Nucleation and Growth Kinetics of Amorphous SrTiO$_3$ Studied by X-ray Diffraction

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Capabilities of Bruker D8 discover diffractometer

- Crystalline materials (metals, ceramics, rocks)
  - Phase identification
  - Lattice parameters
  - Residual strain
  - Average crystallite size of nanoparticles
  - Epitaxy/Texture/Orientation

- Amorphous materials (glass and many polymers)
Different crystalline structures observed by XRD

Crystalline microstructures of fully crystallized SrTiO$_3$ (STO) film
- On STO: Epitaxial layer
- On SiO$_2$/Si: Polycrystalline film
Use XRD to study nucleation and growth of STO

- Amorphous phase transforms into crystalline phase right after annealing

- 600 °C 16 min: nucleation completes, polycrystalline STO starts to form
Kinetics based on amorphous STO scattered x-ray intensity

- Amorphous STO scattered x-ray intensity decreases with increasing annealing time $\rightarrow$ decrease rate $\frac{dI}{dt}$

- Growth velocity:
  $$v = \frac{\frac{dI}{dt}}{I_0 - \Delta I} x_0$$

- Arrhenius temperature dependence:
  $$v(T) = v_0 e^{-E_a/k_BT}$$

Growth of STO on (001) STO

Nucleation of STO on SiO$_2$/(001) Si

$E_{\text{STO/STO}} = 0.7$ eV

$E_{\text{STO/SiO}_2} = 1.4$ eV