Reflective heat-insulating applications using transparent oxide semiconductors based on plasmonic hybridizations

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1. Introduction

A great deal of attention has been given to reducing the levels of infrared (IR) light entering automobiles and buildings in relation to energy-saving technology. The present use of thermal-shielding methods cuts IR radiation not by absorption, but through reflection in an effort to decrease re-radiation of heat indoors. Recent demands for thermal-shielding materials require visible and microwave transmissions with high heat-ray reflections. However, these films are unable to fully transmit electromagnetic waves in the microwave range, which are currently difficult to employ in window applications.

Recently, IR plasmonic excitations on film surfaces have been observed on transparent oxide semiconductors. The sub-wavelength nanostructures are capable of supporting local surface plasmon resonances, which provide a novel concept of thermal-shielding. In this presentation, we employ experimental and theoretical approaches to report on the plasmonic properties of assembled films of ITO NPs. We show that the selective light reflections in the IR range are based on plasmon hybridizations due to field interactions induced at inter-nanoparticle gaps, and which are demonstrated by changes in the structural size of the NPs. We also focus our attention on the field interactions of *E*-fields along the in-plane and out-of-plane directions in an effort to account for the matter by which the assembled films facilitate high IR reflectance. This study provides new insights for the enhancement of heat-insulating capability.

2. Results and Discussion

ITO NPs were synthesized using metal-organic decomposition, and were evaluated from structural and optical aspects. The assembled films of ITO NPs were fabricated by a drop/spin coating technique. Figure 1 shows peal separations of resonant reflections of ITO NP films. The films with D = 8 nm provided a small peak splitting to peak-I and-II, which gradually became large with increasing NP radius. An origin of a resonant reflection at peak-I was different from that at peak-II, which was clarified from FDTD simulations. Peak-I resulted from dipole interactions at inter-nanoparticles along the in-plane, while peak-II was derived from the field interactions along the in-plane and out-of-plane. This plasmon splitting contributes to shielding solar-shielding and heat-insulating. In particular, a high reflection was achieved in the mid- to far-IR range [Fig. 2]. These high reflectance was selectively obtained in the near to far-IR range, which were applied to solar thermal shielding and heat-insulating.

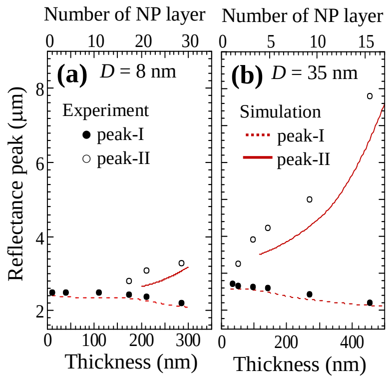

Fig. 1. Peak separations of resonant reflections based on plasmon hybridizations in the ITO NP films with different NP radius.

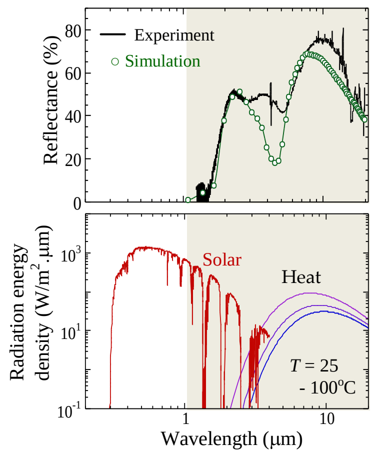

Fig. 2. (a) Experimental and theoretical reflectance spectra. (b) Radiation energy density of solar and heat radiation.

3. Conclusions

We successfully fabricated transparent heat-insulating films with reflective-types using assemblies of ITO NPs, which were achieved on the basis of plasmonic hybridizations.

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References

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