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Quantum stability and superconductive properties of atomically smooth ultrathin alloy films of thermodynamically immiscible metal elements[1] EUN JU MOON, Univ Tennessee, Knoxville, MUSTAFA M. OZER, ORNL, JAMES R. THOMPSON, HANNO H. WEITERING, Univ Tennessee, Knoxville, and ORNL — Pb and Ga are immiscible in bulk form. However, atomically smooth ultrathin films of Pb $_{1-x}$Ga $_{x}$ alloy (x=0.06) can be stabilized on a Si(111)7x7 substrate through the quantum size effect. The quantum stability and superconductive properties of these films were investigated using STM, XPS, and SQUID magnetometry measurements. Quantum stabilized growth defects, consisting of deep holes extending to the film-substrate interface, act as pinning centers for vortices in the superconducting state. The pinning centers support an extraordinarily robust critical state with critical current densities in excess of 3 MA/cm2 in 10 monolayer thick films. Anomalies in the dc magnetization and ac magnetic response below 2.5-3.5 K indicate a reduction of the flux pinning below these temperatures, which we attribute to the nature of the holes (deep holes as opposed to blind holes in pure Pb films). The present study highlights the possibility of growing new alloys beyond the solid solubility limit and controlling critical state properties in the quantum regime.

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