Thermoelectric Generation under Uniform Temperature Environment induced by Metamaterial Thermoelectric Device

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Thermoelectric conversion is a technology based on direct conversion of heat energy into electricity; it is expected to be a promising tool for recovering waste heat for energy saving and more efficient fuel usage [1]. Since a thermal gradient across a thermoelectric device induces a potential difference between the hot and cold sides of the device, technology that increases the thermal gradients is the key for efficient power generation. Several attempts have been made to expand the thermal gradient across thermoelectric devices. Nevertheless, power generation efficiencies of bismuth telluride (Bi_2Te_3) thermoelectric devices remain at ~10%, indicating that further improvements in power generation efficiency are required. Hence, development of novel thermoelectric materials and concepts for enlarging the thermal gradient are necessary for promoting practical applications of thermoelectric devices.

To increase the thermal gradient across a thermoelectric device, we utilized the localized surface plasmon resonance as the local heat source [2, 3], and proposed the attachment of a metamaterial perfect absorber (MPA) on the surface of a Bi_2Te_3 thermoelectric device to realize a thermoelectric device than can generate electricity under homogeneous temperature environment [4].

In this report, we demonstrated a metamateria-Bi_2Te_3 thermoelectric genearation that is able to enlarge thermal gradient across a thermoelectric device under uniform temperature environment. We observed an enhancement in output voltages induced by MPA thermal radiation absorption.

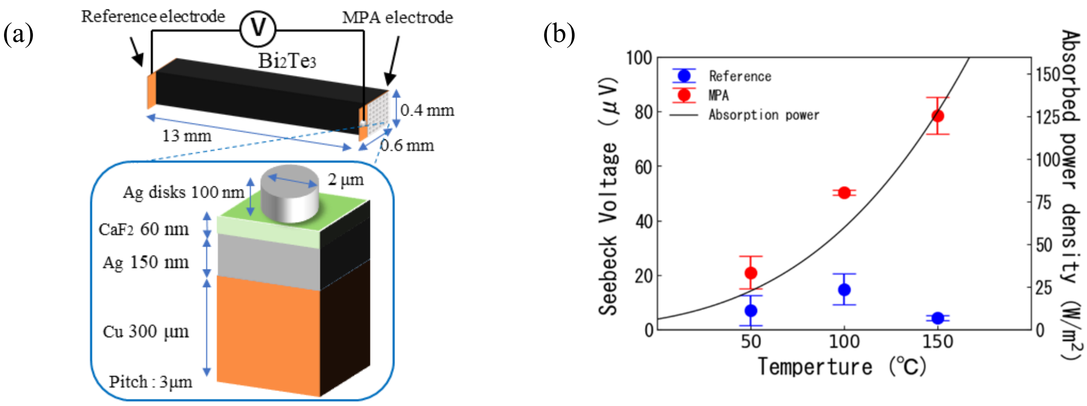

Fig. 1(a) Schematic of a Bi_2Te_3 thermoelectric device loaded with the MPA-fabricated electrode and an enlarged image of the MPA structure, (b) Comparison of Seebeck voltages generated on the device (red plot) and a reference device (blue plot), and the power density absorbed by MPA (black line).

References
[1] R. Fitriani, B. D. Ovik, M. Long, et al., Renew. Sust. Energ. Rev. 64, 635 (2016).
[2] W. Kubo, M. Kondo, and K. Miwa, J. Phys. Chem. C 123, 21670 (2019).
[3] K. Miwa, H. Ebihara, X. Fang, and W. Kubo, Appli. Sci. 10, 2681 (2020).
[4] S. Katsumata, T. Tanaka, and W. Kubo, Opt. Express 29, 16396 (2021).