Pulsed laser deposition of thin films

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Abstract

Statement of the subject: Laser radiation is a powerful tool that is widely used in the dynamically developing world of modern technologies and new materials. The areas of laser application in electronics, biophysics, optoelectronics, lithography, power engineering, and other areas of life and industry are intensively studied. The multifaceted and constantly growing application of laser technology is determined by the characteristics of laser radiation, and the success of processing is determined by the interaction of laser light photons with the processed materials. The PLD technique allows for the creation of thin layers of various materials. In the present work, research focused on the growth mechanism, shaping microstructural changes, chemical and phase composition, and properties of thin nanometric films obtained by laser ablation from β-Al-Mg and δ-Bi_2O_3 targets.

The β-Al-Mg phase belongs to complex metallic alloys, therefore, it is a promising material for hydrogen storage [1]. However, Bi_2O_3 plays an important role in the semiconductor group, especially its high-temperature δ phase [2-5]. Current research aims to obtain it at room temperature by doping δ-Bi_2O_3 with yttrium, molybdenum, niobium, or erbium and deposition on a substrate of a specific orientation.

A Q-switched Nd:YAG laser with pulsed operation was used to deposit the thin films. The influence of changes in fluence (laser energy density), homologous temperature, and photon energy on the microstructure, surface topography, chemical and phase composition, and properties of the films was determined.

Conclusion & Significance: Our research findings indicate that a reduction in the homologous temperature of the substrate (Th<0.44) leads to the formation of Al-Mg thin films with an amorphous crystal structure, while an increase in the homologous temperature and the density of the laser radiation energy contribute to the formation of layers with a nanocrystalline structure.

Doping thin films of δ-Bi_2O_3 led to improved electrical conductivity at low temperature compared to undoped material (Bi_2O_3).

Image

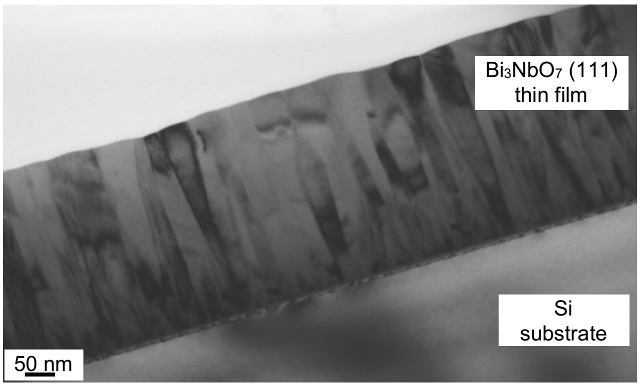

Figure 1: TEM image of a Bi_3NdO_7 thin film deposited on a Si substrate using the pulsed laser deposition technique (λ=266nm, ρ=3.5J/cm$_2$, T_p=400°C).

Recent Publications

1. LeeJS, KimJH, KimSS (2015) Evolution of grains to relieve additional compressive stress developed in Al-Mg alloy films during thermal annealing. Thin Solid Films 595: 148-152.
2. Akazawa H (2023) Selective formation of crystal polymorphs in Er3+-doped Bi_2O_3 thin films and their photoluminescence properties. Ceramics International 49: 9069-9089.
3. GbashiKR, MajimAA, MuhiMA, SalihAT (2019) Structural, morphological, and optical properties of nanocrystalline $(Bi_2O_3)_{1-x}(TiO_2)_x$ thin films for transparent electronics. Plasmonics 14: 623-630.
4. GbashiKR, SalihAT, NajimAA, MuhiAH (2020) Nanostructure characteristics of Bi_2O_3:Al_2O_3 thin films and the annealing temperature effect on morphological, optical, and mechanical properties. Superlattices and Microstructures 146: 106656.
5. Guo L, Shuai L, Yuanyuan L, Jing Z, Zhaochi F, Can L (2016) Controllable synthesis of α-Bi_2O_3 and γ-Bi_2O_3 with high photocatalytic activity by α-Bi_2O_3→γ-Bi_2O_3→α-Bi_2O_3 transformation in a facile precipitation method. Journal of Alloys and Compounds 689: 787-799.

Photograph

Biography

Assoc. Prof. Agnieszka Radziszewska, Ph.D., D.Sc. specialises in materials engineering, mainly surface engineering, and she is focused on materials for energy, medicine, nanomaterials, magnetic materials, their structure, and properties, as well as laser treatments, X-ray microanalysis, and electron microscopy.

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