

Supplementary information

Gallium-Modified Zinc Oxide Thin Films Prepared by Chemical Solution Deposition

Izabela Stojanoska, Brigita Kmet, Hana Uršič, Danjela Kuscer

1. Surface roughness of GZO thin films

The RMS surface roughness of GZO_O, GZO-A and GZO_H is 1.708 nm, 1.759 nm and 2.062nm measured at 20 μm x 20 μm region (Figure S1).

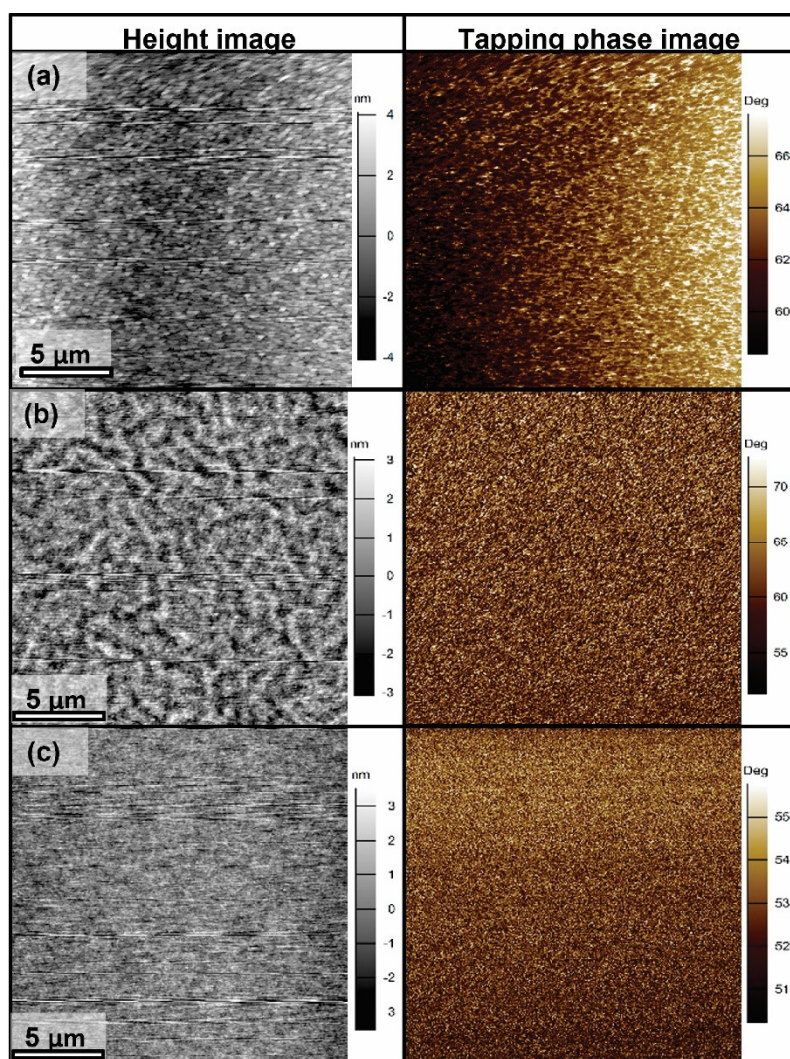


Figure S1: AFM topography images; (left)-height image, (right)-tapping phase image of a) GZO_O, b) GZO_A, c) GZO_H.

2. X-ray photoelectron spectroscopy analysis of GZO thin film annealed in hydrogen

The X-ray photoelectron spectroscopy (XPS) analyses were carried out on the PHI-TFA XPS spectrometer produced by Physical Electronics Inc equipped with Al-monochromatic source. The analyzed area was 0.4 mm in diameter. The analyzed depth during XPS analyses is about 3-5 nm. The high-energy resolution spectra were acquired with analyzer operating at resolution of 0.6 eV and pass energy of 29 eV. The accuracy of binding energies was about ± 0.3 eV.

The XPS survey spectrum of the surface of the GZO thin film is shown in Figure S2. In the survey spectrum we clearly identify the peaks that correspond to zinc (Zn 2p, Zn LMM, Zn 3p, Zn 2s, Zn 3d), oxygen (O 1s), carbon (C 1s) and gallium (Ga 2p_{3/2}, Ga 2p_{1/2}, and Ga LMM). The Ga 2p_{3/2} and Ga 2p_{1/2} peaks at 1118 eV and 1145 eV have low intensity. From the intensity of the XPS peak Ga 2p_{3/2} we calculated the concentration of Ga in the surface layer to be (1.5 ± 0.5) at.%. In order to undoubtedly confirm the presence of Ga in the thin film, we performed a high-energy resolution XPS analysis of Ga 2p spectrum. In the high-energy resolution XPS spectra of GZO thin film, collected in the binding energy range 1110-1155 eV (Figure S3), one can identify the two peaks. The peak at 1118 eV is characteristic for Ga 2p_{3/2} and the peak at 1145 eV is characteristic for Ga 2p_{1/2}. Binding energies of both peaks indicate the Ga-oxide chemical bonding.

