A Topological Superconductor Tuned by Electronic Correlations

H. Lin,[1] C. L. Jacobs,[2] C. Yan,[1] G. Nolan,[3] P. Singleton,[1] Y. Bai,[1] Q. Gao,[1] G. Berruto,[1] D. Nguyen,[1] X. Wu,[4] C. Liu,[5] N. Guisinger, [6] P. Huang, [3] S Mandal, [2] S. Yang[1]

[1] Pritzker School of Molecular Engineering, The University of Chicago, Chicago, IL, USA.
[2] Department of Physics and Astronomy, West Virginia University, Morgantown, WV, USA.
[3] Department of Materials Science and Engineering, University of Illinois, Urbana-Champaign, Urbana, IL, USA.
[4] Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing, P.R.China.
[5] Department of Physics, Pennsylvania State University, University Park, PA, USA.
[6] Argonne National Laboratory, Lemont, IL, USA.

A topological superconductor, characterized by either a chiral order parameter [1] or a chiral topological surface state in proximity to bulk superconductivity [2], is foundational to topological quantum computing. Similar to other topological phases of matter, it can be profoundly tuned by electronic correlations through the modification of low-energy Fermiology, but not elucidated so far.

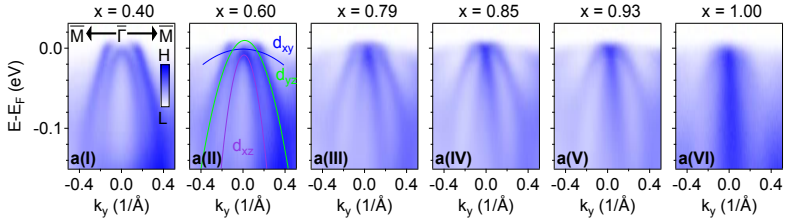

Figure 1. **a(I)-a(VI)** Evolution of the ARPES spectra for 10-unit-cell thick $FeTe_xSe_{1-x}$ with different Te content (x) near the $\overline{\Gamma}$ point.

We present the study of a unique topological superconducting phase emerging in 10-unit-cell-thick $FeTe_xSe_{1-x}$ films grown on $SrTiO_3$ substrates [3]. By combining molecular beam epitaxy (MBE) growth with *in-situ* angle-resolved photoemission spectroscopy (ARPES) (Fig. 1), we investigate the electronic band structures of these thin films. When the Te content x exceeds 0.7, we observe a rapid increase of the effective mass for the Fe d_{xy} band, with the emergence of a topological surface state and superconductivity; however, near the FeTe limit, the system enters an incoherent regime where the topological surface state becomes unidentifiable, and superconductivity is suppressed. Theory [4] suggests that the electron-electron interactions in the odd-parity xy^- band with a strong d_{xy} character lead to an orbital-selective correlated phase. Our work establishes $FeTe_xSe_{1-x}$ thin films as a unique platform where electronic correlations sensitively modulate topological superconductivity, suggesting opportunities to use tunable electron-electron interactions to engineer new topological phases in a broad class of materials.

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Supplementary Page

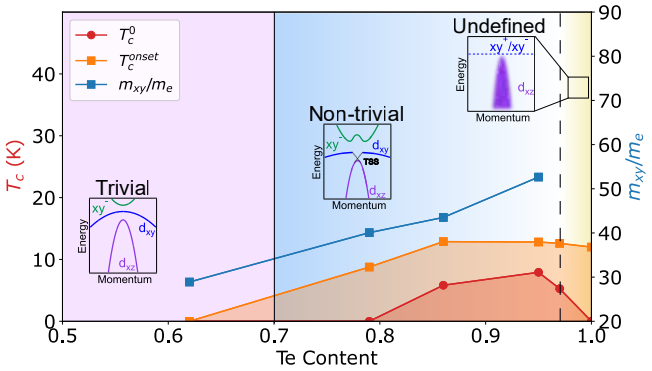

Figure 2. Topological phase diagram of 10 UC $FeTe_xSe_{1-x}$ thin films. The onset transition temperature (T_c^{onset}) and the temperature (T_c^0) at which the resistance reaches 1% of the normal state resistance at 20 K are plotted against Te content, x. The blue curve shows the effective mass of the d_{xy} band as a function of x. Near the FeTe limit, an undefined phase emerges, characterized by smeared topological surface states originating from localized electrons within the OSCP. Concurrently, this region also exhibits a suppression of superconductivity.