Supplementary Material: Elastic properties of few unit cell thick superconducting crystals of $Bi_2Sr_2CaCu_2O_{8+\delta}$

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Modeling details to extract the Young's modulus and pre-stress from the compliance data:

To simulate the elastic deformation of circular BSCCO flakes, under the load applied by an AFM tip, we use the solid mechanics environment in the *structural mechanics* module of COMSOL multiphysics. The model geometry consists of a thin circular cylinder representing the suspended BSCCO flake, and an AFM tip having a radius of curvature of 40 nm. The circular boundary of the flake is constraint to have no displacement. A *contact pair* is defined at the common surface between BSCCO and the AFM tip in the *component* menu of the model builder window. This is necessary for problems with moving boundary conditions. In the *material selection* window, silicon is used as the material for the AFM tip. For BSCCO, the required material properties like density (2360 kg-m^{-3}) and Poisson's ratio ($\nu = 0.2$) are added manually by creating a new material. While defining the physics, we have taken BSCCO and the AFM tip as *linear elastic materials* with an added *initial stress* to the BSCCO flake. A body load is specified for the AFM tip, which defines the force for indentation. The predefined *contact pair*, forming a union of two surfaces is again selected as a *contact* inside the *solid mechanics* module. A *parametric sweep*, varying the Young's modulus and pre-stress, is then carried out until the radial profile of the compliance matches with the experimental data.

Data from additional flakes:

Data from additional flakes with thinckesses in the range from 20 nm to 55 nm is shown in Figure S1 and S2.

