Fabrications and electrical properties of Co doped Bi_2Te_3 thin films deposited by direct current magnetron sputtering

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Abstract

Bismuth telluride is a thermoelectric material at room temperature, and its electrical properties have an important influence on the thermoelectric conversion efficiency. In this study, a DC magnetron sputtering system was used to sputter the bismuth telluride thin film by co-sputtering and introducing cobalt to try to improve its thermoelectric properties. By adjusting the sputtering power of the cobalt target and fixing the bismuth target and the tellurium target Sputtering power to control the amount of doping.

Watch

Internet of things

Thermoelectric application

Process

sputter | α-step | EPMA | Hall effect | XRD | FE-SEM | Thermoelectric properties

Deposition film → Thickness test → Material components → Electrical properties → Phase structure → Surface topography → Thermoelectric properties

Result and discussion

EPMA

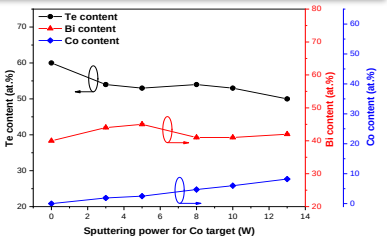


Fig.1 Variation of element composition with Co sputtering power

XRD

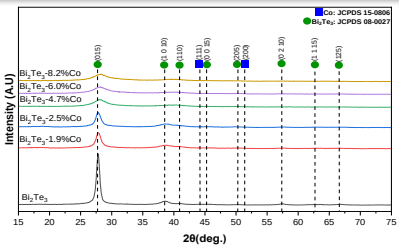


Fig.2 X-ray diffraction patterns of different Co content

Hall effect

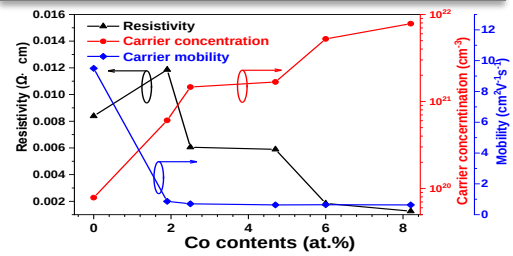
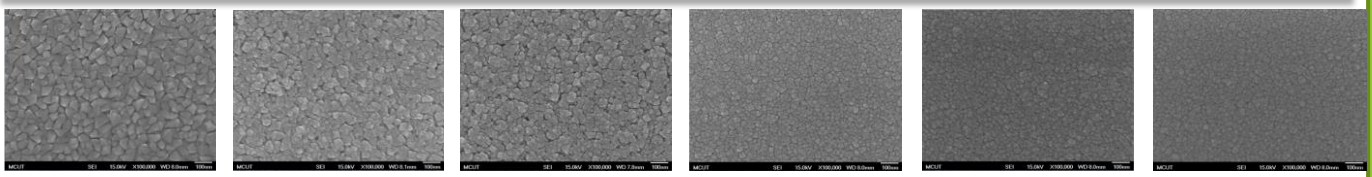


Fig.3 Variation of electrical properties with Co content

FE-SEM



Co:0% Co:1.9% Co:2.5% Co:4.7% Co:6.0% Co:8.2%

Fig.4 Graph of different Co contents on FE-SEM surface topography images

Average grain size

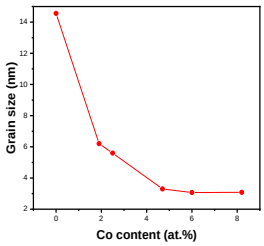


Fig.5 The effect of Co content on grain size

Thermoelectric properties

Tab.1 Comparison of resistivity, seebeck coefficient and power factor with different Co content

T=300K	Seebeck (uV/K)	Resistivity (Ω-cm)	Power factor (uW/m-K²)
Co:0 at.%	-80	3.1×10^{-3}	205
Co:2.5 at.%	-70	1.9×10^{-3}	260
Co:8.2 at.%	-45	1.0×10^{-3}	225

Tab.2 Comparison of different reference

Reference	material	Seebeck (uV/K)	Resistivity (Ω-cm)	power factor (uW/m-K²)
This work	Co doped Bi_2Te_3	-70	1.9×10^{-3}	260
[8]	Ni doped Bi_2Se_3	-165	2.6×10^{-2}	104
[9]	Bi_2Te_3	-32	7.7×10^{-4}	133
[10]	Bi_2Te_3	-32	7.1×10^{-4}	144

Conclusion

1.Co element will contribute large amount of point defect, that can provide free electron and help to reduce resistivity.

2. When the Co element was introduced into Bi_2Te_3 film, no Co phase was form, But we found Co doping will refine the crystal grains, cause more interfaces in the film, and make carriers and phonons more likely to be scatter during the transport process, thus improving the thermoelectric properties.

3. We found the highest power factor 260 uW/m-K² at 2.5 at.% Co.