Abstract for an Invited Paper
for the MAR10 Meeting of
The American Physical Society

Quantum-size effects in ultrathin Pb-islands on Si(111): From quantum well states to the reduction of the superconducting gap[1]

WOLF-DIETER SCHNEIDER, Ecole Polytechnique Federale de Lausanne (EPFL)

Using low-temperature scanning tunneling spectroscopy at 5 and 50 K, we studied the linewidth of unoccupied quantum-well states in ultrathin Pb islands, grown on Si(111) on two different Pb/Si interfaces. A quantitative analysis of the differential conductance spectra allowed us to determine the electron- electron (e-e), electron-phonon (e-ph), and the interface contributions to the lifetime. Layer-dependent ab initio calculations of the e-ph linewidth contribution are in excellent agreement with the data. Importantly, the sum of the calculated e-e and e-ph lifetime broadening follows the experimentally observed quadratic energy dependence [1]. The energy gap of these superconducting Pb islands, in a thickness range between 60 and 5 monolayer, was found to decrease from its bulk value as a function of inverse island thickness. Corresponding values of the critical temperature Tc, estimated using the bulk gap-to-Tc ratio, are in quantitative agreement with ex-situ magnetic susceptibility measurements, however, in strong contrast to previous scanning probe results. Layer-dependent ab initio density functional calculations for freestanding Pb films show that the e-ph coupling constant, determining Tc, decreases with diminishing film thickness [2].

[1] I.-P. Hong, C. Brun, F. Patthey, I. Yu. Sklyadneva, X. Zubizarreta, R. Heid, V. M. Silkin, P. M. Echenique, K. P. Bohnen, E. V. Chulkov, and W.-D. Schneider, Phys. Rev. B (RC) 80, 081409 (2009).
[2] C. Brun, I.-P. Hong, F. Patthey, I. Yu. Sklyadneva, R. Heid, P. M. Echenique, K. P. Bohnen, E. V. Chulkov, and W.-D. Schneider, Phys. Rev. Lett. 102, 207002 (2009).

[1]This work has been supported by the Swiss National Science Foundation.