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B-XRD2025 - Analysis of uniaxially oriented film by wide-range RSM

Introduction

Reciprocal space mapping (RSM) is an XRD technique used to evaluate the lattice spacing and orientation distribution of thin film materials, especially for epitaxial films. The TDI (time delay integration) scan mode of a 2-dimensional X-ray detector can obtain wide-range RSM in a relatively short time. The combination of reciprocal lattice simulation with uniaxial orientation, a new function of SmartLab Studio II, can easily evaluate film orientation.

Measurement and results

Figure 1 shows a schematic of wide-range RSM. In $2\theta/\theta$ data collected with the TDI scan mode of a 2-dimensional detector, diffraction signals from the lattice planes that are parallel to the sample surface or are slightly tilted are detected. By merging scan data from multiple χ -axis positions and converting the coordinates, a wide-range RSM is obtained.

Figure 2 shows the results of the wide-range RSM measurement of a Ti thin film (thickness: about 90 nm) deposited on a Si 100 substrate. The measurement time was approximately 20 minutes each. The arrangement of diffraction spots of Si, a single crystal, changed with the incident X-ray direction. On the other hand, the arrangement of the diffraction spots of titanium (marked with \circ in Figure 2) did not change with the incident X-ray direction. Since each coordinate of titanium diffraction spots showed good agreement with a simulation (Figure 3), it suggests that the Ti film had 001 uniaxial orientation with respect to the stacking direction.

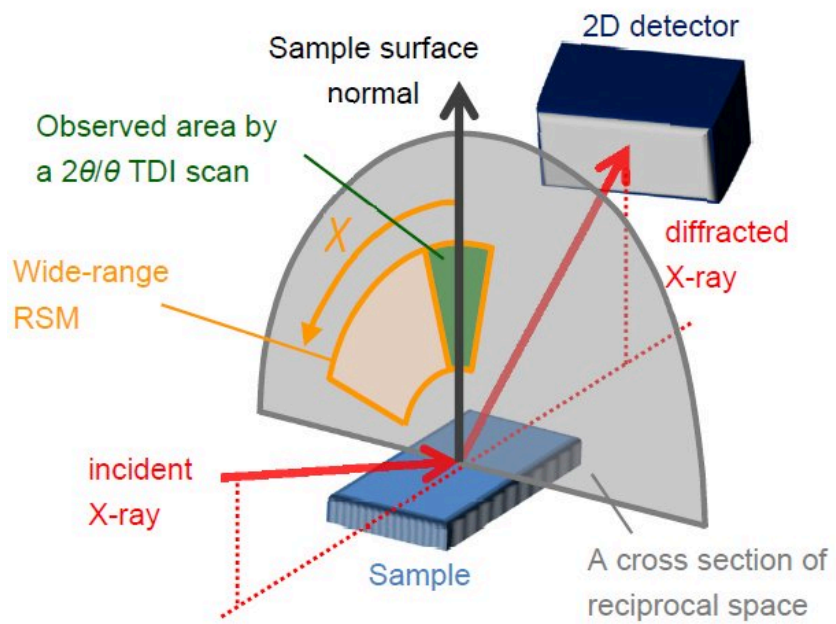


Figure 1: schematic of wide-range RSM.

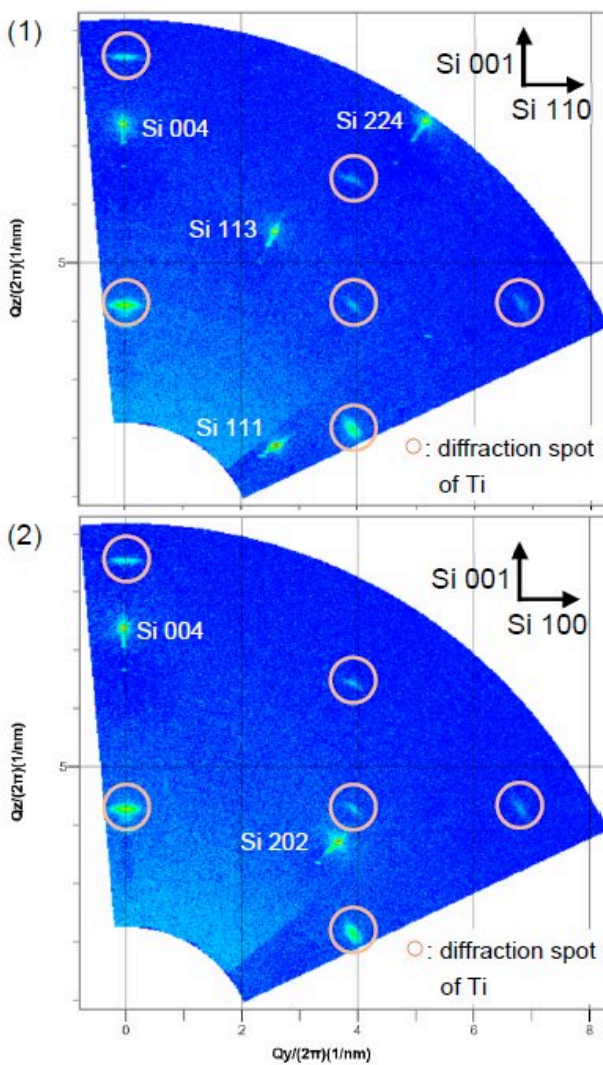


Figure 2: wide-range RSM for Ti film on Si substrate (1) incident X-ray // Si 110, (2) incident X-ray // Si 100

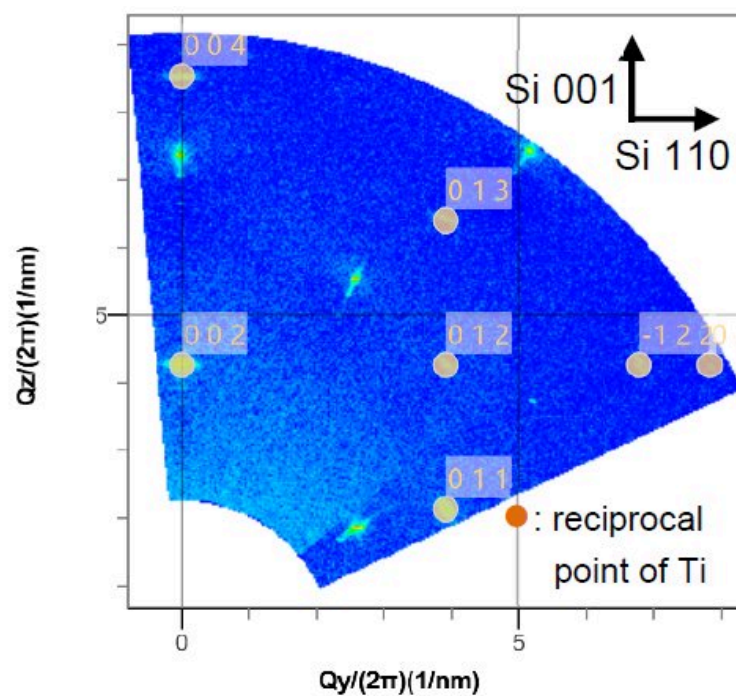


Figure 3: reciprocal space simulation (uniaxial oriented Ti)

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SmartLab Studio II

Windows-based software suite for Rigaku's X-ray diffractometers