Abstract Submitted
for the MAR15 Meeting of
The American Physical Society

Nanophotonic photon echo memory based on rare-earth-doped crystals TIAN ZHONG, JONATHAN KINDEM, EVAN MIYAZONO, ANDREI FARAON, Caltech, CALTECH NANO QUANTUM OPTICS TEAM — Rare earth ions (REIs) are promising candidates for implementing solid-state quantum memories and quantum repeater devices. Their high spectral stability and long coherence times make REIs a good choice for integration in an on-chip quantum nano-photonic platform. We report the coupling of the 883 nm transition of Neodymium (Nd) to a Yttrium orthosilicate (YSO) photonic crystal nano-beam resonator, achieving Purcell enhanced spontaneous emission by 21 times and increased optical absorption. Photon echoes were observed in nano-beams of different doping concentrations, yielding optical coherence times T_2 up to 80 μs that are comparable to unprocessed bulk samples. This indicates the remarkable coherence properties of Nd are preserved during nanofabrication, therefore opening the possibility of efficient on-chip optical quantum memories. The nano-resonator with mode volume of $1.6(\lambda/n)^3$ was fabricated using focused ion beam, and a quality factor of 3200 was measured. Purcell enhanced absorption of 80% by an ensemble of $\sim 1 \times 10^6$ ions in the resonator was measured, which fulfills the cavity impedance matching condition that is necessary to achieve quantum storage of photons with unity efficiency.

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Date submitted: 14 Nov 2014 Electronic form version 1.4