THERMAL CONDUCTIVITY OF UNCORRELATED Ge QUANTUM DOT SUPERLATTICES

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A drastic reduction of the temperature dependent cross-plane thermal conductivity is found to take place in Ge quantum dot superlattices (QDSLs) depending primarily on the degree of vertical correlation between dots across the layers. Conductivity measurements were performed by the 3ω method on samples grown on the same Si wafer with 20-nm wide Si spacers, which ensures almost perfect vertical alignment of the Ge islands due to strain field propagation. Addition of a submonolayer of carbon in half of the wafer prior to dot formation in each layer is used to erase the strain memory, leading to complete suppression of the vertical correlation. We observe a two to fourfold decrease of the thermal conductivity in the uncorrelated structures. The observed impact of disorder on the thermal conductivity of QDSLs is confirmed by calculations using two independent approaches, one based on the relaxation-time approximation and other on an extension of the Fourier equation. The results of this work have implications for the development of highly efficient thermoelectric materials and on-chip nanocooling devices.

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