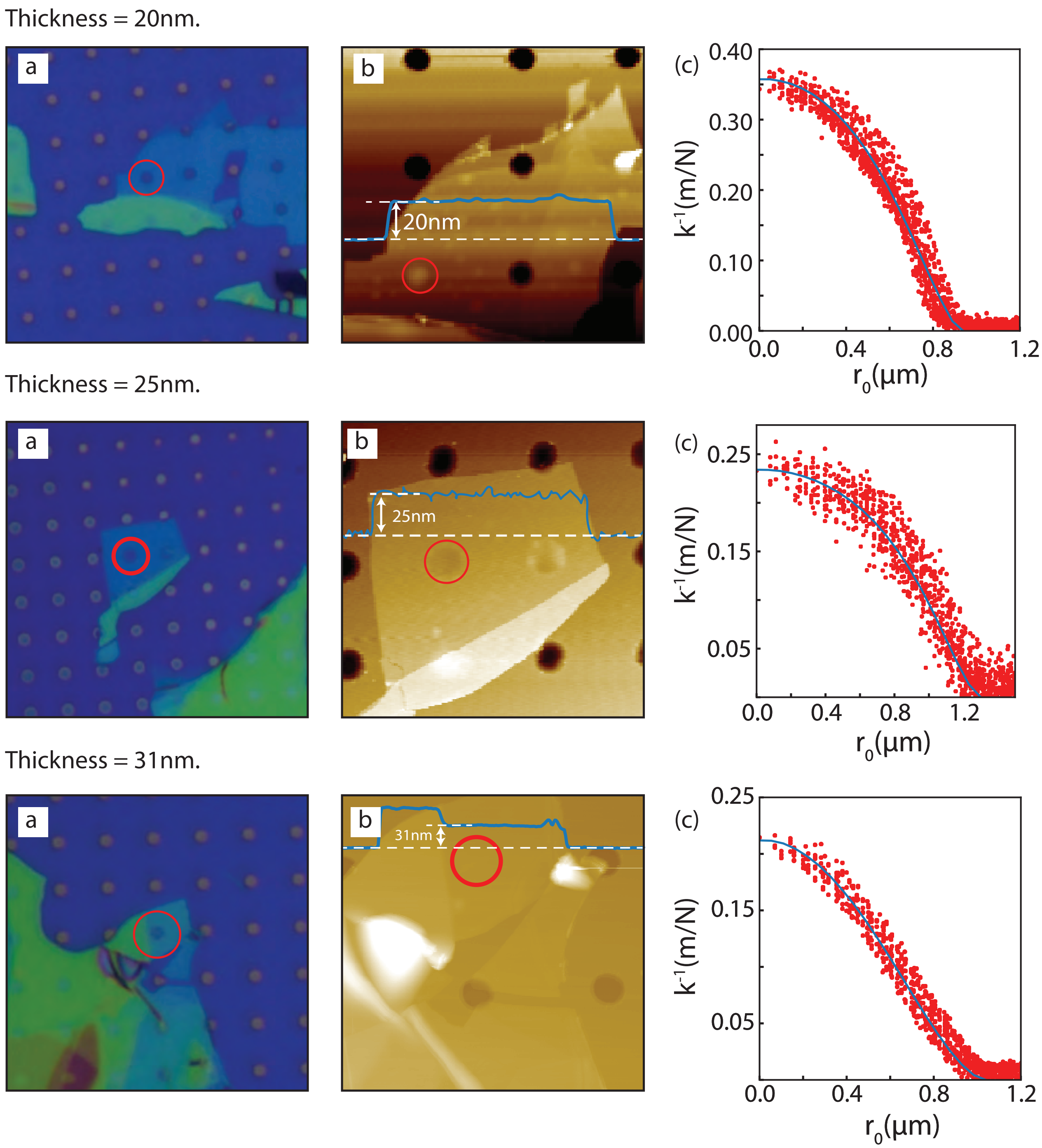

FIG. S1. Optical microscope (a) and AFM images (b) of the transfered BSCCO flakes on top of the patterned Si substrate coated with 285 nm of SiO_2. The suspended area probed by AFM is marked with red circle. (c) Radial profile of the compliance extracted from volumetric measurements.

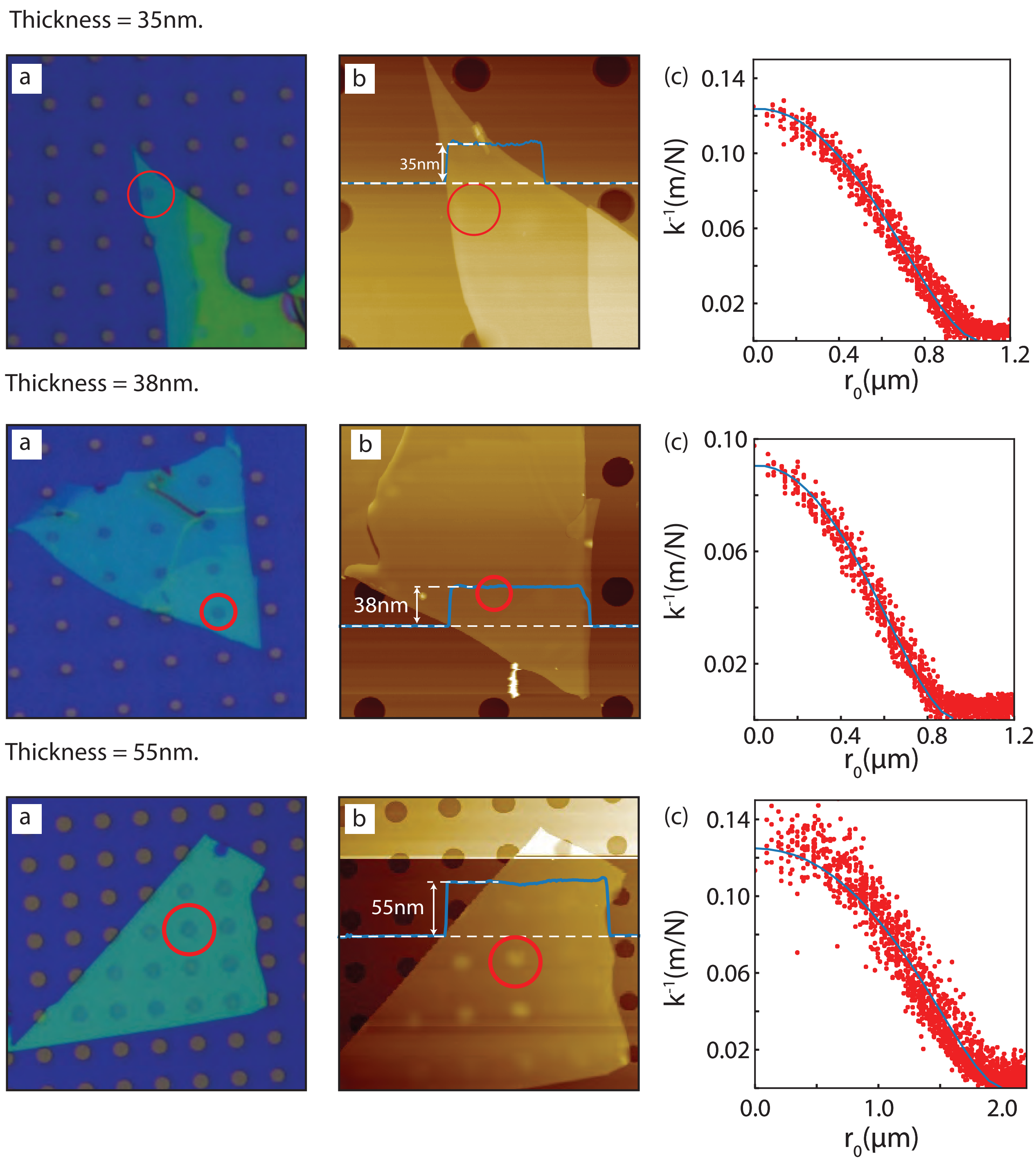

FIG. S2. Optical microscope (a) and AFM images (b) of the transfered BSCCO flakes on top of the patterned Si substrate coated with 285 nm of SiO_2. The suspended area probed by AFM is marked with red circle. (c) Radial profile of the compliance extracted from volumetric measurements.