Studying the influence of a capping layer on interfacial superconductivity in $FeSe/SrTiO_3$ heterostructures

Process Development

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Understanding the superconductivity at the interface of $FeSe/SrTiO_3$ is a problem of contemporary interest in condensed matter physics because of the significant increase in the critical temperature (T_c ~ 50 K) for the onset of superconductivity compared to that of bulk FeSe crystals (T_c ~ 9 K). Additional interest in this problem arises from the possibility of an unconventional pairing mechanism. We used the 2DCC multimodule molecular beam epitaxy (MBE) and surface characterization facility to study the influence of various capping layers on the T_c of ultrathin films of FeSe grown on $SrTiO_3$. The multimodule facility's *in vacuo* four-probe electrical resistance measurement capability provided critical information about the T_c of MBE-grown FeSe films in their pristine state, while *ex situ* magneto-transport measurements elucidated the key role of distinct charge transfer from different capping layers (compound FeTe, non-metallic Te, and metallic Zr). Our results show that FeTe provides an optimal cap that barely influences the inherent T_c found in pristine $FeSe/SrTiO_3$, while the transfer of holes from a non-metallic Te cap completely suppresses superconductivity and leads to insulating behavior. We also used *ex situ* magneto-resistance measurements in FeTe-capped FeSe films to extract the angular dependence of the in-plane upper critical field. Our observations reveal an almost isotropic in-plane upper critical field. Although this does not show any obvious signature of exotic physics, our study provides insight into the symmetry and pairing mechanism of high temperature superconductivity in FeSe.

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