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優勝作品專輯

作品編號	160031
參展科別	物理與天文學
作品名稱	Determining Crystal Orientation via Reflection High Energy Electron Diffraction
得獎獎項	二等獎

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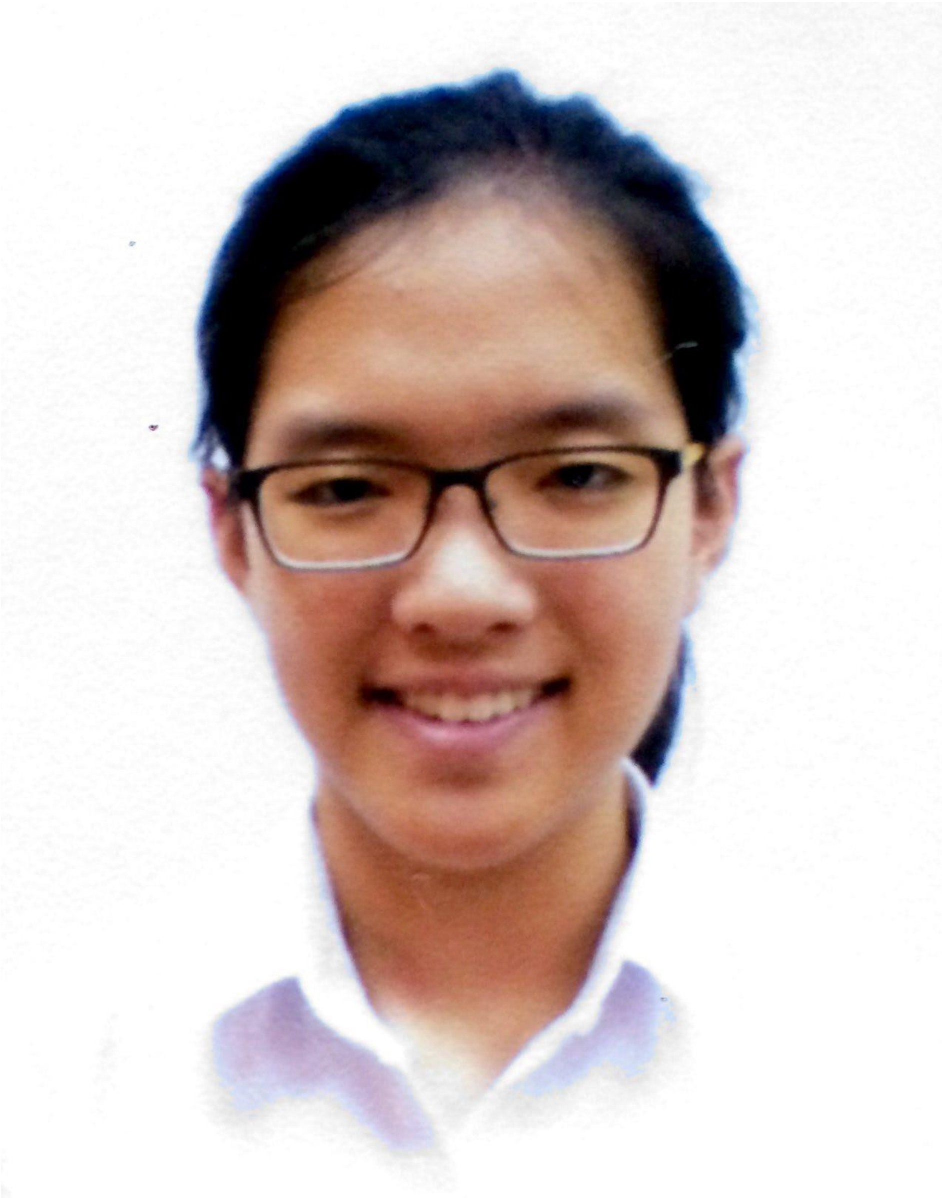

Abstract

1 Purpose of the Research

Nanocrystal thin films exhibit many useful properties, including electrochromicity and superconductivity. When synthesised via Molecular Beam Epitaxy (MBE), selection of substrate, specifically knowledge of crystal orientation, is critical. Reflection High Energy Electron Diffraction (RHEED) is an in situ crystal characterisation method highly compatible with MBE. This study explores a new method of RHEED analysis to determine crystal orientation.

2 Procedure/Theoretical Framework

RHEED characterization is the incidence of a beam of high-energy electrons at a low angle with respect to the sample surface. Electrons diffract, and interfere to form patterns on the detector. Traditionally, studies of RHEED analyse one static image as a representation of the surface structure, or observations of RHEED patterns over time.

