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Al-doped ZnO: RF- or DC-sputtering?

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Abstract

The electrical properties of ZnO:Al thin films grown by sputtering often depend on deposition pressure and position on the substrate. For RF sputtering, we recently showed that the electrical properties are, at a more general level, quantitatively correlated to changes in compressive stress in the films and partially to gradients in oxygen content [1]. Grain size, texture, and Al content were also observed to be generally dependent on compressive stress.

In this work, we add newly characterized properties and new data from DC-sputtered ZnO:Al films to the picture. This allows a parallel comparison of the trends in the ZnO:Al film properties with the two different sputtering methods. In particular, we see that both compressive stress (determined by x-ray diffraction peak position) and microscopic strain (determined by detailed analysis of x-ray diffraction peak broadening) are in general larger in DC-sputtered films than in RF-sputtered films, but their spatial distributions are similar. On the other hand, a number of film properties (including grain size and texture coefficient) do not follow the same spatial distributions in RF- and DC sputtering. A particularly interesting effect is that the depth-resolved distribution of the dopant (aluminum) changes significantly depending on deposition conditions. Even though inhomogeneity in aluminum content through the depth of ZnO:Al films has been investigated before [2], it has not been related systematically to the deposition conditions, nor to the resulting electrical properties.

By highlighting the changes in film properties and by reviewing the expected differences in ion bombardment effects between RF- and DC-sputtering, we propose slightly different physical mechanisms at the origin of inhomogeneity in the electrical properties of ZnO:Al deposited with the two sputtering methods.

[1] A. Crovetto *et al.*, *J. Phys. D: Appl. Phys.* **49**, 295101 (2016).

[2] Bikowski *et al.*, *APL Mater.* **3B** 060701 (2015).