Synchrotron X-ray Reflectivity Studies of Deformation-Textured Nickel Surfaces Before and After Deposition of Ceramic Buffer Layers

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Introduction

Much of the present-day research on the high-critical-temperature superconductor $YBa_2Cu_3O_7$ (YBCO) is focused on the development of a biaxially textured YBCO coated conductor.[1] In this embodiment, a biaxially textured YBCO film is deposited on a templating substrate surface. One approach to creating the templating surface involves the use of a cube-textured metal or alloy covered with a suitable buffer layer that transmits the cube-texture epitaxy and, at the same time, provides a chemical diffusion barrier that prevents reaction of the YBCO phase with the underlying metal substrate. Cube-textured nickel in long-length ribbon form (produced by a deformation texturing process) is a prominent candidate for this application. The preparation of an optimized buffered substrate architecture requires attention to the details of how the buffer layer grows on the textured metal surface, with particular emphasis on epitaxy transmission and smoothness. We have begun to explore the utility of synchrotron-based x-ray reflectivity (XRR) analysis for characterization of the surface morphology and roughness of deformation-textured (DT) nickel substrates prior to and following deposition of the buffer layers. The results of one series of experiments on DT nickel foils, before and after application of two candidate buffer layers (Gd_2O_3 and Y_2O_3), are reported below.

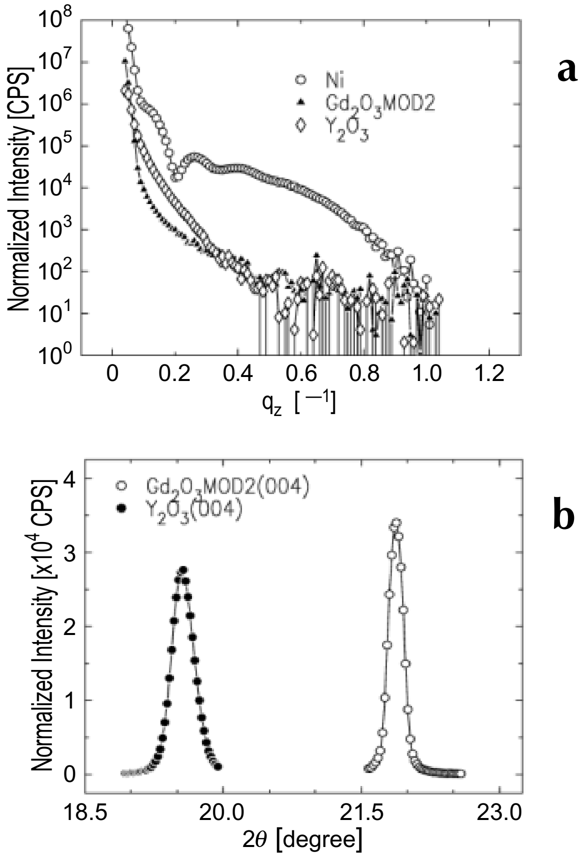

FIG. 1. (a) X-ray reflectivity scans for a bare DT nickel foil specimen, a Gd2O3 on DT nickel specimen, and a Y2O3 on DT nickel specimen. (b) Powder scans of the [004] reflections for Gd2O3 and Y2O3 films on DT nickel substrates.

Materials and Methods

The XRR data described in this report were obtained on a focused bending-magnet beamline at the Advanced Photon Source/Basic Energy Sciences Synchrotron Research Center using 12 keV (1 Å) x-rays. Foil specimens (10 mm × 10 mm) of DT nickel foil, Gd_2O_3-buffered DT nickel foil, and Y_2O_3-buffered DT nickel foil were supplied by American Superconductor.[2]

Results and Discussion

Background-corrected XRR results for the bare DT nickel foil specimen, the Gd_2O_3 on DT nickel specimen, and the Y_2O_3 on DT nickel specimen are shown in Fig. 1a. The results can be interpreted as follows. The oscillation in the reflectivity curve for the bare DT nickel surface reveals that it is covered with a ~5-nm-thick film (presumably NiO). The sharp drop-off in reflectivity

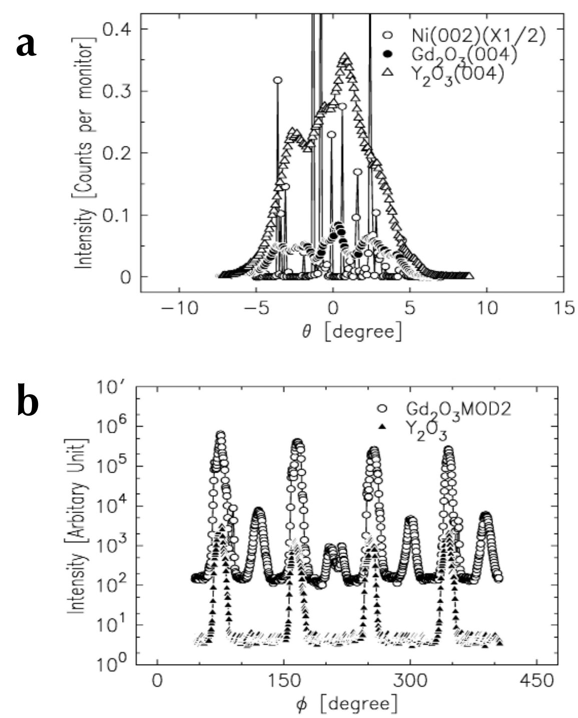

*FIG. 2. (**a**) Azimuthal scans of the [222] reflection of Gd_2O_3 and Y_2O_3 buffer layers on DT nickel substrates. (**b**) Rocking curves for the DT nickel [002], the Gd_2O_3 [004], and the Y_2O_3 [004] reflections.*

for the Gd_2O_3 and Y_2O_3 buffered samples indicates a significant increase in the surface roughness compared to that of the bare DT nickel—more so for the Gd_2O_3 than for the Y_2O_3. The thickness values for the Gd_2O_3 and Y_2O_3 layers are too large (i.e., >100 nm) to determine from the data in Fig. 1a. The powder scans of the [004] reflections for Gd_2O_3 and Y_2O_3 in Fig. 1b give evidence that the buffer layers are well ordered with domain sizes in the c-direction of 22 and 25 nm, respectively.

The [222] reflection azimuthal scans in Fig. 2a show the existence of 45º in-plane-turned domains for the Gd_2O_3/Ni specimen (representing something less than 10% of the Gd_2O_3 grains present) but no evidence of such domains for the Y_2O_3/Ni specimen. The rocking curves in Fig. 2b provide information about the quality of the mosaic distributions. In particular, the spikes in the curve for the bare DT nickel specimen indicate that the nickel [001] domains consist mostly of large grains, while the curves for the Gd_2O_3/Ni and Y_2O_3/Ni specimens give evidence of a smoother but broader mosaic distribution. Seemingly, the buffer layers exist as ordered arrays of small grains on much larger Ni [001] grains that act like pallets. The connection between the mosaic properties of the buffer layer and the surface grain architecture of the DT nickel substrate has an important bearing on the effectiveness of the buffer layer as a template for the growth of high quality, biaxially textured YBCO films.

Acknowledgments

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