adjusted to maximize damping of undesired mode families while not appreciably increasing the damping of desired mode families.

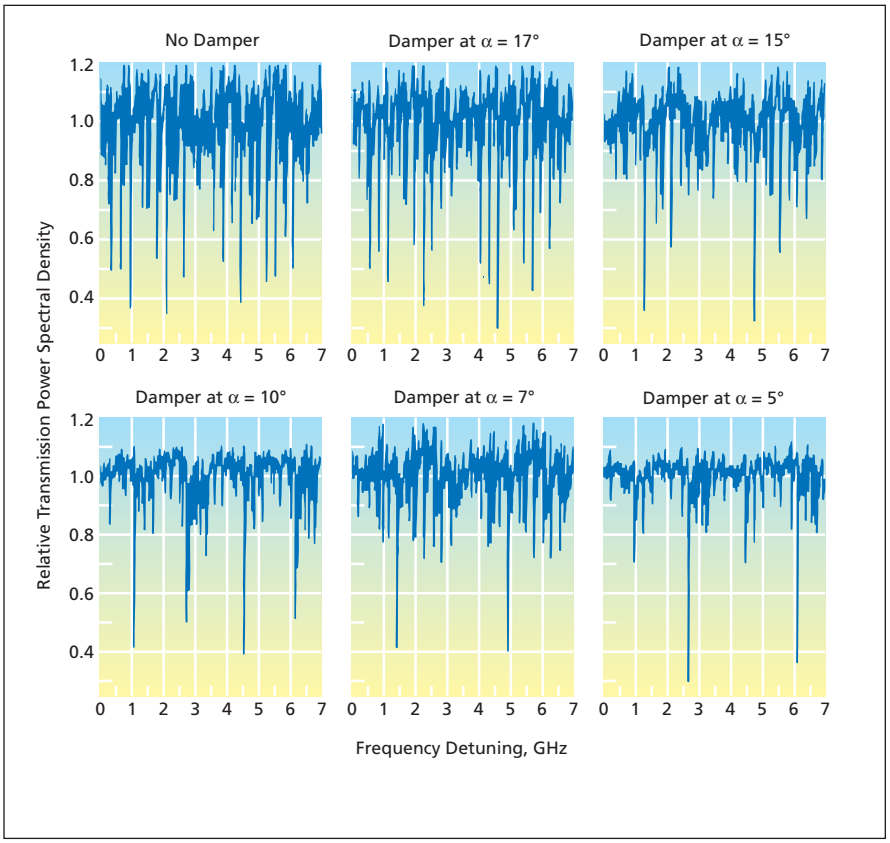

Figure 2. The **Relative-Transmission-Power Spectrum** of a resonator like that of Figure 1 in band-stop configuration was measured without the damper and with the damper placed at various values of α. When the damper was placed at the optimum α, the density of resonant-mode families was significantly reduced.