TWO-DIMENSIONAL SUPERCONDUCTIVITY AT THE INTERFACE OF A Bi_2Te_3/FeTe HETEROSTRUCTURE

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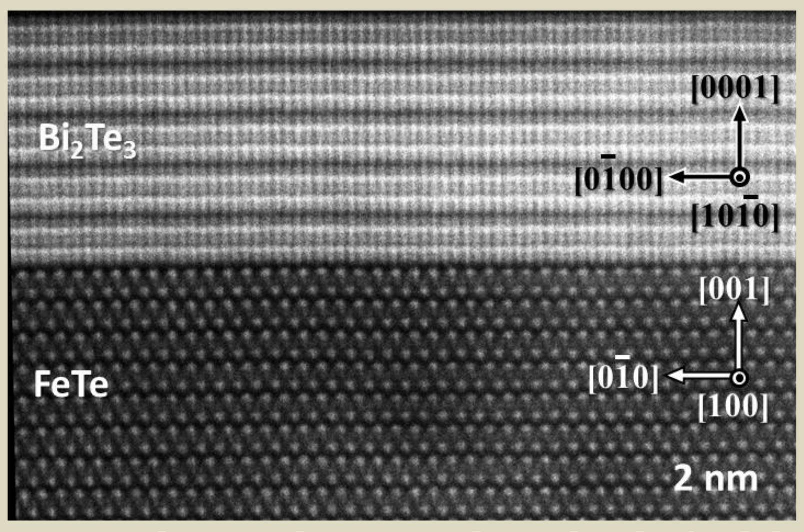
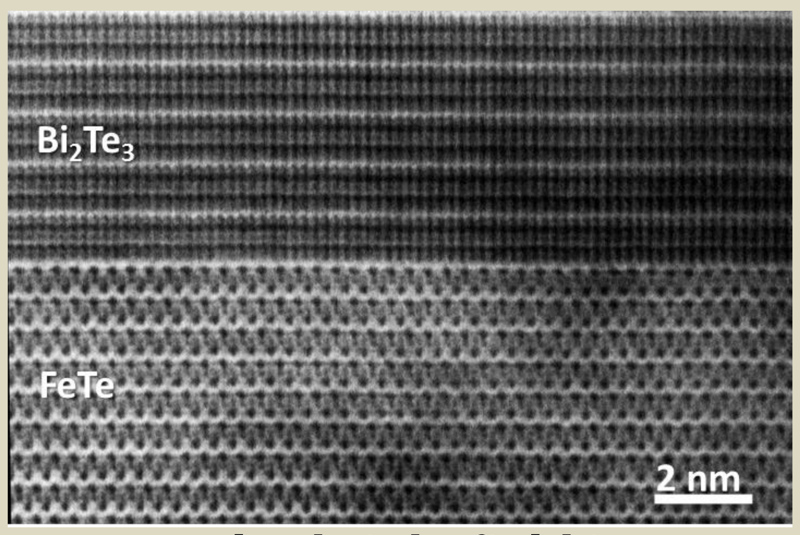
ABSTRACT

The realization of superconductivity at the interface between a topological insulator and an iron-chalcogenide compound is highly attractive for exploring several recent theoretical predictions involving these two new classes of materials. Here we report transport measurements on a Bi_2Te_3/FeTe heterostructure fabricated via van der Waals epitaxy, which demonstrate superconductivity at the interface is induced by the Bi_2Te_3 epilayer with thickness even down to one quintuple layer, though there is no clear-cut evidence that the observed superconductivity is induced by the topological surface states. The two-dimensional nature of the observed superconductivity with the highest transition temperature around 12 K was verified by the existence of a Berezinsky-Kosterlitz-Thouless transition and the diverging ratio of in-plane to out-plane upper critical field on approaching the superconducting transition temperature. With the combination of interface superconductivity and Dirac surface states of Bi_2Te_3, the heterostructure studied in this work provides a novel platform for realizing Majorana fermions.

