IRG-3: Single Photon Bound States in Microwave Photonic Crystals (DMR-1420541)

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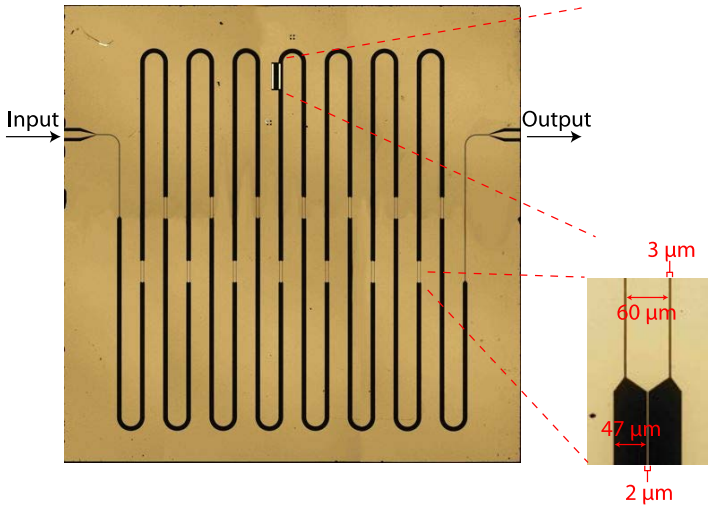
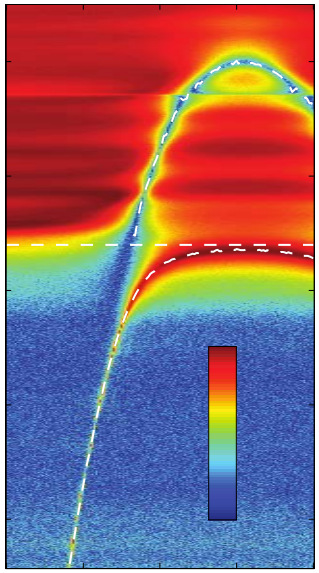
Photonic crystals provide an extremely powerful toolset for manipulation of optical dispersion and density of states. The unique control afforded by these media make them a beautiful, if unexplored, playground for strong coupling quantum electrodynamics, where a single, highly nonlinear emitter hybridizes with the band structure of the crystal. In this work we demonstrate that such hybridization can create localized cavity modes that live within the photonic band-gap, whose localization and spectral properties we explore in detail. We then demonstrate that the colored vacuum of the photonic crystal can be employed for efficient dissipative state preparation. This work opens exciting prospects for engineering long-range spin models in the circuit QED architecture, as well as new opportunities for dissipative quantum state engineering. Moreover, this cavity structure is a promising platform for controlling and measuring high coherence quantum spin systems.

Reference: Yanbing Liu and Andrew Houck, "Quantum Electrodynamics Near a Photonic Bandgap," arXiv:1603.02998, Submitted (2016).



Creating a microwave photonic bandgap. A microwave photonic bandgap is created by periodically modulating impedance along the length of a transmission line, achieved by changing the width and gap sizes of the coplanar waveguide. A single qubit is strongly coupled to one of the bands in this transmission line photonic crystal. This system has been predicted to realize single photon bound states, which can be used to probe and manipulate interacting quantum systems.



Evidence for a single photon bound state in a photonic bandgap medium. A qubit is tuned through the band edge while monitoring transmission through the system. An avoided crossing with the band edge, and the emergence of a defect state in the bandgap when the qubit is tuned above the band edge, are evidence for sthe existence of single photon bound states.

Photonic bound states with qubit in filter