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THE SUMMARY OF Ph.D. DISSERTATION

School of Integrated Design Engineering		SHIMAZAKI, Kazunori

Title

Application of metal-insulator transition material to functional thermal control device for space use

Abstract

The spacecraft performing the interplanetary missions is exposed to the distinct thermal conditions from the orbit around the earth. New functional thermal control devices are required to solve the problem of various temperature changes of the spacecraft. In the field of the space development, thermal control materials or devices were reported, which change the emittance with the electrical and mechanical instruments. In the present study, we proposed new functional thermal control device, referred to as the Smart Radiation Device (SRD), using manganese oxide, $La_{1-x}Sr_xMnO_3$, with a perovskite-type structure. First, the variation of the thermal radiative properties by metal-insulator (M-I) transition was measured. Second, the method of design of multilayer films for the improvement of the thermal radiative properties of the SRD was proposed. Finally, the SRD that changes the emittance depending on temperature was developed, and the multilayer films for reducing the solar absorptance α_S was evaporated on the surface of the SRD.

Chapter 1 summarizes the background and the object of the present study.

Chapter 2 describes thermal radiative properties of $La_{1-x}Sr_xMnO_3$. The total hemispherical emittance ε_H of $La_{1-x}Sr_xMnO_3$ was measured by calorimetric method between 173 and 373 K. The ε_H of the SRD, which is doped an appropriate amount of Sr^{2+}, changed rapidly by the M-I transition. Moreover the temperature dependence of the spectral reflectance and the optical constants were measured. It was confirmed that the variation in the ε_H of the SRD could be attributed to the remarkable variation in the far-infrared optical properties by the M-I transition. The α_S of the SRD was measured with the spectroscope and the integrating sphere. The obtained value was too large to use the SRD as a radiator for the spacecraft.

Chapter 3 proposed the method of design of multilayer thermal control materials by a genetic algorithm (GA). The method, based on the GA, designs the multilayer films for dropping the α_S to acceptable level, keeping the variation in the ε_H of the SRD. The GA could optimize the sequence of materials as well as the thickness of each layer of multilayer film. The degree of freedom of this design was large because the merit function used the α_S and the ε_H integrating spectral reflectance. The temperature dependence of the optical constants of the SRD was used to calculate the variation in the ε_H of the SRD. The performance of the GA for multilayer films design was evaluated by trial optimization for the simple model of multilayer films. It is possible that the thermal control materials with optional thermal radiative properties are designed by this method.

In the chapter 4, the GA could design the multilayer film that reduces the α_S below 0.3, keeping the large variation in the ε_H of the SRD. The multilayer film consisted of the nine layers was evaporated on the surface of the SRD by electron beam evaporation method. The designed α_S was 0.24 and the measured α_S was 0.28. The measured ε_H showed good agreement with the calculated result.

Chapter 5 summarized the result of this study.