REFLECTIONLESS METAMATERIALS WITH HIGH REFRACTIVE INDICES FOR MANIPULATION OF THERMAL RADIATION

T. Suzuki[1,2,*], H. Asada[1], K. Watai[1], H. Nakao[1], K. Endo[1]

[1]Tokyo University of Agriculture and Technology, 2-24-16 Naka-cho, Koganei-shi, Japan
[2]Japan Science and Technology Agency, PRESTO, 4-1-8 Hon-cho, Kawaguchi-shi, Japan

Understanding details of the directivity control of thermal radiation [1,2] is of scientific interest and also opens the doors to thermal management of path-breaking applications. However, it has remained unclear whether thermal radiation once emitted from heat sources can be manipulated because the electromagnetic waves involved are incoherent, quasi-isotropic, and unpolarized. Here, we present a concept for reflectionless metamaterials with high refractive indices in the infrared region in a quest for directivity control. Figure 1 and Table 1 show such a metamaterial consisting of symmetrically aligned paired cut wires on both the front and back of a substrate. For the initial verification, the structure of the cut wires depends on providing a polarized direction of electromagnetic radiation. Simultaneous control of the dielectric and magnetic properties makes it possible to design material characteristics with an extremely high refractive index and no reflection, while Fresnel reflection would frequently be caused in naturally occurring materials. The metamaterial in the 6.0-μm waveband has an extremely high refractive index of $8.0 + j1.0$, extremely low reflectance of 6.0%, and transmittance of 57% in Fig. 2 (a). The metamaterial in the 1.5-μm waveband has a high refractive index of $5.2 + j1.0$, low reflectance of 16%, and transmittance of 50% in Fig. 2 (c). Such unprecedented materials would be able to contribute to the directivity control of thermal radiation in the infrared region and also support the thermal management of a wide range of applications.

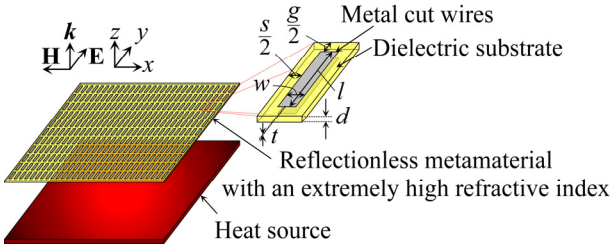

Fig. 1 Metamaterial with a high refractive index and no reflection.

Table 1 Parameters of the metamaterials.

λ	6 μm	1.5 μm
l	2200 nm	270 nm
g	300 nm	90 nm
w	440 nm	50 nm
s	580 nm	75 nm
t	100 nm	50 nm
d	82.5 nm	9 nm

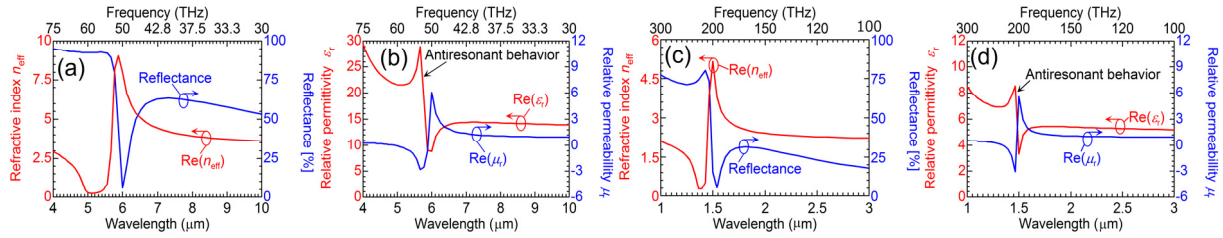

Fig. 2 Wavelength characteristics of the metamaterials with high refractive indices and low reflectance.

References

[1] Z. Yu et al., Nat. Commun. **4**(1730), 1−7 (2013).
[2] W. Li and S. Fan, Opt. Express **26**(12), 15995−16021 (2018).

* Corresponding Author: takehito@go.tuat.ac.jp