Effective and Stable H doping in ZnO by Photochemical Radical Insertion

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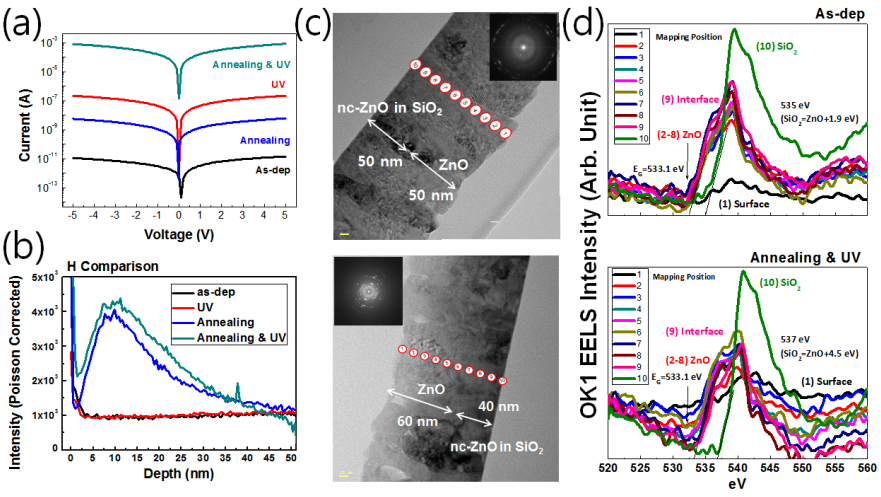
Abstract

Among many metal oxides, ZnO has various advantages such as low manufacturing cost, relatively stable surfaces, and great tunability of surface conductivity by post anneal process. Furthermore, the highly conductive ZnO can be applied to the transparent electrode in the visible light region due to its ultraviolet range band gap. Absorption or emission of light in the wide photon range from the blue region to the ultraviolet region of ZnO are possible is ideal for a broad light-emitting diodes, optical filters, optical detectors, and solar cells. In spite of these merits of ZnO, the application of ZnO as the transparent electrode still requires improved electrical conductivity without transparency degradation.
In this study, ZnO surface electronic structure was modified by annealing in vacuum and exposing to UV light which improves the surface conductivity of ZnO. From experimental results, we confirmed that the annealed ZnO thin film is polycrystalline. The exposure of UV light to ZnO in air led to the surface OH bond formation by photochemical H incorporation by the adsorbed water dissociation and forming O-vacancy sites in ZnO. This is believed to act as strong n-type donor providing excess conduction electrons in ZnO surface and bulk. The modified electronic structure of UV-exposed ZnO did not affect the visible light absorption and transparency. Regardless of the initial resistivity of ZnO samples prepared by varying RF sputtering conditions, the electrical conductivity was improved by up to x1000. As a consequence, it was found that, the H doping is more effective for the annealed samples compared to un-annealed one. The preliminary physical mechanism is also suggested to explain the origin of photochemical tunability of ZnO by UV photochemistry.

References

1) C. G. Van de Walle, Physical Review Letters, **85**, 1012 (2000)
2) Anderson Janotti and Chris G. Van De Walle, Nature Materials, **6**, 44 (2007).

Figures



Analysis of Hydrogen doped ZnO by the UV treatment (a) I-V spectroscopy graph, (b) TOF-SIMS depth profile of ZnO film samples on the SiO_2 substrate, (c) Cross-sectional HR-TEM images, (d) OK1 edge STEM-EELS spectra.