Oxide semiconductor plasmonics for infrared thermal-shielding techniques

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Limiting the infrared (IR) radiation that enters automobiles and buildings is an area of growing interest in energy-saving technologies for window applications. The purpose of windows is to prevent the penetration of near- and mid-IR light into rooms. Heat shielding is required to limit the IR radiation not by absorption but through reflection to decrease reradiation of the heat indoors. In addition, transmission at visible and microwave wavelengths with high heat-ray reflections is required for information society such as IT/IoT and AI. It is therefore necessary to achieve optical and electromagnetic control with a wide range of wavelengths, from ultraviolet (UV) to microwaves. In this work, we focus on infrared surface plasmons based on oxide semiconductors. Recently, oxide semiconductors have received considerable attention due to strong plasmonic resonances in the IR range [1 - 3], which provide new insight for high light reflections through high plasmonic fields at interfaces between nanoparticles [4 - 8]. Above all, three-dimensional assemblies of nanoparticles are functionalized to "*plasmonic metasurfaces and metamaterials*", which produces interesting optical phenomena in the IR range [9]. In this presentation, we report new solar thermal-shielding based on oxide semiconductor plasmonics.

Figure 1(a) shows reflectance spectrum of ITO nanoparticle (ITO-NP) films, revealing that reflectance enhanced up to 60%. A surface SEM image revealed that the nanoparticles had a close-packed structure [inset of Fig. 1]. The spectrum was composed of two peaks of peak-I and peak-II in the near- and mid-IR range, respectively. Besides, IR ellipsometric spectroscopy cleared that dielectric functions of ITO NP films showed an Lorentz dispersion in relation to a bounded electron oscillation. In the near-IR range, the dispersion showed a metallic behavior ($\varepsilon_1 < 0$, $\varepsilon_2 > 0$), which allowed to excite a propagated SPR mode. In contrast, the mid-IR range provided an optical behavior ($\varepsilon_1 > 0$, $\varepsilon_2 \sim 0$) of a high-permittivity material. These characters resulted from realization of plasmonic metasurfaces. From FDTD simulations, optical properties in the near-IR range are based on 3-*D* field interactions. On the other hand, 2-*D* field coupling determined optical characters in the mid-IR range, which produced standing waves. Difference in optical properties between near- and mid-IR ranges was related to local plasmonic characters in the assembled NP films. Our presentation purposes new optical control as plasmonic metasurfaces based on oxide semiconductors for solar thermal-shielding.

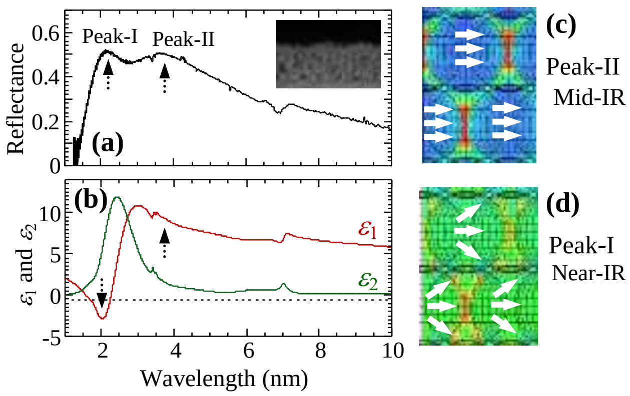

Figure 1 (a) Reflectance and (b) dielectric functions of ITO NP films. Electric-fields and charge vectors of internanoparticle gaps of (a) peak-I and (b) peak-II.

参考文献

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