Realization of a High-Finesse Cavity Platform for Functionalization of Emitters

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The race for the idealization of a quantum-computing device has led to the demand for an efficient single-photon generation device with optimized attributes of purity, indistinguishability, and brightness. The two latter parameters can be improved by incorporating single-photon emitters inside a photonic cavity. Here, we present a cavity platform, where the top mirror consists of a concave Gaussian-like shape, while the bottom mirror is planar. This cavity geometry achieves high finesse values since the upper wavefront of the Hermite-Gaussian beam matches the mirror geometry and is reflected into the cavity mode with minimal losses. It also facilitates achieving low-mode volume since the beam waist rests at the bottom mirror. Both factors are crucial for high-Purcell Factors. The bottom mirror rests on a piezo stage while the top rests on a tunable kinematic mount. The elements are connected by a stiff and lightweight cage mount to shift the mechanical resonance frequencies above the typical acoustic and seismic environmental noise frequencies.

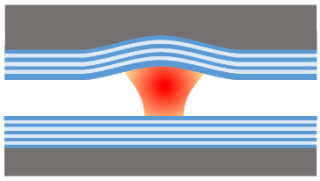

Figure 1. Schematics of the cavity design.

The cavity length was scanned to characterize the cavity setup with an oscillating voltage applied to the piezo, which holds the bottom mirror. Two lasers, one acting as a reference and the other tunable, were shined upon the cavity. The resulting distance between the two corresponding peaks for a cavity mode was utilized to provide information about the slopes of the cavity modes. With that, we could determine the broadening of the cavity modes in the wavelength domain, which led to the information about the Q-factors of the cavity. Since, for a cavity without internal losses, the Q-factor varies linearly with the mode numbers thus, we were able to calculate the finesse parameter. For our mirrors with 500 ppm transmission, we were able to achieve Q-Factors up to 10^5 and Finesse of $6 \cdot 10^3$, which is comparable to the theoretical values for the mirrors.

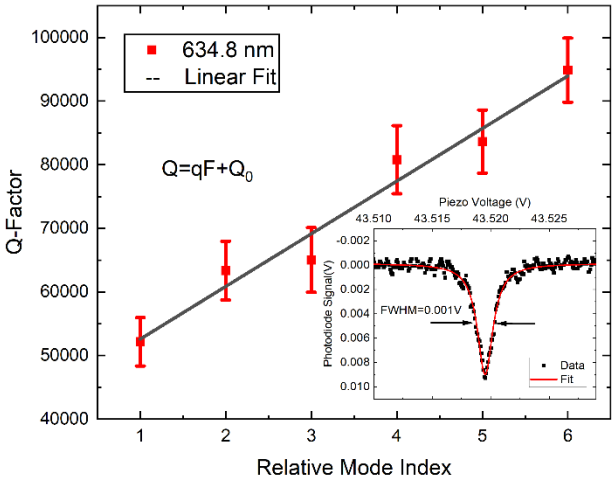

Figure 2. Q-Factors for different modes. In subset, photodiode voltage with cavity length detuning.

[1] Tomm, N., Javadi, A., Antoniadis, N.O. et al. A bright and fast source of coherent single photons. *Nat. Nanotechnol*. 16, 399–403 (2021).