Microkelvin Nanoelectronics

Nikolai Yurttagül[a], Matthew Sarsby[a], and Attila Geresdi[a]

[a]Qutech and Kavli Institute of Nanoscience,
Delft University of Technology, 2600 GA Delft, The Netherlands

While cooling bulk metals to microkelvin temperatures with adiabatic nuclear demagnetization is well established, temperatures below 1 mK on the nanoscale were unobtained up until now. Opening this temperature scale for nanoelectronics creates enormous opportunities for existing and emerging quantum technologies by enabling the implementation of yet unaccessible states of matter on the nanoscale. The main obstacle for cooling nanoelectronics to microkelvin temperatures is the weak electron-phonon interaction in miniaturized structures in combination with electronic noise directly heating electronic devices in cryogenic environments. We broke the 1 mK frontier for nanoelectronics by co-integrating indium as a powerful nuclear refrigerant directly on-chip, galvanically connected to a nanoelectronic device and attaching the device leads individually to nuclear demagnetization stages. We integrate this technique with a Coulomb blockade thermometer and demonstrate a stable electron temperature below 500 µK for several days while operating the device below 1 mK on the same timescale when exposed to significant, intentionally applied Joule heating. Based on our experiments we illustrate how our implementation of nuclear magnetic cooling will work as platform for quantum-nanoelectronics in the microkelvin regime.