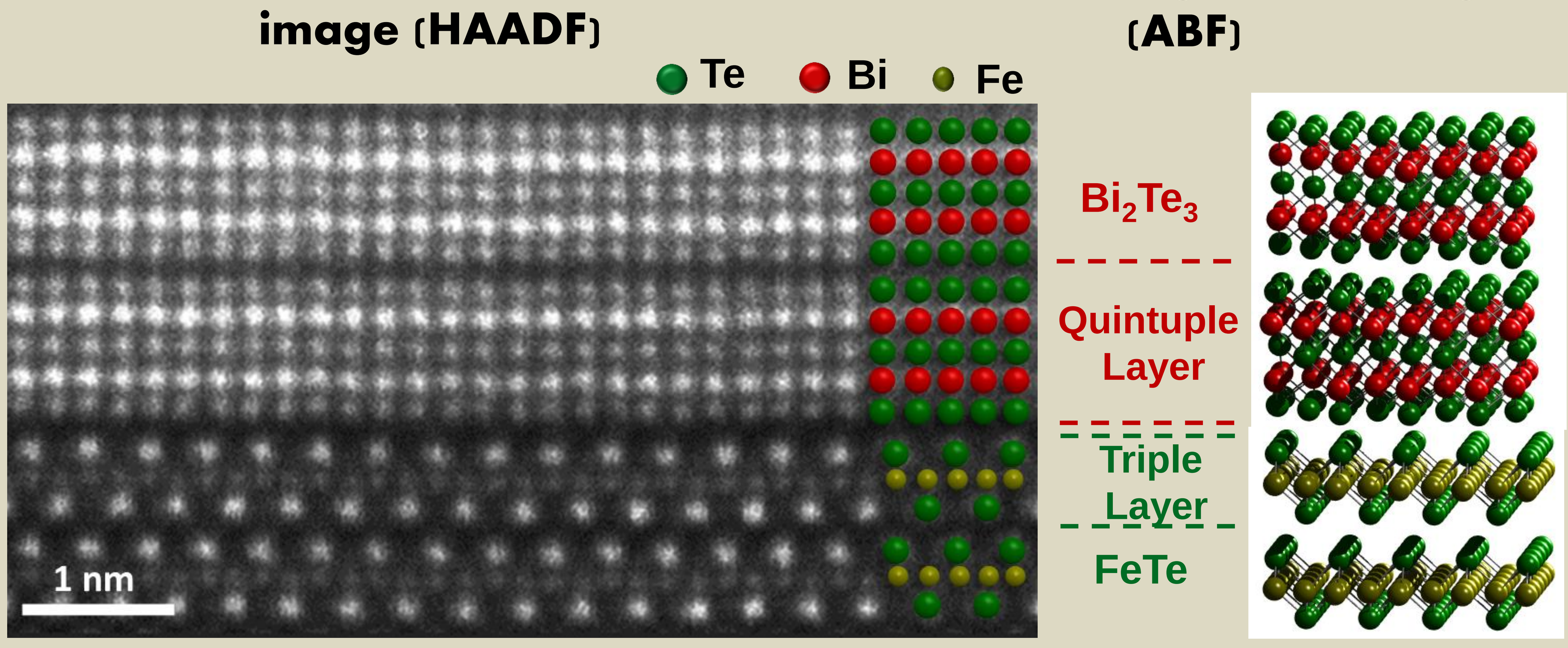
Spherical Aberration Corrected STEM Imaging



❖ High-angle annular dark field image (HAADF)



