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Low-Temperature Crystallization of Indium-Free Transparent Conductive Niobates on Glass Using Nanosheet Seed Layer

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Abstract

Indium tin oxides (ITO) is the most widely used transparent conducting oxide (TCO) in optoelectronic applications such as displays, solar cells, and sensors. However, the scarcity and high cost of indium pose significant challenges to the long-term scalability and sustainability of ITO-based technologies, driving the search for efficient indium-free alternatives.

Recently, correlated oxides such as $CaVO_3$ and $SrVO_3$ have emerged as promising TCOs, combining metallic conductivity with optical transparency properties [1]. In this context, another correlated oxide $SrNbO_3$, has attracted attention as a potential indium-free transparent conductor, offering excellent performance not only in the visible region but also in the ultraviolet (UV) range [2]. However, the technological potential of these materials is constrained by the critical requirement for the film to adopt a perovskite crystal structure. This crystallized phase is essential for optimal performance but is challenging to achieve when directly grown on conventional substrates used in optoelectronic applications. These substrates often fail to provide the necessary epitaxial conditions for the proper formation of the perovskite phase, limiting the material's functionality and integration potential.

This study addresses this limitation by demonstrating the crystalline growth of niobate TCOs on glass substrates at temperatures below 600°C using pulsed laser deposition (PLD). This is achieved through the use of 2D nanosheets [3] with varying compositions and crystallographic orientations which act as transparent seed layers to promote textured perovskite growth. The resulting niobate TCO films are compared to those deposited on single crystals of $SrTiO_3$ (STO) and $(LaAlO_3)_3(Sr2AlTaO_6)_7$ (LSAT), showing similar performance and structural quality, even at reduced deposition temperatures.

[1] L. Zhang, Y. Zhou, L. Guo, W. Zhao, A. Barnes, H.-T. Zhang, C. Eaton, Y. Zheng, M. Brahlek, H. F. Haneef, N. J. Podraza, M. H. W. Chan, V. Gopalan, K. M. Rabe, R. Engel-Herbert, Nature Mater. 2015, 14, 204.

[2] Y. Park, J. Roth, D. Oka, Y. Hirose, T. Hasegawa, A. Paul, A. Pogrebnyakov, V. Gopalan, T. Birol, R. Engel-Herbert, Commun. Phys. 2020, 3, 102.

[3] A. Boileau, S. Hurand, F. Baudouin, U. Lüders, M. Dallocchio, B. Bérini, A. Cheikh, A. David, F. Paumier, T. Girardeau, P. Marie, C. Labbé, J. Cardin, D. Aureau, M. Frégnaux, M. Guilloux-Viry, W. Prellier, Y. Dumont, V. Demange, A. Fouchet, Adv. Mater. 2022, 32, 2108047.

Annexes

Low-Temperature Crystallization of Indium-Free Transparent Conductive Niobates on Glass Using Nanosheet Seed Layer

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Figure 1: Abstract
Figure 2