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# Growth of $BiFeO_3$ thin films by pulsed laser deposition

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This application note describes the growth and characterisation of $BiFeO_3$ thin films grown in the Royce Deposition System by pulsed laser deposition. The film was characterised by X-ray reflectivity and X-ray diffraction.

## 1 Introduction

$BiFeO_3$ (BFO) is a room temperature multiferroic with a perovskite crystal structure.

## 2 Growth

The BFO film was deposited by pulsed laser deposition (PLD) in the Royce Deposition System. The target was mounted below the substrate with a target-substrate distance of 55 mm and was scanned during ablation at a speed of 2.5 mm/s. The base pressure of the system was to 2.1 x$10^{-9}$ mbar. $O_2$ gas was flowed through the chamber at 10 sccm with the main gate valve to the turbo pump closed and a bypass butterfly valve controlled by a feedback loop to maintained an equilibrium process pressure of 0.13 mbar. The sample was deposited onto a (100) cut $SrTiO_3$ substrate. The substrate was heated to 700 °C at a rate of 10 °C/minute. A pyrometer set to an emissivity of 0.8 gave the temperature of the surface as 543 °C prior to deposition. A KrF excimer laser with a wavelength of 248 nm was used to ablate the target. The fluence was measured before deposition as 1.45 $\mathrm{J/cm^2}$.

During heating and deposition the sample was rotated at 1 rpm. A $SrRuO_3$ (SRO) seed layer was deposited before the BFO. The (SRO) target was cleaned with a pre-ablation of 2000 pulses at a repetition rate of 2 Hz, then the shutter was opened and SRO was deposited onto the substrate using 7000 pulses at a rate of 10 Hz. The BFO target was cleaned with a pre-ablation of 2000 pulses at a repetition rate of 5 Hz, then the shutter was opened and BFO was deposited onto the seed layer using 21000 laser pulses at a repetition rate of 5 Hz. After growth a pyrometer set to an emissivity of 0.8 gave the temperature of the BFO surface as 590 °C. The sample was cooled at 10 °C/minute in 0.13 mbar of oxygen.

## 3 Properties

The BFO thin film was measured using X-ray reflectivity (XRR) and X-ray diffraction (XRD) in a Bruker D8

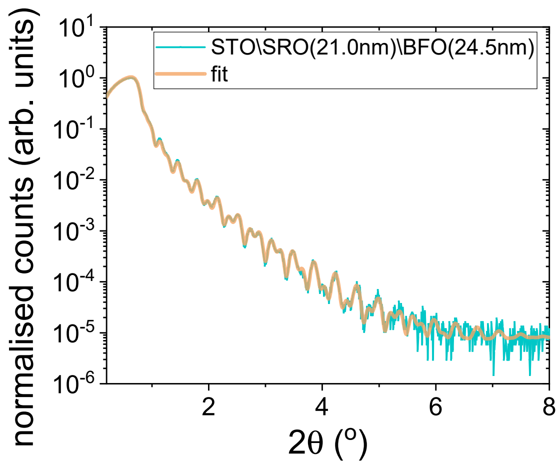


Figure 1: X-ray reflectivity data of the BFO thin film on an SRO seed layer and a GenX fit to the data.

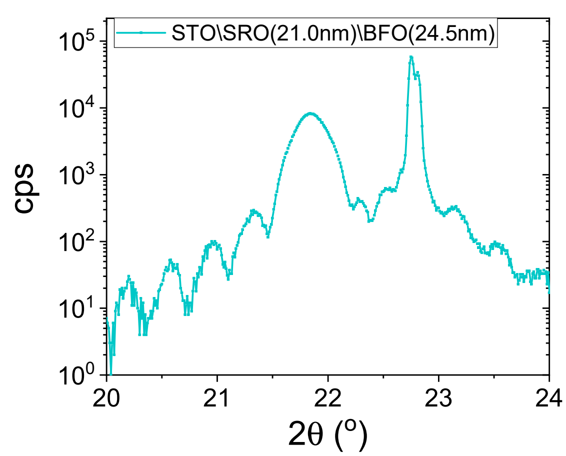


Figure 2: X-ray diffraction data of the BFO thin film on an SRO seed layer. The data shows the $\langle 2\,0\,0 \rangle$ peaks of the STO substrate (sharp peak at $2\theta$ = 22.8°) and the BFO film (broad peak at $2\theta$ = 21.8°.

diffractometer in Bragg-Brantano geometry with a Cu source ($\lambda$ = 1.5406 Å).

Figure 1 shows the XRR of the SRO/BFO thin film. The XRR data was fitted with GenX. The fit gave an SRO thickness of 21.0 nm and a BFO thickness of 24.5 nm with an average surface roughness of 0.5 nm. The growth rates are therefore 0.30 Å/pulse for SRO at 10 Hz and 0.01 Å/pulse for BFO at 5 Hz. The GenX fitted densities for the SRO and BFO in the film are consistent with the bulk values.

Figure 2 shows the XRD of the SRO/BFO thin film. Both the (200) peaks of the STO substrate and the BFO film are present in the XRD spectrum. The film has grown epitaxially with no phases other than the perovskite crystal structure. The double peak at $2\theta$ = 22.8° is due to $Cu_{K\alpha}$ and $Cu_{K\beta}$ X-radiation. The Pendellosung fringes around the BFO (200) peak at $2\theta$ = 21.8° indicate a smooth epitaxial film.

## 4 Further Information

The Royce Deposition System is a multichamber, multitechnique thin film deposition tool based at the University of Leeds as part of the Henry Royce Institute. Materials from the Royce Deposition System are available as a facility service and for collaborations.

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