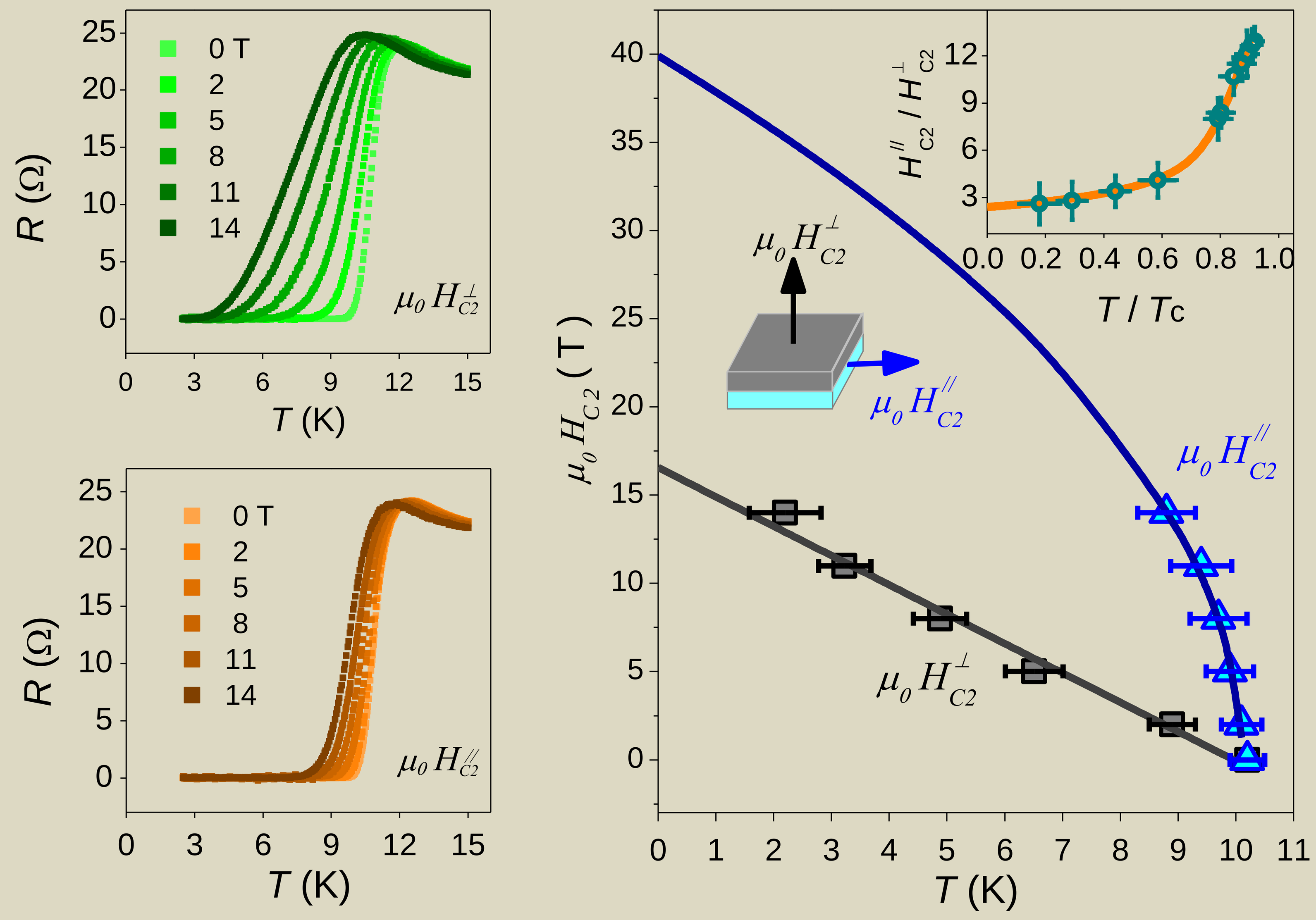
❖ Annular bright field image (ABF)



❖ High-magnification HAADF image shows atomically sharp interface between Bi2Te3 and FeTe;

❖ Two layers are separated by a vdW gap and form their own lattices independently.