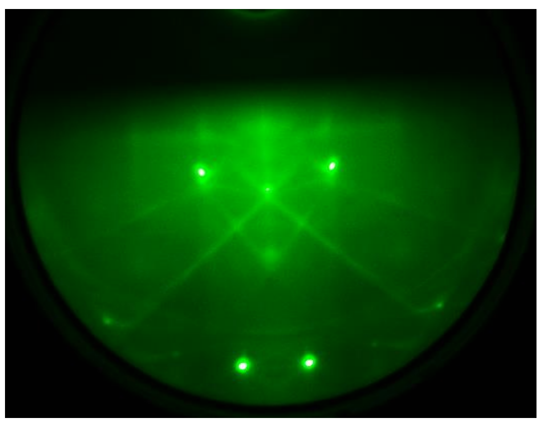

Figure 1: RHEED pattern with Kikuchi lines

The approach to RHEED analysis in this study exploits changes in RHEED patterns given a rotating substrate. Having specific rotational symmetries along different axes, crystal structures can be differentiated by determining rotational symmetry through RHEED. Electrons scatter upon incidence with crystal planes within the crystal to form Kikuchi lines on the RHEED detector (Fig. 2). The orientation of crystal with respect to incident electron beam affects the Kikuchi line patterns. If the crystal is rotated, crystal planes change orientation, and electrons would diffract from crystal planes in different directions. As such, as the crystal is rotated, the Kikuchi lines move. When the degree of rotation of the crystal corresponds to the rotational symmetry of the crystal (Fig. 1), the Kikuchi lines return to their original position. As crystals with different crystal plane orientations exhibit different orders of symmetries, analyzing the Kikuchi line patterns of the crystal at different degrees of rotation can reveal the rotational symmetry and consequently crystal plane orientation of a crystal.

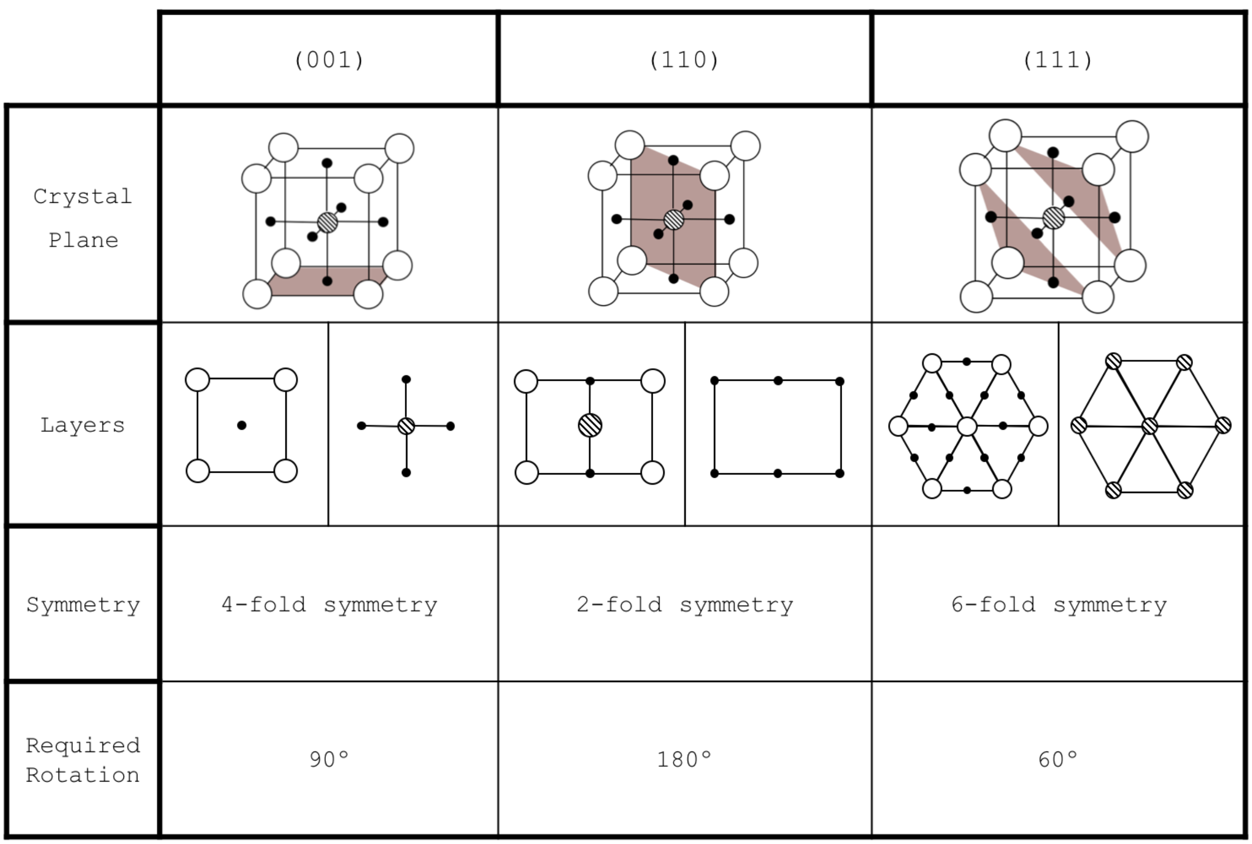

Figure 2: Rotational symmetries of different crystal plane orientations of perovskite structure

3 Data/Experimental Testing

In order to assess the practical viability of the proposed method, experiments were conducted on SrTiO3 (001), (110), and (111). SrTiO3 exists as a typical perovskite structure (Fig. 3), often used in the synthesis of superconductors via MBE.

