首届致远学术节
学生科研成果展示

Monolayer FeSe superconductor by epitaxy growth on $SrTiO_3$ (100) substrates processed in a new method

Key Words: FeSe superconductor,molecular beam epitaxy, heterostructure,$SrTiO_3$

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Background

FeSe has been the most prospective superconductor since being discovered,with the highest Tc of 109K so far among all the materials with superconductivity. Different thichness give rise to different Tc,which put an emphasis on monolayer FeSe due to both the difficulty of growing such a thin film and its potential for high Tc. The epitaxy growth on specifc substrates is a regular method for realization of its superconductivity,which largely depends on the surface morphology of the substrates. $SrTiO_3$(STO), a perovskite, is one of the few substrates that can be used to grow FeSe superconductor. There is an experimental law that only STO with di-layer of TiO_2 termination can realize the superconductivity of FeSe. In this way,how to experimentally pepare such STO substrates with good quality become a key topic.

Summary of work

In this project, we focus on working out an efficient method of processing STO substrate with good quality as well as the condition of MBE growth of FeSe. My main reponsibility is to prepare STO substrates and compare their quality by AFM and RHEED. By adjusting the etching time and annealing condition,we have got an optimized recipe of acquiring ideal STO on which we have successfully grown monolayer FeSe with relatively high Tc.

Etching procedure of $SrTiO_3$

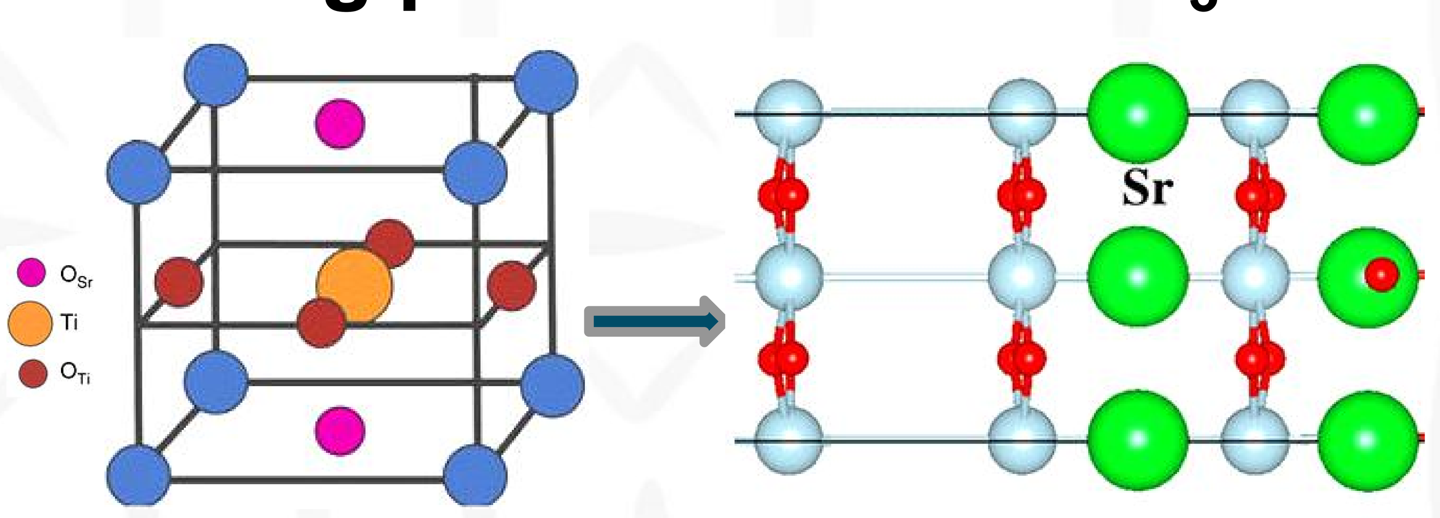

Figure 1 The realization of di-layer TiO2 termination on the suaface of STO(100) after etching procedure

The main steps of etchnig procedure:
(1)place substrates in DI water and heat on hot plate at 80 ℃ for 45 min
(2)place substrates into HCl solution(10%,by volumn) polished-side up for 45min
This is followed by annealing in O_2 furnace 980 ℃ for 3 hours. Set O_2 flow rate to >45 ml/min

We have realized the following effects during this procedure:
(1)formation of $Sr(OH)_x$
(2)removal of Sr in form of $Sr(OH)_x$

As STO tend to lose oxygen atoms, we set up an annealing process in O_2 furnace with two purposes:
(1)realize surface reconstruction to get a better morphology
(2)prevent oxygen atoms from loosing

By doing AFM characterization, we can see that the STO has good surface condition with clear steps.

