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On-chip electrical control of nonlinear quantum optics using a quantum dot in a waveguide

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We demonstrate on-chip electrical control of the non-linear optical response at the single/few photon level using a single semiconductor quantum dot embedded in a p-i-n junction nano-photonic waveguide. We study the nonlinear response using resonant transmission of a weak narrow band, tunable laser source and through quantum statistics measurements of the scattered photons, which contain contributions from an entangled photon-photon bound state. The electrically tunable and switchable transmission change is as large as 30% on resonance in a single pass. Observation of a clear, voltage-controlled bunching signal in the photon statistics of the transmitted light demonstrates the single-photon character of the nonlinear response. Control of the quantum dot charge state with applied bias enables the study of the neutral and charged exciton complexes, with future potential for spin-photon studies. Our work represents an important step towards deterministic quantum-information processing with photons.

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