ELECTRODEPOSITION OF Bi_2Te_3 THIN FILMS

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1. Introduction

Bismuth telluride compound semiconductors have attracted considerable interest for thermoelectric (TE) materials. These were widely produced as bulk materials by pyroprocesses. However, fabrication of thin films was recently required for miniaturization of electronic devices and can be also produced by electrodeposition from aqueous solutions in wet process.

In this study, we have investigated the effects of the electrodeposition conditions such as applied potential and the composition of solution on thermoelectric properties, morphology and composition of the films consisting of bismuth and tellurium, and examined pertinent thickness of the films and the deposition current efficiency.

2. Experimental

Bismuth telluride films have been electrochemically deposited from acid solution containing Bi(III), Te(IV) with argon gas bubbling to deaerate. The cell was composed of a Pt coil counter electrode, Ag/AgCl (sat. KCl) reference electrode and Ni sheet working electrode. Thickness, current efficiency, morphology and composition of the films were analyzed by XRD, XPS, SEM observation and ICP.

The electrodeposition process was clarified by using the cathodic polarization curve and mass change by electrochemical quartz crystal microbalance, EQCM, technique. Thermoelectric property is evaluated as power factor ($=\sigma\alpha^2$). And electric conductivity(σ) is measured by 4 probes method and seebeck coefficient(α) is measured by handmade equipment using the seebeck effect.

3. Result and conclusions

The film of single phase of Bi_2Te_3 with gray color and luster surface was obtained from 0 V to 70 mV and single phase Te co-deposited at less than 0 V in the solution containing 2 mM $Bi_2(SO_4)_3$ and 2.8 mM K_2TeO_3 at 293 K, pH 0.5 as shown in Fig. 1. The current efficiency was more than 80% at the potential deposited single phase Bi_2Te_3. In this study, the surface morphology of single phase Bi_2Te_3 was the needle shape and a variant by the deposition of single phase of Te as shown in Fig.2. Deposits became the dendrite and the current efficiency decreased at the potential less than -150 mV.

It was found that the compositions of films were greatly more dependent on the mole ratio, $[Bi^{3+}] / [HTeO_2^+]$, in the solution than the deposition potential. The films deposited at 0V had a compact surface and the highest electric conductivity (σ). Seebeck coefficient (α) was high at the potentials of single phase Bi_2Te_3 and has the C axis orientation on the films.

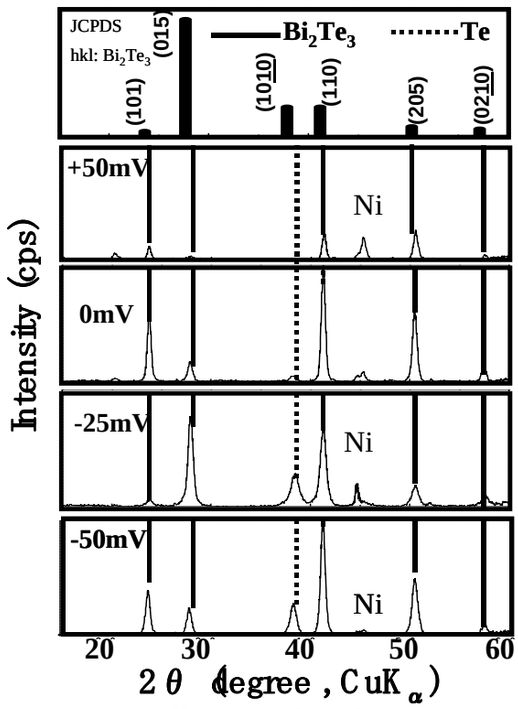

Fig. 1. X-ray diffraction profiles of representative electrodeposition potentials

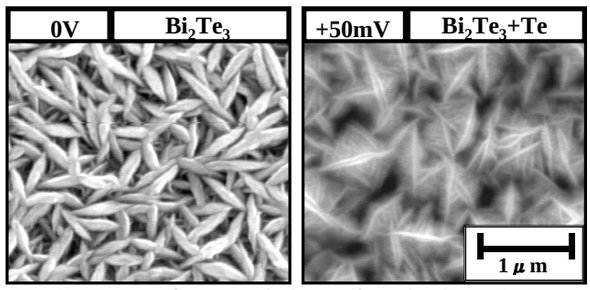

Fig. 2. SEM surface morphology of single phase Bi_2Te_3 and mixed Bi_2Te_3, Te