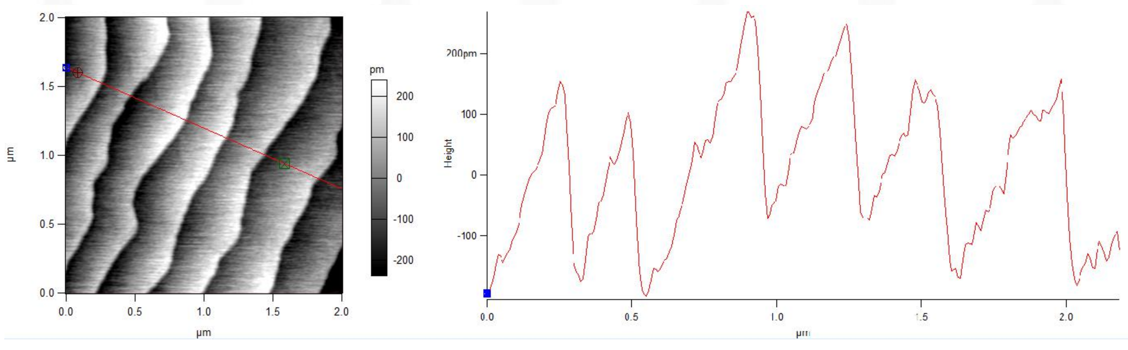

Figure 2 The AFM result of STO after the procedure

High quality 1uc FeSe superconductor grown by MBE on our substrates

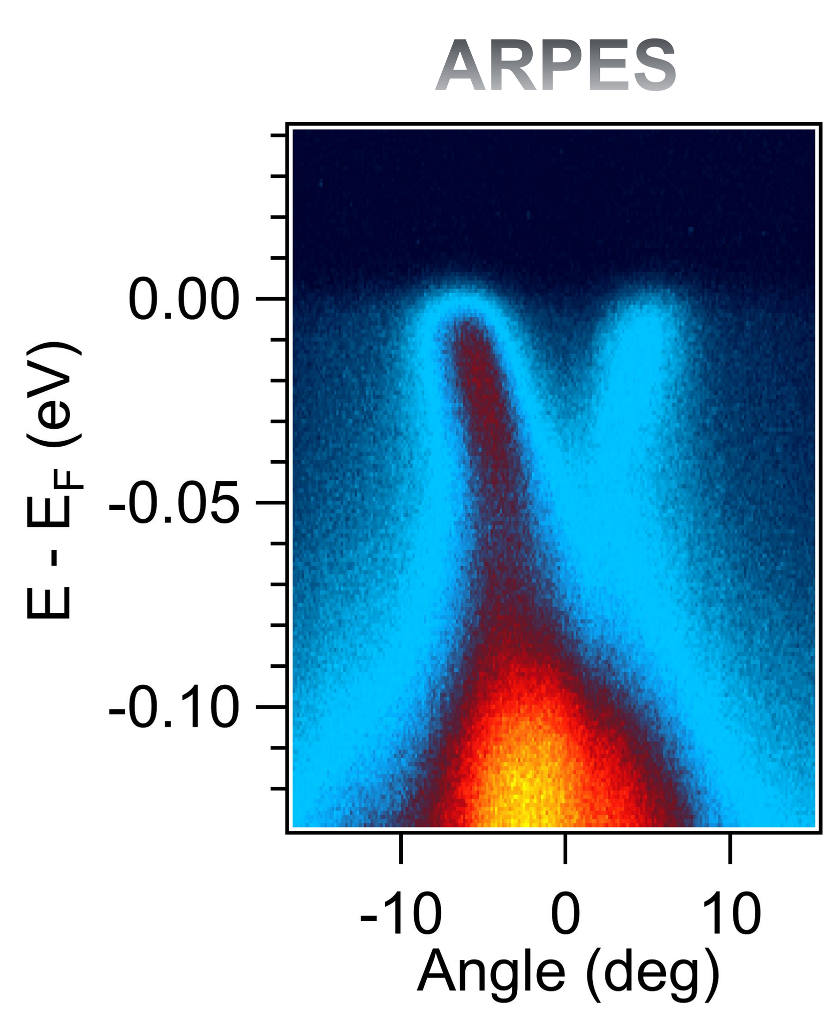

Figure 3 The band structure of the 1uc monolayer FeSe superconductor by ARPES measurement

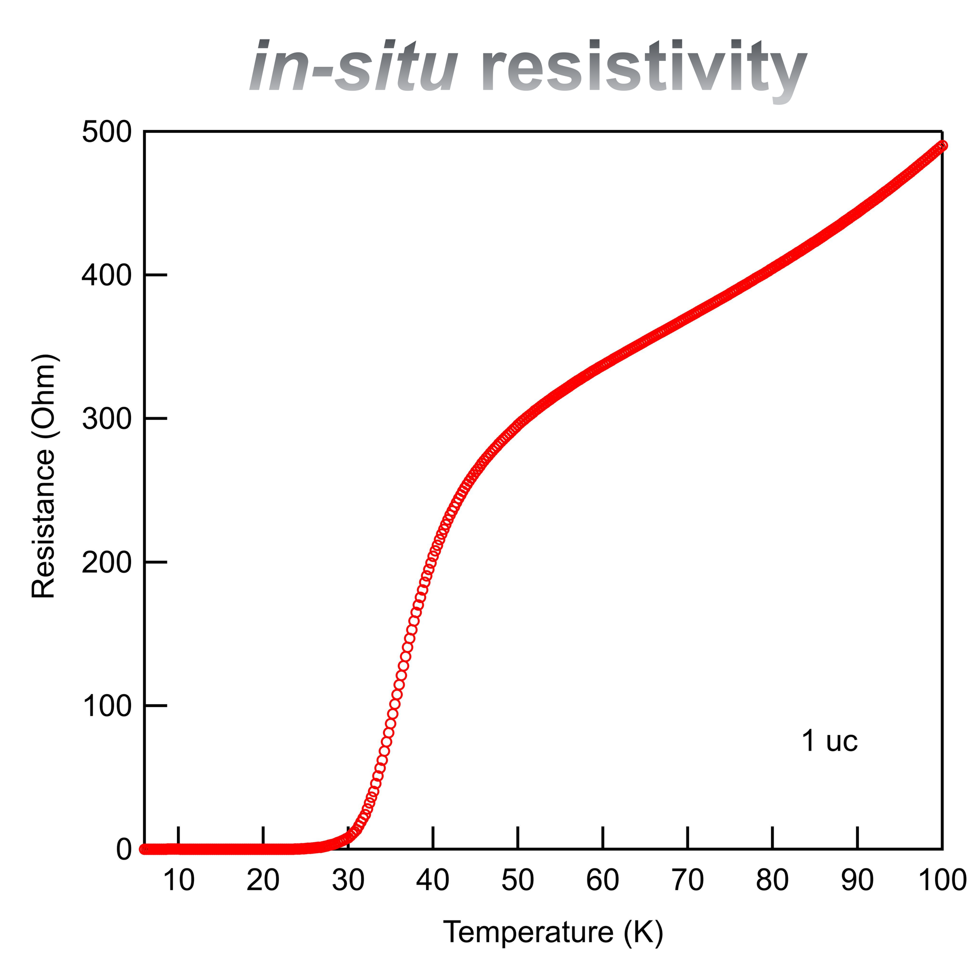

Figure 4 The *in-situ* resistivity measurement of the 1uc monolayer FeSe superconductor

As shown in figure 3, the band structure of the 1uc monolayer FeSe fits quite well with theoretical results.

By doing in-situ resistivity measurement, we confirmed that the FeSe thin film is superconductor and got the Tc between 40K and 50K. This is rather high compared with other monocystals.

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