Preparation of ZnO and Cu_2O Semiconductor Thin Films by Soft Solution Process and Their Application to Optoelectronics

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The n-type ZnO semiconductor is industrially important optoelectronics material owing to its optical and electrical characteristics. At present, the ZnO film is mainly produced by the dry process such as chemical vapor deposition (CVD) and molecular beam epitaxy (MBE). Recently, soft solution process using an aqueous solution is remarkably noticed as the semiconducting thin films can be produced economically at low temperatures under the normal pressure.

In this paper, the factors influencing on crystal structure, surface morphology and orientation of ZnO film deposited from zinc nitrate solution by the cathodic electrolysis was examined in the view point of thermodynamics and kinetics, and the deposition mechanism of ZnO film was clarified. The resulting ZnO film showed the photoconductive effect under the ultraviolet radiation with larger energy than band gap (3.3 eV), and it was disclosed that Schottky type solar cell could be constructed by laminating a Au thin film.

A new process employing a zinc nitrate solution containing dimethylamine borane (DMAB) as a reducing agent was developed so as to deposit the ZnO film of high transparency directly on non-conducting substrate. Lattice constants and electric conductivity increased with increasing the B content of chemically deposited ZnO film up to 0.02 wt%. In order to further improve the electric conductivity, ZnO film was deposited on a resin substrate by the two-step laminating method in which chemical and electrochemical depositions were combined. As the result, the B content of ZnO film increased up to 0.60 wt%, which gave rise to increase in carrier density, and then the specific resistance of the film was reduced to 10^{-2} Ω cm.

In order to construct the heterojunction solar cell, p-type semiconductor Cu_2O with low toxicity was cathodically electrodeposited on the ZnO film from an alkaline copper sulfate solution containing malic acid as a complexing agent. Performance of solar cell with a construction of p-Cu_2O/n-ZnO/NESA, which was fabricated by two-step electrodeposition, was evaluated by solar simulator. It was figured out that the characteristics of the heterojunction cell was superior to that of Schottky type solar cell.