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Remarkable effects of disorder on superconductivity of single atomic layers of lead on silicon[1]

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It is well known that conventional superconductivity is very robust against non-magnetic disorder [1]. Nevertheless for thin and ultrathin films the structural properties play a major role in determining the superconducting properties, through a subtle interplay between disorder and Coulomb interactions [2]. Unexpectedly, in 2010 superconductivity was discovered in single atomic layers of lead and indium grown on silicon substrate using scanning tunneling spectroscopy [3] and confirmed later on by macroscopic transport measurements [4]. Such well-controlled and tunable crystalline monolayers are ideal systems for studying the influence of various kinds of structural defects on the superconducting properties at the atomic and mesoscopic scale. In particular, Pb monolayers offer the opportunity of probing new effects of disorder because not only superconductivity is 2D but also the electronic wave functions are 2D. Our study of two Pb monolayers of different crystal structures by very-low temperature STM (300 mK) under magnetic field reveals unexpected results involving new spatial spectroscopic variations [5]. Our results show that although the sheet resistance of the Pb monolayers is much below the resistance quantum, strong non-BCS corrections appear leading to peak heights fluctuations in the dI/dV tunneling spectra at a spatial scale much smaller than the superconducting coherence length. Furthermore, strong local evidence of the signature of Rashba effect on the superconductivity of the Pb/Si(111) monolayer is revealed through filling of in gap states and local spatial variations of this filling. Finally the nature of vortices in a monolayer is found to be very sensitive to the properties of step edges areas.

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