Upper Critical Fields



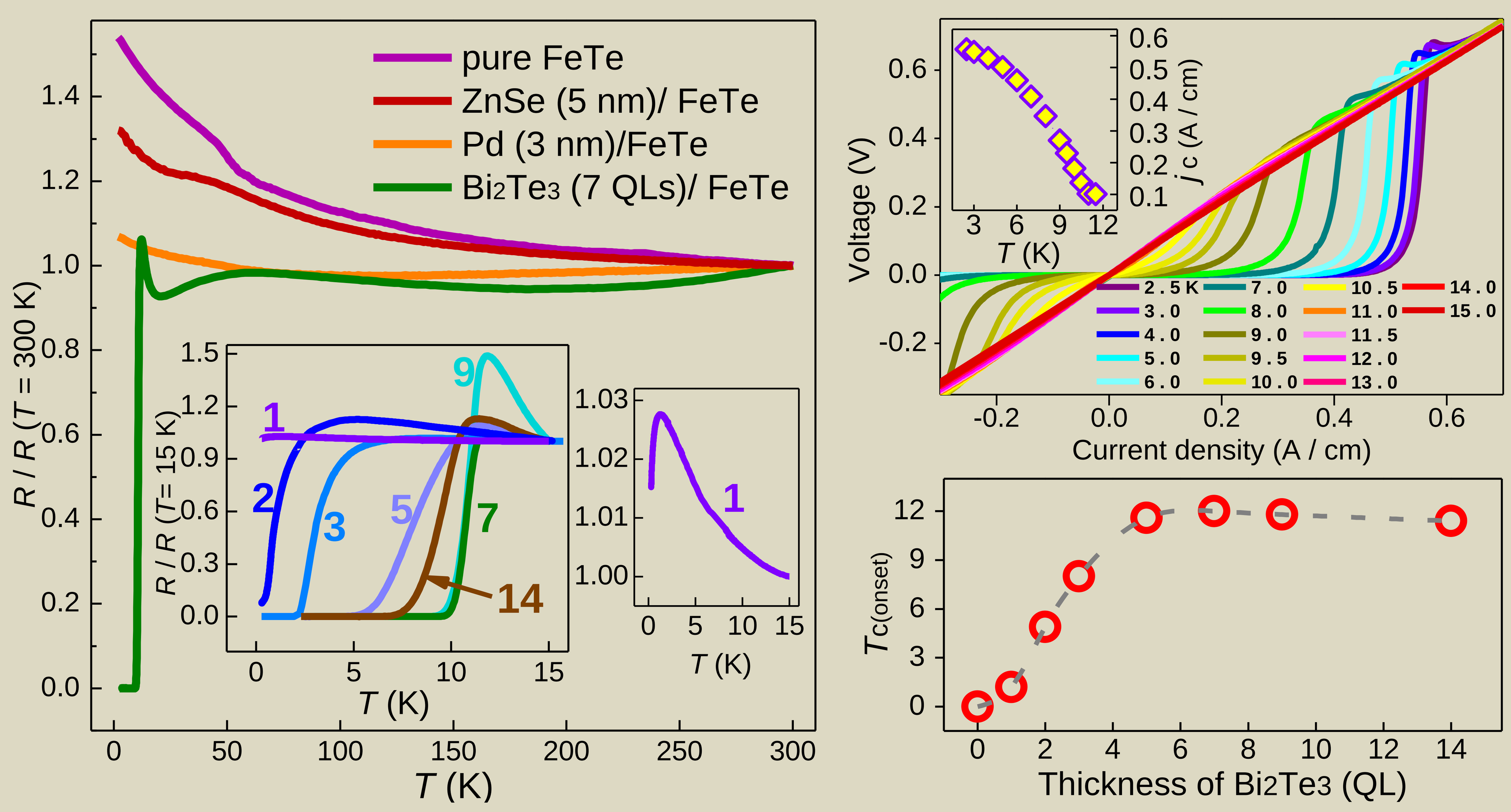
❖ Large anisotropy regarding the direction of the applied magnetic field;

❖ The diverging ratio of Hc2(∥)/Hc2(⊥) on approaching T_c;

❖ Data are well fitted with Ginzburg-Landau (GL) theories for a 2D SC film:

$$H_{C2}^{//}(T) = \frac{\sqrt{3}\Phi_0}{\pi\xi_{GL}(0)d_{sc}}\left(1-\frac{T}{T_C}\right)^{1/2} \propto \left(1-\frac{T}{T_C}\right)^{1/2} \qquad H_{C2}^{\perp} = \frac{\Phi_0}{2\pi\xi_{GL}(0)^2}\left(1-\frac{T}{T_C}\right) \propto \left(1-\frac{T}{T_C}\right)$$

Transport Measurements



❖ With 3, 5, 7, 9 and 14 QLs of Bi2Te3, R→ 0 ;

