New Optical selection rules from GaAs quantum dots via highly variable uniaxial stress actuators

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A novel micro-machined piezoelectric actuators featuring geometrical strain amplification is developed to explore the optical properties of GaAs quantum dots subject to variable uniaxial tension up to mechanical fracture. First of all, due to the modification of band gap from the stress, the emission energy of an exciton confined in a GaAs "artificial atom" can be continuously shifted by more than 100 meV, as illustrated by scanning it through the D_2 and D_1 transitions of ^{87}Rb vapors. This strain-induced shift overcompensates the confinement energies, leading to emission well below the bandgap of GaAs, and this is the largest reported so far for piezoelectric-semiconductor devices. Second, valence band mixing leads to dramatic changes in the optical selection rules for excitonic transitions: one light component emitted from the sample surface becomes fully polarized perpendicular to the pulling direction while initially forbidden vertically polarized transitions become bright. By exploiting hole mixing and a wedge-waveguide geometry we are able to observe the whole transition process of neutral exciton under variable uniaxial stress without resorting to the magnetic field. Under the high tension stress effect, two new bright states displace the old ones, which indicates a new quantization axis should be chosen. These results show a promising route to tailor the polarization properties of single-photons emitted by epitaxial quantum dots and allow us to test the reliability of state-of-the-art methods ($\mathbf{k}\cdot\mathbf{p}$ and empiricial pseudopotential) under extreme conditions.

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