Resonance Spectroscopy of Novel Bottle Microresonators and their Applications in Sensing

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Optical microresonators supporting whispering-gallery modes (WGM), with a variety of geometries and associated small mode volumes and large optical quality factors (Q), thereby yielding high optical intensities and long photon lifetimes have attracted considerable interest recently for applications including narrow linewidth microlasers, all-optical switching and biosensors (1). We recently fabricated fiber and capillary based double-neck bottle-shaped solid and hollow microresonators and made the first experimental demonstration of high-Q WGMs in them (2,3). Although bottle microresonators support WGMs, they have very different characteristics from the conventional equatorial WGM microresonators such as microspheres and microtoroids. Bottle microresonators are highly oblate resonators and sustain non-degenerate WGMs that exhibit two well-separated spatial regions with enhanced field strength, corresponding to modal turning points. We have experimentally observed these intensity maxima on both sides of the bottle microresonator near the turning points and measured the resonance spectrum for the first time, as shown in Fig. 1.

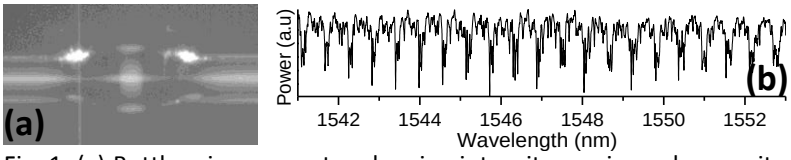

Fig. 1: (a) Bottle microresonator showing intensity maxima when excited at the turning point and (b) corresponding resonance spectrum.

The dense spectral features may be a serious hindrance when these microresonators are used for refractometric optofluidic sensing applications. We have used various approaches to clean the spectrum, resulting in only a very few modes remaining within the free spectral range and these results will be discussed.

The field maxima at the turning points and the high Qs are very useful in sensing applications, to provide enhanced signal strength and multiple sampling points, enabling ultrasensitive detection. We will present initial results on sensing experiments using bottle microresonators.

References:

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