

# Superconducting properties of the strain-free Fe(Se,Te) film

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The mismatch in lattice or thermal expansion coefficients between iron-based superconducting thin films and their substrates significantly affects the superconducting transition temperature ( $T_c$ ) [1]. Bulk single crystals, generally used as strain-free references, are not ideal for comparison due to the non-equilibrium growth conditions of thin films. Freestanding thin films, grown under identical conditions and separated from the substrate, are better for accurate comparisons. This study used Fe(Se,Te), the simplest iron-based superconductor, to fabricate freestanding thin films via three methods.

The films were prepared by pulsed laser deposition with a KrF excimer laser. Initially, a CeO<sub>2</sub> buffer was deposited on an SrTiO<sub>3</sub>(STO)(001) substrate. Freestanding thin films were fabricated through three methods: (1) peeling the superconducting layer with a razor blade (Film B), (2) applying epoxy resin to a quartz substrate, placing Fe(Se,Te) thin films on top, and holding for 10 hours to ensure sufficient solidification, followed by cleaving the film, and (3) using water-soluble Sr<sub>3</sub>Al<sub>2</sub>O<sub>6</sub> layers on STO and LaAlO<sub>3</sub>(LAO) (001) substrates, followed by immersion in deionized water (Film D and E).

Figure 1(a) shows X-ray diffraction (XRD) patterns of as-grown thin films, Film B, and Film C. The weak 00 $l$  peak intensity in Films B and C is due to reduced Fe(Se,Te) volume fractions after detachment or cleavage. Figure 1(b) highlights the 004 peak shift to higher angles in Films B and C compared to as-grown films. The onset  $T_c$  decreased from about 17 K (as-grown) to 14 K for Films B and C, comparable to bulk crystals [2]. Figure 1(c) shows the XRD patterns of Films D and E, with all layers oriented along [001]. Before immersion, we confirmed zero resistance at approximately 4 K and 6 K for Films D and E, respectively.

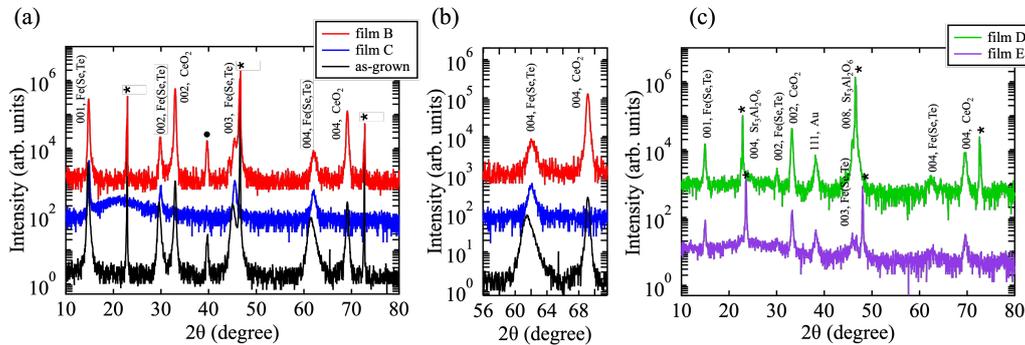


Fig. 1 (a) X-ray diffraction pattern of the films B, C, and as-grown film. The respective symbols “\*” and “•” indicate the SrTiO<sub>3</sub> substrate and the sample holder. (b) Enlarged view near the 004 peaks. (c) X-ray diffraction pattern of the films D and E.

## References

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- [2] K. Terao *et al.*, *Phys. Rev. B* **100**, 224516 (2019).