AMTC Letters
Vol. 2 (2010)

Electrolytic synthesis of Al-doped ZnO powders with low electrical resistivity

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The electrical resistivity of ZnO can be decreased by doping trivalent atoms such as Al, In and Ga, whereas increased by doping monovalent atoms such as Li and K [1]. Among those dopants, doping of Al has been very popular because it produces highly conductive ZnO with high transparency in the visible spectral region due to the close covalent bond length of Al–O (0.192 nm) to that of Zn–O (0.197 nm) [2]. In the present work, we report physical properties and characterization of Al-doped ZnO nanopowders prepared by electrolytic synthesis.

Al-doped ZnO nanopowders with different Al content were prepared by electrolytic method, then its electrical resistivities were measured by a cell method which reached its minimum (28 Ω·cm) at 0.93 at% of Al. Microstructures of powders were characterized by X-ray diffraction pattern and transmission electron microscopy (TEM), which showed that the grain size decreased with increase of Al content. In addition, the distributions of Al were characterized by scanning-TEM with energy dispersive X-ray spectroscopy (STEM-EDS).

FIG 1(a) to (c) show characteristic BF-TEM images showing homogeneous but agglomerated particles of undoped, 0.93 at% Al-doped and 2.94 at% Al-doped ZnO nanopowders, respectively. These TEM images revealed that the presence of nanoparticles with average diameter ~ 20 nm. FIG 1(d) to (f) and (g) to (i) show BF-STEM images and elemental maps by STEM-EDS from similar region of the same set as (a) to (c), respectively.

Although, substitution of Al for Zn in ZnO is difficult due to the difference in oxidation state, in ionic radius and in coordination preference, elemental mapping carried out by STEM-EDS showed that the even distribution of Al atoms, which strongly suggests the solidly-solutioned Al atoms into ZnO lattice. Further characterization by high-resolution STEM images, the substitutional incorporation of Al atom (Al^{3+} ion) into the ZnO lattice (Zn^{2+} ion) was clearly indicative of.

References

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[3] This research was supported by JSPS (Japan).

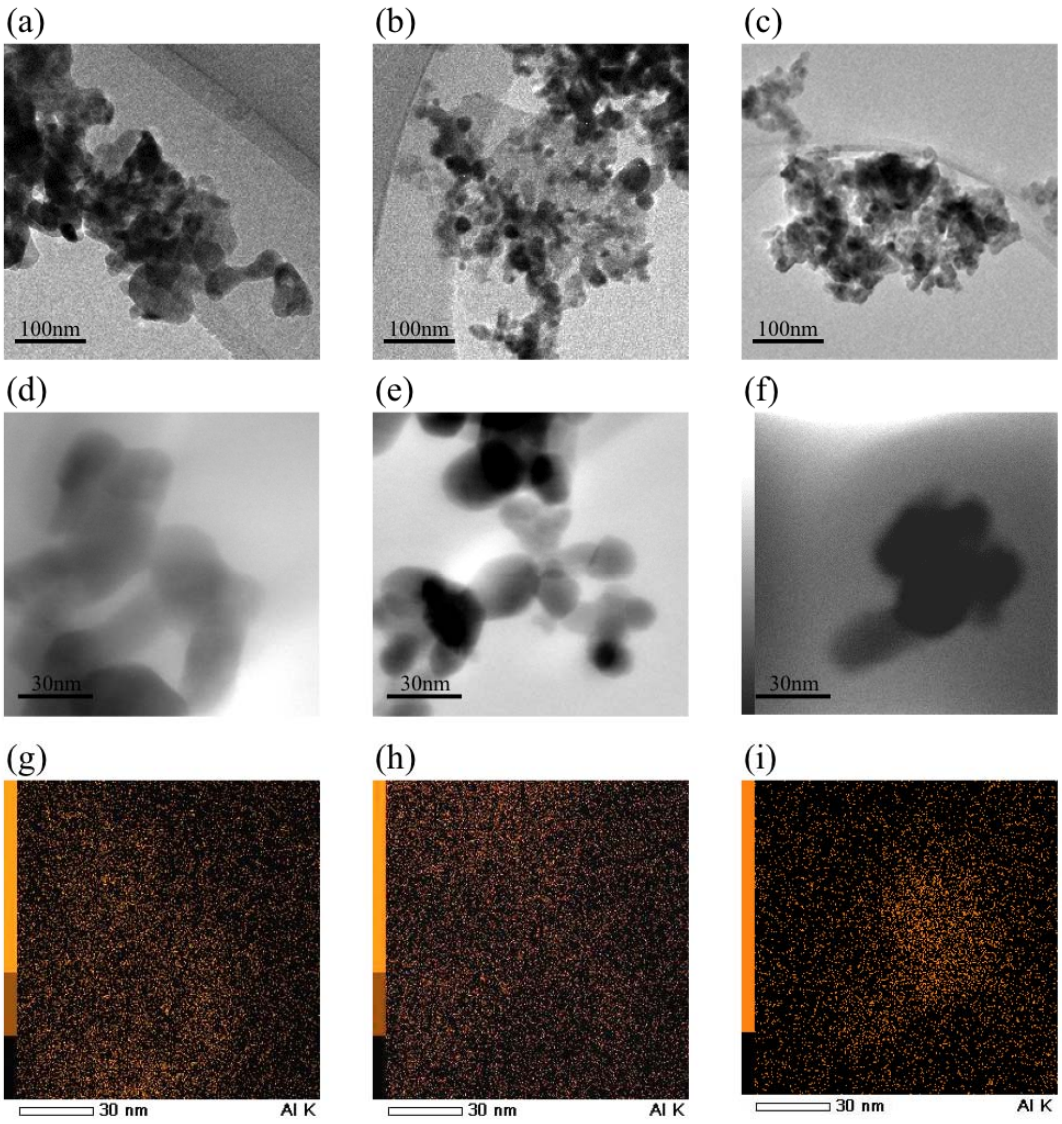

FIG. 1. (a) to (c) show characteristic BF-TEM images of undoped, 0.93 at% Al-doped and 2.94 at% Al-doped ZnO nanopowders, respectively. (d) to (f) and (g) to (i) show BF-STEM images and elemental maps by STEM-EDS from similar region of the same set as (a) to (c), respectively.