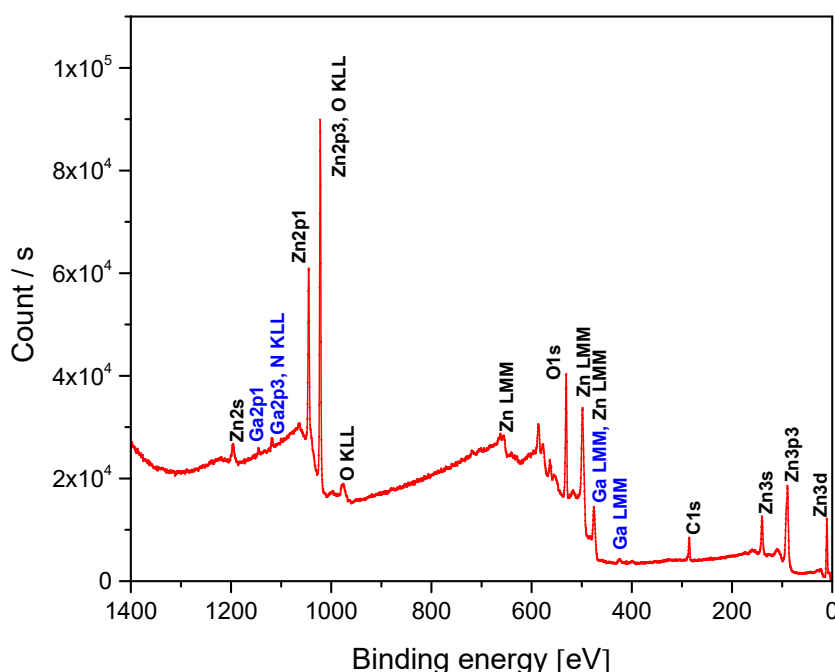


Figure S2: XPS survey spectrum of the surface of the GZO thin film, annealed in Ar/H₂.

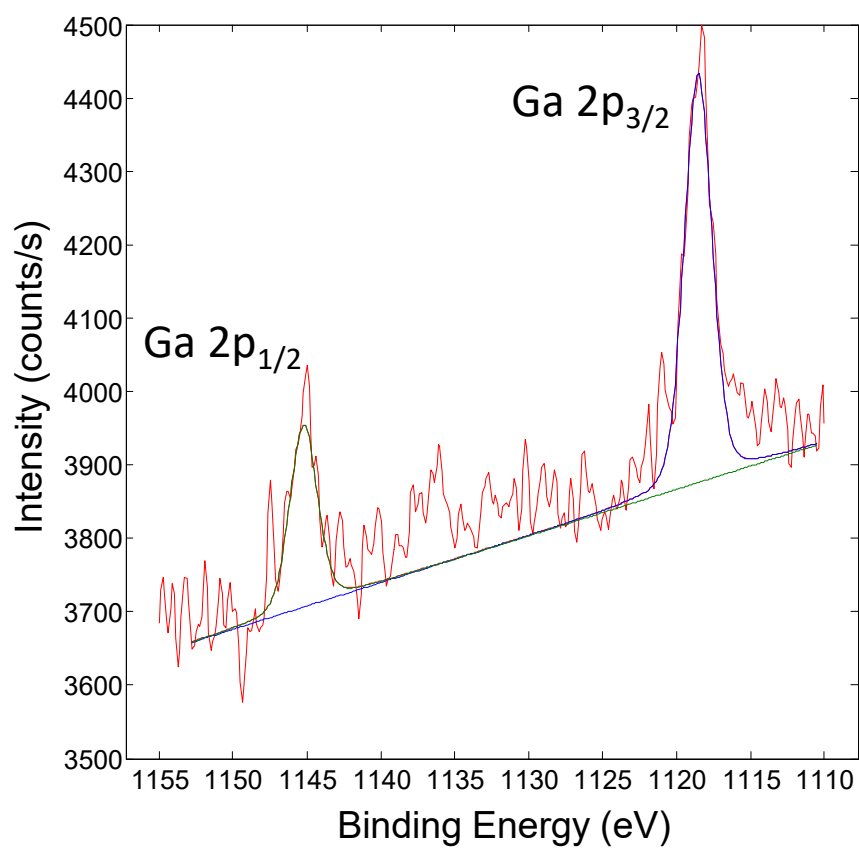


Figure S3: High-energy resolution XPS spectrum Ga 2p of the surface of the GZO thin film, annealed in Ar/H₂.