Effect of Irradiation on the Morphological and Optical Properties of Zinc Oxide Thin Films

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Zinc oxide (ZnO) thin films have attracted significant attention due to their exceptional optical, electronic, and chemical properties, which make them highly suitable for applications in sensors, optoelectronics, photocatalysis, and protective coatings. Understanding how external factors such as irradiation influence their surface and structural characteristics is essential for advancing the design and optimization of ZnO-based devices.

In this study, we investigate the effects of irradiation on the morphological and optical properties of ZnO thin films. The analysis is based on a comparative study of irradiated and non-irradiated samples, using image analysis and statistical evaluation of surface parameters. Quantitative data derived from particle size distributions show a reduction in the average and maximum particle radii after irradiation, indicating the disintegration of larger aggregates and a transition toward a finer, more homogeneous surface morphology. Histogram analysis of surface images reveals a noticeable increase in surface brightness following irradiation, accompanied by a slight rise in overall contrast. These changes suggest modifications in optical reflectance and an improvement in surface uniformity, which are likely associated with alterations in the microstructure and defect states induced by irradiation.

The observed modifications have important implications for the practical use of ZnO thin films in technologies where surface activity, optical properties, and nanoscale uniformity are critical. In particular, the ability to tune particle size and surface characteristics via controlled irradiation offers a promising approach for improving the performance of ZnO-based sensors, UV detectors, and catalytic coatings. This study contributes to a deeper understanding of the interaction between irradiation and semiconductor thin films and provides valuable insights into the development of advanced material systems for a wide range of scientific and industrial applications.

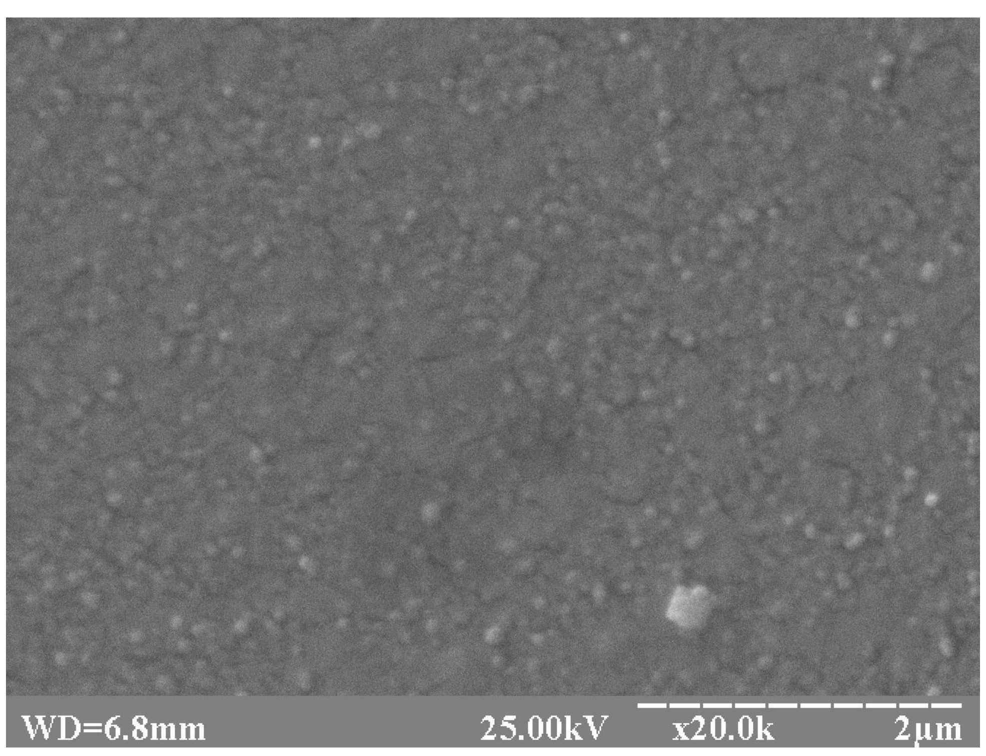

Figure 1. Sample A - regular ZnO

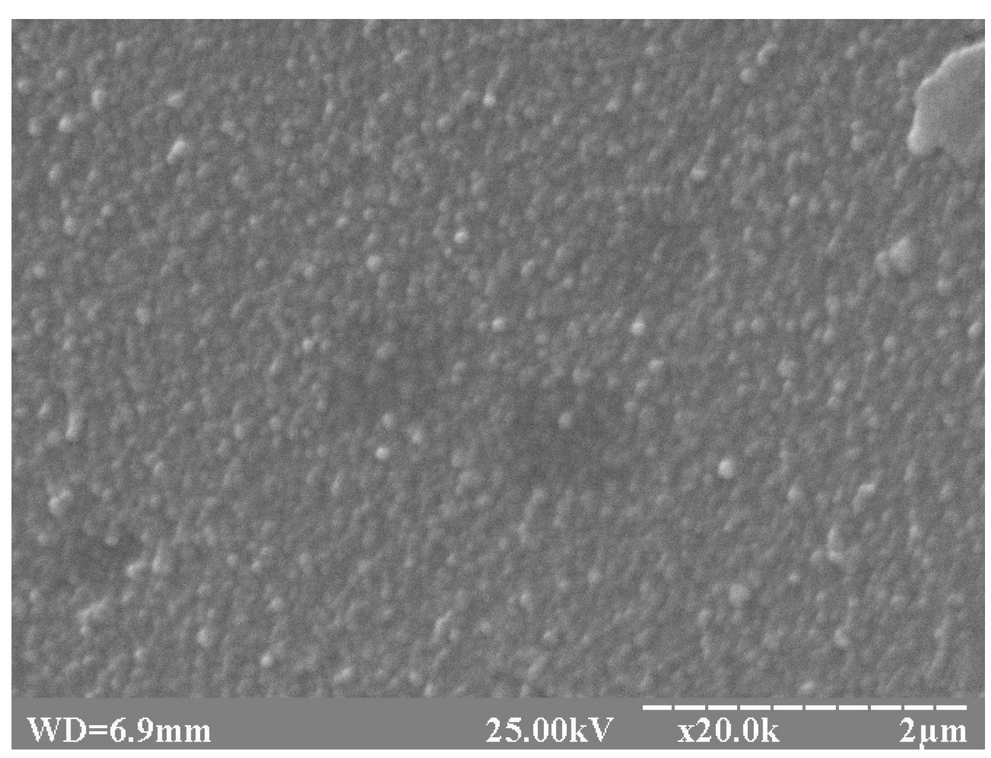

Figure 2. Sample B - ZnO irradiated with UV laser

Summary

This study explores the effects of UV laser irradiation, below the melting threshold of ZnO, on its structural, morphological, and photoelectric properties. The grain sizes of both the original and irradiated films were assessed, with the distribution of these sizes found to follow a Gaussian profile. The results indicate that UV irradiation causes fragmentation of the grains in the films, leading to a decrease in their average size. This grain fragmentation is linked to changes in the material’s photoelectric properties. Specifically, the irradiated films exhibited a noticeable signal delay in their photoelectric characteristics, suggesting a modification in charge transport or recombination processes. The study highlights the potential of laser irradiation as a tool for tuning the properties of ZnO thin films, which could be beneficial for various applications in optoelectronics and photovoltaic devices. Further analysis of the mechanisms behind these changes could provide deeper insights into the interaction between laser irradiation and the electronic properties of ZnO materials.