Electronic Supplementary Material (ESI) for Nanoscale

Designer Ge/Si composite quantum dots with enhanced thermoelectric properties

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1. Experimental details for thermal conductivity measurement

For $\kappa_{\perp}$ characterization, the thin-film-like CQD samples were capped with a 50-nm-thick SiO_2 layer using inductively coupled plasma CVD followed by Al deposition and lift-off process to produce 200-μm-length, 4-μm-width, and 500-nm-thick Al heater lines. Variable-temperature measurements on $\kappa_{\perp}$ using the differential 3ω technique were performed in a high-vacuum cryostat (~10^{-6} torr) to prevent heat conductive or convective loss to the surrounding gaseous media. The thermal resistance contribution from a controlled sample of SiO_2/Si was measured separately as a subtraction reference for SiO_2/CQDs/Si samples. For a given QD or CQD system, more than three samples of different thicknesses were fabricated and measured to rule out artifacts caused by additional thermal resistances from the interfaces between the heater/sample and sample/substrate. More than five measurement points were performed for each sample at each testing temperature. The $\kappa_{\perp}$-T curve was then obtained by fitting measured data from samples of different thicknesses using a linear regression. The measurement errors mainly come from the uncertainties in the thin film heater/thermometer calibration, temperature fluctuation of the thermal chuck and the environment, and systematic errors from the measurement system.

2. Experimental details for electrical conductivity measurement

Temperature-dependent electrical conductivity characterization was conducted using the four-point-probe technique. Definition of Al electrodes was conducted onto the experimental QDs samples through photolithographic, 500-nm-thick Al deposition, and lift-off processes. The electrode sizes are 10-μm in length and 10-μm in width. In order to reduce the electrical contact resistance, the native oxide layer over the thin-film-like samples was removed using a HF (10%) dip for 10 s prior to Al deposition. A constant current was injected through the outer electrodes, and then the voltage drop between the inner electrodes that are separated by 400 μm apart was extracted to determine the electrical conductivity. More than five measurement points were performed for each sample at each testing temperature.

3. Effective thermal conductivities of thin-films-like regular-QD and CQD materials

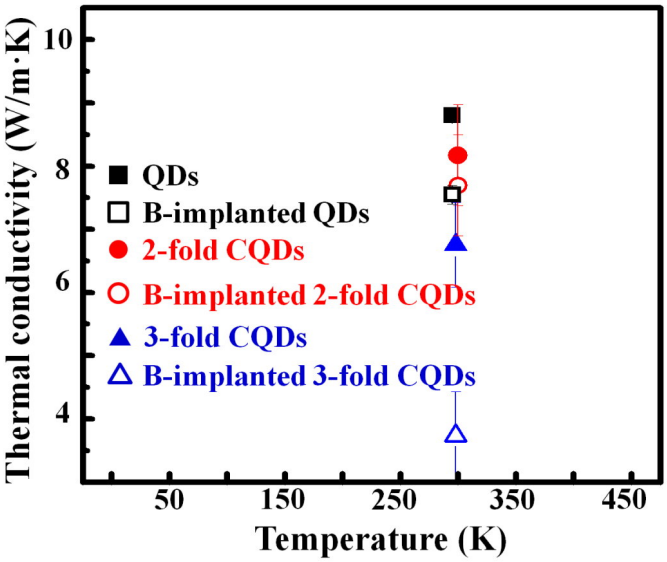

Figure S1 Effective thermal conductivities measured at 300 K for the thin-films-like regular-QD and CQD materials before and after ion implantation.