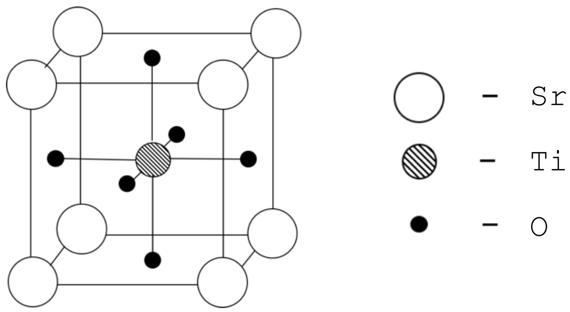

Figure 3: Perovskite structure

3.1 Methodology

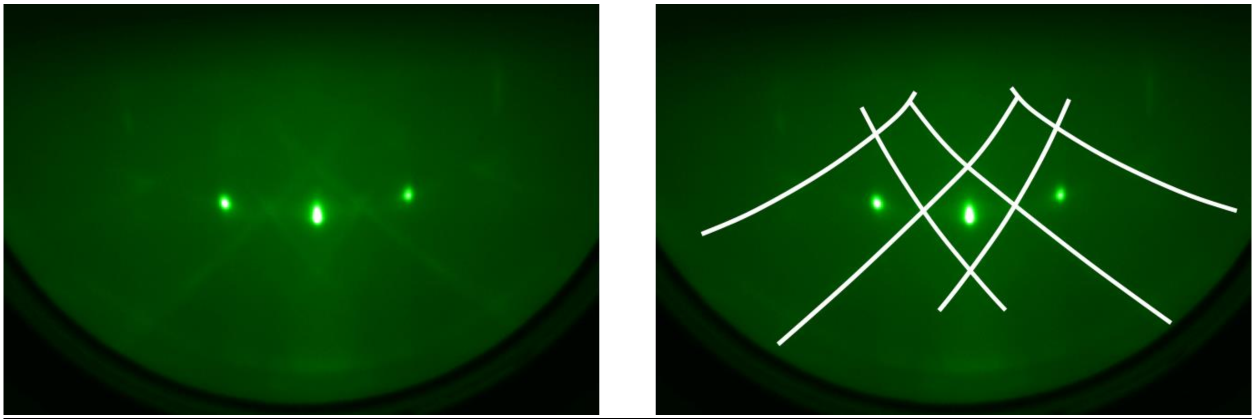

Figure 4: Left: Original RHEED image, Right: Curves fitted over Kikuchi lines observed in RHEED image

RHEED images of each sample were taken at 0◦, 60◦, 90◦ and 180◦. Curves were fit to each Kikuchi line observed in the image (Fig. 4). These Kikuchi line approximations are compared by superimposing the curves traced and qualitatively assessing the degree of similarity between the Kikuchi lines of 2 images, to verify the order of symmetry and crystal orientation of the crystal.

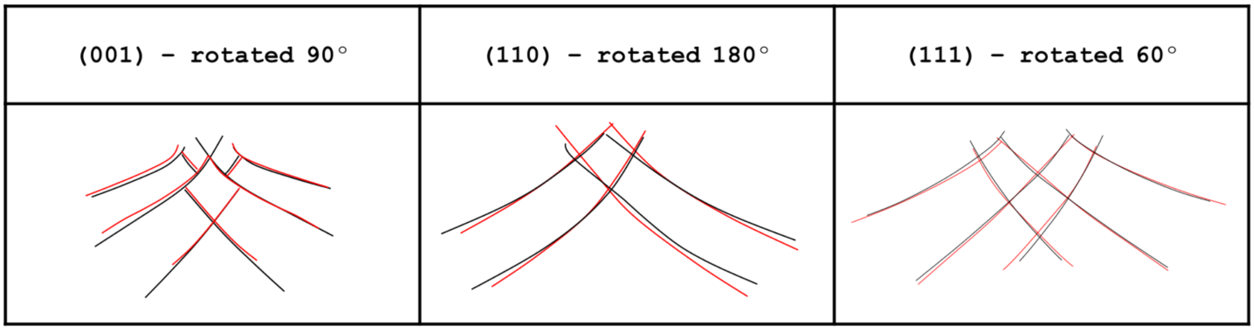

Figure 5: Curves constructed from Kikuchi lines before and after rotation are superimposed

In the images of the superimposed Kikuchi lines illustrated in Fig. 5, there is similarity between the Kikuchi lines when only when the sample has been rotated by an angle corresponding its degree of symmetry.

4 Conclusions

This study offers a method to determine the crystal orientation of thin film through determining the degree of rotational symmetry of the sample, by observation of Kikuchi lines in the RHEED pattern as the sample is rotated. Experimental data was analyzed qualitatively to verify the viability of this theoretical method in practice. This method could be extended to analyze the symmetry of other crystal structures. As it does not require information on the machine settings or usage of complex functions to produce a reliable output, this method is fast and straightforward, opening doors to more streamlined RHEED analysis.

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Using inelastic scotty to identify the diffraction and reflection plans of the in-situe growth. The project is nicely performed and is useful thin grouch.