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Nanoindentation study of niobium nitride thin films on niobium fabricated by reactive pulsed laser deposition

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Abstract

Nanomechanical and structural properties of NbN_x films deposited on single crystal Nb using pulsed laser deposition for different substrate temperature were previously investigated as a function of film/substrate crystal structure [Mamun et al., 2012]. In this study we focus on the effect of laser fluences and background nitrogen pressure on the nanomechanical and structural properties of NbN_x films. The crystal structure and surface morphology of the thin films were tested by X-ray diffraction, scanning electron microscopy, and atomic force microscopy. Using nanoindentation, the investigation of the nanomechanical properties revealed that the hardness of the NbN_x films was directly influenced by the laser fluence for low background nitrogen pressure, whereas the nanomechanical hardness showed no apparent correlation with laser fluence at high background nitrogen pressure. The NbN_x film hardness measured at 30% film thickness increased from 14.0±1.3 to 18.9±2.4 GPa when the laser fluence was increased from 15 to 25 J/cm^2 at 10.7 Pa N_2 pressure. X-ray diffraction showed NbN_x films with peaks that correspond to δ-NbN cubic and β-Nb_2N hexagonal phases in addition to the δ′-NbN hexagonal phase. Increasing the laser fluence resulted in NbN_x films with larger grain sizes.

Keywords: niobium nitride, surface morphology, X-ray diffraction, pulsed laser deposition, nano-indentation, and nanohardness.

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