Photochemical Metallic Conduction Channel Creation in InGaZnO by H Radical Doping

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Abstract

The photochemical tunability of charge transport mechanism in metal-oxide semiconductors is of great interest since it may offer a facile but effective semiconductor-to-metal transition, which results from photochemically modified electronic structure for various oxide-based device applications.[1,2] This might provide a feasible hydrogen (H)-radical doping to realize the effectively H-doped metal oxides [3], which has not been achieved by thermal and ion-implantation technique in a reliable and controllable way.[4] In this study, we report a photochemical conversion of InGaZnO (IGZO) semiconductor to a transparent conductor via hydrogen doping to the local nanocrystallites formed at the IGZO/glass interface at room temperature (RT). In contrast to thermal or ionic hydrogen doping, ultraviolet exposure of the a-IGZO surface promotes a photochemical reaction with H radical incorporation to surface metal–OH layer formation and bulk H-doping which acts as a tunable and stable highly doped n-type doping channel and turns a-IGZO to a transparent conductor. This results in the total conversion of carrier conduction property to the level of metallic conduction with sheet resistance of ~16 Ω/□, RT hall mobility of 11.8 $cm^2V^{-1}sec^{-1}$, the carrier concentration at ~10^{20} cm^{-3} without any loss of optical transparency. We demonstrated successful applications of photochemically highly n-doped metal oxide via optical dose control to transparent conductor with excellent chemical and optical doping-effect stability.

References

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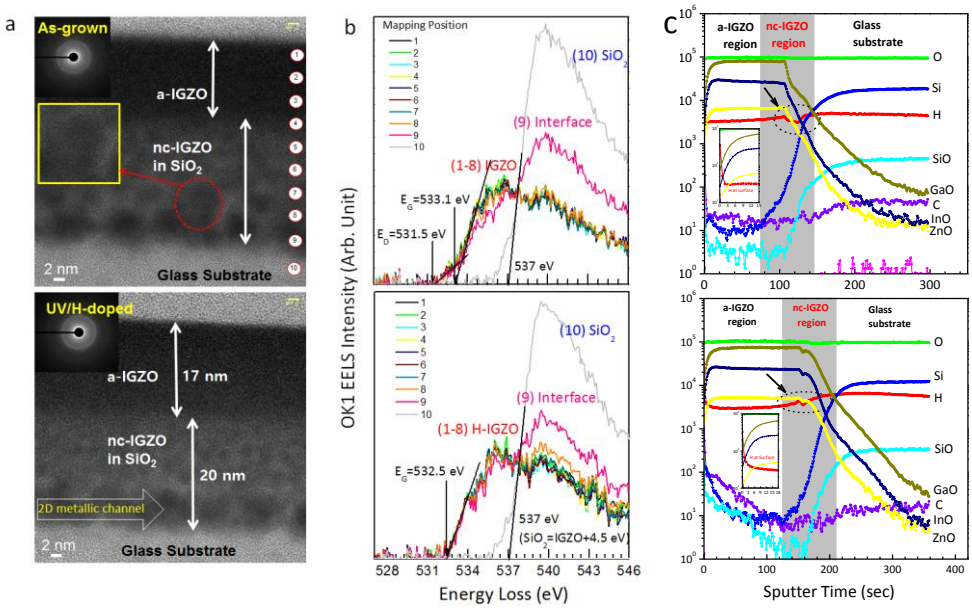
Figures



Morphology of IGZO film the modified electronic structure for H-doped local nanocrystallites by doping activation. (a) Cross-sectional HR-TEM images, (b) OK1 edge STEM-EELS spectra, (c) TOF-SIMS depth profile of (top) the as-deposited and (bottom) UV-exposed IGZO films on the glass substrate.