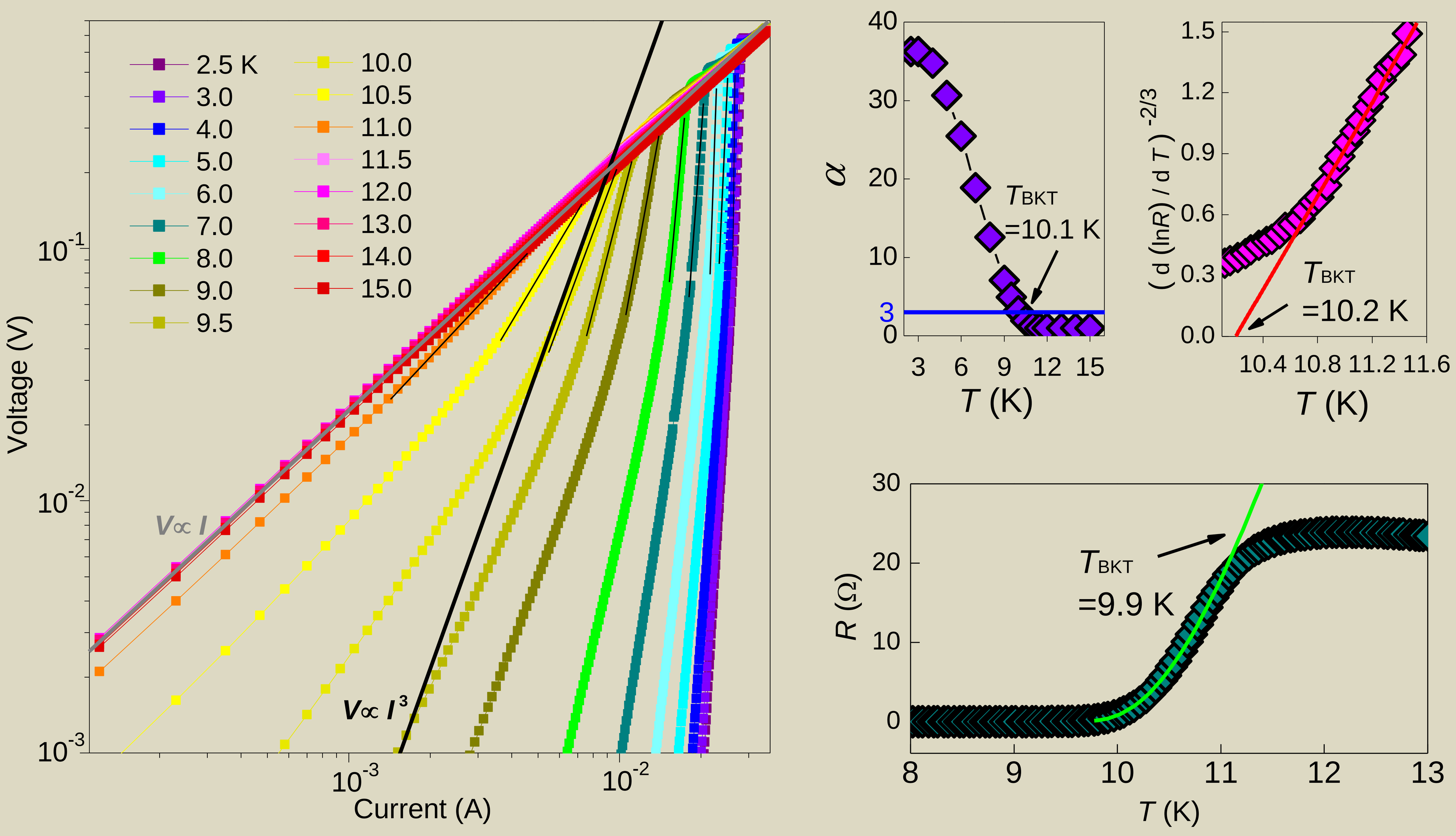
❖ With 1 and 2 QLs, SC transition could still be observed;

❖ Pure FeTe, ZnSe/FeTe & Pd/FeTe do not show any SC signature;

❖ A step-like critical current density profile at T<11K;

❖ Large magnitude of j_c: 0.1 A/cm.

Berezinsky-Kosterlitz-Thouless Nature



❖ All T_{BKT} values extracted are so similar

→ Strong evidence of the 2D nature

DISCUSSION

❖ Anomalous high j_c and H_{c2} → SC may be associated with a SC induced in FeTe;

❖ Bi2Te3 is indispensable for the observed SC in the heterostructure;

❖ Finite-size effect (inhomogeneous effect);

❖ Possible Origin of the observed 2D superconductivity

I. Extrinsic Bi doping? II. Strain from lattice mismatch? III. Topological Surface States !?

❖ GL Coherence Length : $\xi_{GL}(0)$ = 5.2 ± 1.7 nm;

❖ Superconducting thickness: d_{SC} = 7.0 ± 1.1 nm;

❖ ξ_{GL} and d_{SC} are close → 2D nature of the observed SC.