The Meissner effect in a strongly underdoped cuprate well above its critical temperature

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The Meissner effect and the associated perfect bulk diamagnetism are, besides zero resistance and gap opening, characteristic features of the superconducting state. In the pseudogap phase of cuprates unusual diamagnetic signals as well as anomalous proximity effects have been detected but a Meissner effect has never been observed. Here, we have probed by low energy μSR the local diamagnetic response in the normal state of an underdoped (UD) $La_{1.94}Sr_0.06CuO_4$ layer (up to 46 nm thick, critical temperature $T_c^{'}$ $\leq$ 5 K) brought in close contact with two nearly optimally doped (OP) $La_{1.84}Sr_0.16CuO_4$ layers ($T_c \approx 32$ K). We show that the entire barrier layer of thickness much larger than typical c-axis coherence lengths of cuprates exhibits Meissner effect for temperatures well above $T_c^{'}$ but below T_c. We determine the temperature dependence of the effective penetration depth and superfluid density in the different layers. The results indicate that superfluidity with long-range phase coherence is induced in the underdoped layer by the proximity of optimally doped layers; however, this order is very sensitive to thermal excitation[1].

[1]E. Morenzoni et al., Nat. Commun. **2**:272 doi: 10.1038/ncomms1273 (2011).