

Nano-Meter Thick Single Crystal Y_2O_3 Films Epitaxially Grown on Si (111) with Structures Approaching Perfection

Chun-Wen Nieh (聶君文)¹, Yi-Jiun Lee (李毅君)¹, Wei-Chin Lee (李威縉)¹,
Zhi-Kai Yang (楊智凱)², Ahmet Refik Kortan¹, Ming-Hwei Hong (洪銘輝)¹,
Ray-Nien Kwo (郭瑞年)³, and Chia-Hung Hsu (徐嘉鴻)⁴

¹Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan

²Department of Chemistry, National Taiwan University, Taipei, Taiwan

³Department of Physics, National Tsing Hua University, Hsinchu, Taiwan

⁴National Synchrotron Radiation Research Center, Hsinchu, Taiwan

Cubic phase Y_2O_3 films 1.6-10 nm thick of excellent quality have been epitaxially grown on Si (111) with $\text{Y}_2\text{O}_3(111)\parallel\text{Si}(111)$ using electron beam evaporation of Y_2O_3 in ultrahigh vacuum. Structural and morphological studies were carried out by x-ray scattering and reflectivity, and high-resolution transmission electron microscopy, with the growth being in-situ monitored by reflection high energy electron diffraction. There are two Y_2O_3 domains in the initial stage of the oxide growth with equal population, and the B-type domain of Y_2O_3 $[2-1-1] \parallel \text{Si}[11-2]$ become predominating over the A-type domain of Y_2O_3 $[2-1-1] \parallel \text{Si}[2-1-1]$ with increasing film thickness. Besides the excellent crystallinity of the films as derived from the record small ω -rocking curve width of 0.014° , our results also show atomically sharp smooth surface and interfaces.

0.014° , and 0.014° , respectively. The y-axis is in a logarithmic scale.

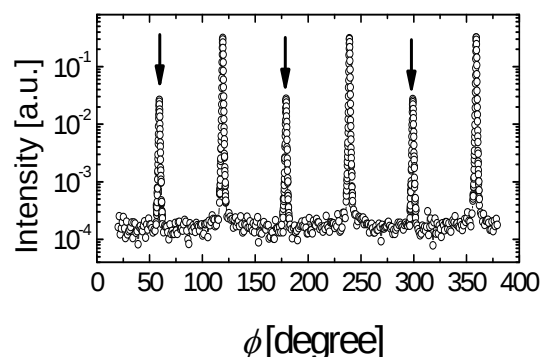


Figure 2. Phi cone scan over the family of cubic Y_2O_3 $\{400\}$ reflections to confirm a three-fold symmetry and the coexistence of A/B type (111) domains. The arrows mark the angular positions of the Si $\{400\}$ reflections, which coincide with the $\{400\}$ reflections of minor A type domain determined at 2.5 Å resolution.

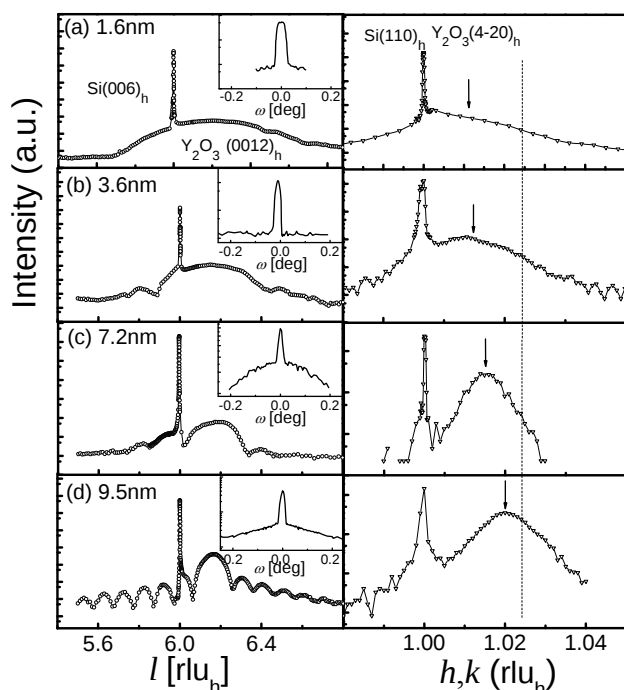


Figure 1. The radial scans along surface normal i.e. along $(001)_h$ (left panel) and lateral $(110)_h$ direction (right panel). The position of Y_2O_3 (4-20) surface reflections are marked by arrows. The ω -rocking curves (insets) of (a) 1.6, (b) 3.6, (c) 7.2, and (d) 9.5 nm thick Y_2O_3 layers on Si(111) substrate, with the FWHM values of 0.033, 0.017,

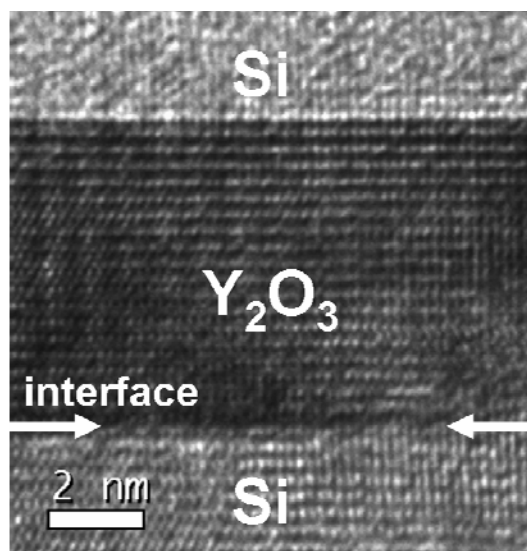


Figure 3. A cross-sectional HR-TEM image of $\text{Y}_2\text{O}_3/\text{Si}(111)$ heterostructure with film thickness of 7.2 nm in $[\]$ projection.