Developing a method for predicting the whispering gallery mode spectrum of microresonators

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Abstract

In this paper, we present computational simulations of whispering gallery modes (WGMs) excited in microspheres and microrings. We show how our computational tool, a finite-difference time-domain (FDTD) method, can be used to study the resonant phenomena of microresonators, which can range from a single microsphere to an array of microrings, typically only a few hundred nanometers in diameter. We focus on the prediction of the WGM spectrum of a polystyrene microsphere, which is excited by a tangential electric dipole source. The FDTD method is able to predict both the resonance frequencies and the mode shapes of the WGMs, even at the fundamental radial and azimuthal mode numbers corresponding to the fundamental radial mode of WGMs in a microsphere.

Methods

Finite-Difference Time-Domain Method (FDTD): The FDTD method is a numerical technique for solving Maxwell's equations for time-varying electromagnetic fields. It discretises space and time into a 3D spatial lattice, and solves for the electromagnetic fields at each point. This produces a finite number of time increments as the system evolves. The method is capable of accurately simulating a wide range of phenomena, including the excitation of whispering gallery modes in microresonators.

Experimental comparison: A comparison is made between the experimental results for a variety of sizes of microsphere, and the computational results for a variety of sizes of microsphere. This may provide a way to distinguish modes at different orders, and calculation of the mode Q-factors.

Conclusions

The computational tool FDTD is a promising candidate in developing a WGM prediction method for microresonators. It can provide a comprehensive output spectrum including all radiation modes and bands of modes. It is capable of accurately simulating the excitation of WGMs in microspheres, and can be used to study the resonant phenomena of microresonators, which can range from a single microsphere to an array of microrings, typically only a few hundred nanometers in diameter.