

Preparation and characterization of stoichiometric FeTe thin films grown on SrTiO₃(001) by molecular beam epitaxy

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Abstract

The crystallinity of FeTe films was characterized *in-situ* by reflective high energy electron diffraction (RHEED), low energy electron diffraction (LEED) and by *ex-situ* X-ray diffraction (XRD). The stoichiometry of the Fe_xTe films was determined by soft X-ray absorption spectroscopy (XAS) at Fe *L*-edges and Te *M*₅-edge and by X-ray photoelectron spectroscopy (PES) at Fe *3p* and Fe *4d* shallow core-levels. Resistivity measurements on thin films show a similar behavior as in bulk Fe_xTe: metallic at low-temperatures with a magnetic transition at around 60 K. The fact that we are able to stabilize a nominally stoichiometric FeTe thin film with good overall crystallinity opens up new opportunities to achieve a single-phase compound and possibly also superconductivity by for example doping with non-magnetic ions.

Keywords - FeTe, thin film, MBE, XAS, PES.

Introduction

The mechanism giving rise to superconductivity in iron chalcogenides [1] has been the subject of tremendous interest. FeSe is one of the most studied material in the Fe-based superconductor family due to its simple crystal structure [2]. However, its sister compound FeTe, which orders antiferromagnetically at low temperature [3], surprisingly does not exhibit superconductivity. The behavior of FeSe and FeTe under external pressure is also different: FeTe becomes metallic and orders ferromagnetically [4-5] while FeSe enhances its superconducting transition temperature [6-8]. Furthermore, bulk FeTe only forms with presence of excess Fe [9-11] where FeSe is known to exhibit a negligible homogeneity range only. The excess Fe in Fe_xTe bulk crystals appears essential to stabilize the compound as a phase separation occurs when synthesizing stoichiometric FeTe single crystals without excess Fe [11]. The absence of superconductivity in the bulk Fe_xTe may be attributed to the excess of Fe in Fe_xTe [3], but direct evidence remains inadequate.

Experiments

Based on a previous study of FeTe thin films on MgO(001) [12], we now prepared epitaxial FeTe thin films on SrTiO₃(001) substrates with well-controlled stoichiometry by molecular beam epitaxy (MBE) under the Te-limited growth conditions.

Results

In order to verify the crystallinity of the films, *in-situ* RHEED, LEED and *ex-situ* XRD were performed. Figure 1 shows the (a) RHEED, (b) LEED and (c) XRD results of a nominally stoichiometric FeTe film.

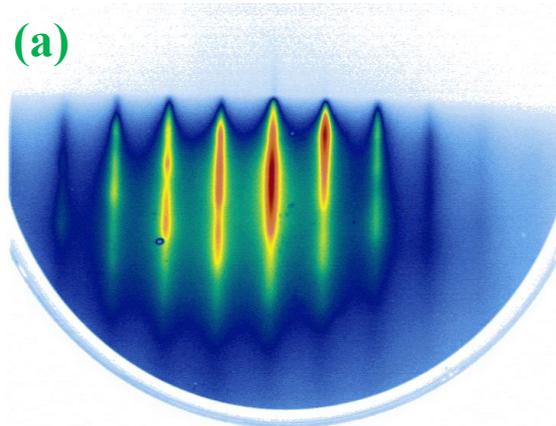


Figure 1 (a) RHEED result for Fe_{1.01}Te film

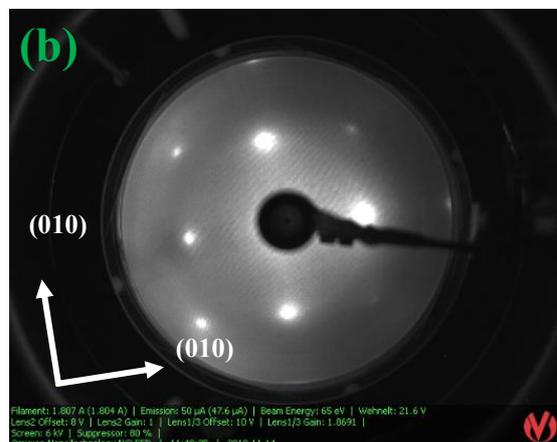


Figure 1 (b) LEED result for Fe_{1.01}Te film

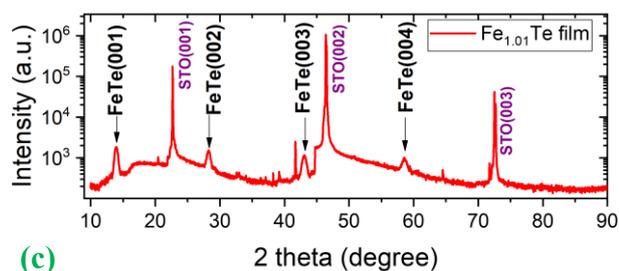


Figure 1 (c) XRD result for $\text{Fe}_{1.01}\text{Te}$ film

The stoichiometry of the Fe_xTe films was determined by both XAS and PES to verify the stoichiometry of the FeTe film. Figure 2 summarizes the composition results determined by XAS and XPS.

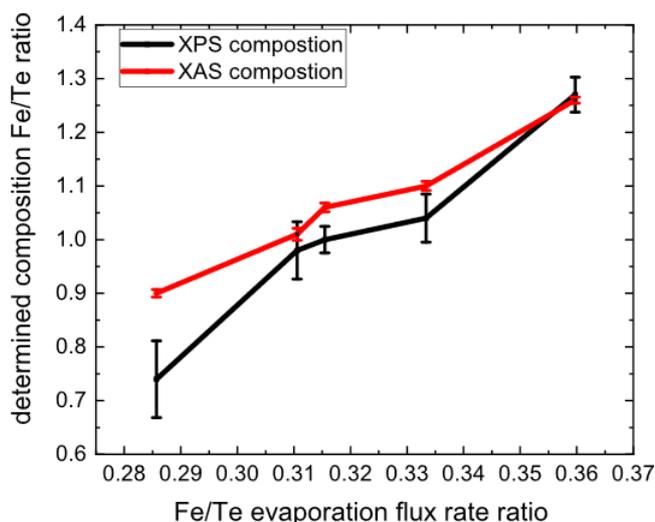


Figure 2. Comparison of XAS and XPS determined Fe_xTe composition.

Discussion

The R-T transition is however considerably broader. This suggests the possibility of phase separation in the nominally stoichiometric FeTe film. An ARPES study is required to investigate this aspect.

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