Electron-phonon relaxation in hot-electron detectors below 1 K

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Recently proposed submillimeter hot-electron direct detectors rely on the thermal coupling between electrons and phonons. Their sensitivity can be greatly enhanced if the coupling is made very weak. According to the theory, use of impure films should allow to achieve this goal. So far, the experimental situation has been somewhat confusing about this issue. A number of works have shown a cubic temperature dependence of the electron-phonon relaxation rate below 1 K. A conventional explanation is that this dependence is caused by direct interaction between electrons and phonons. We show that in most of these studies the pure limit was not reached. In this case, the electron scattering from vibrating impurities/boundaries dominates. The electron-phonon scattering rate varies from T^4*l for ql << 1 to T^2/l for 1 << ql < 2(u_l/u_t)^3 ~ 20-40 (u_l and u_t are the longitudinal and transversal sound velocities). In a wide temperature range around T ~ u_t/l the relaxation rate should have a T^3 temperature dependence along with a weak l-dependence. Our recent experimental data for W and Ti films are in good agreement with the discussed interaction mechanism. The measured electron-phonon relaxation time followed the T^{-4} dependence and was a record-long (25 ms) at 40 mK.