A self-emissivity-controlling radiator for spacecrafts by making use of a metal-insulator transition in magnetoresistive manganites

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Spacecraft usually expel excess heat into deep space with radiators, keeping the temperature of all the elements of a spacecraft system within the allowable limits for all mission phases. As the infrared emissivity of the radiator is constant, the temperature $T$ of these components is affected by heat inputs which are highly variable with time over the life of the mission. Thus, some devices are required for active thermal control. The Smart Radiation Device (SRD) is one of the next generation thermal control materials for spacecrafts [1]. It is a light ceramic tile that changes its emissivity according to its own $T$. SRD makes use of perovskite-type magnetoresistive Mn oxides $L^{3+}_{1-x}B^{2+}_x\text{MnO}_3$ ($L=$lanthanides and $B=$alkaline earths) that show a drastic metal-to-insulator transition (MIT) with increasing $T$. Such an exceptional MIT allows these compounds to have low infrared emissivity ($\varepsilon$) at low $T$’s due to metallic behavior and high $\varepsilon$ at high $T$’s due to insulating behavior and this change of $\varepsilon$ is suitable for a spacecraft radiator. The first SRD used for a spacecraft HAYABUSA (in operation 2003-2010) employed $\text{La}_{0.775}\text{Sr}_{0.115}\text{Ca}_{0.11}\text{MnO}_3$ which has a large change of $\varepsilon$ (from $\varepsilon<0.23$ at 173 K to $\varepsilon>0.63$ at 353 K) across a MIT around the room temperature.

For further improvements of the radiation property of SRD, we have studied various compositions of A-site ions ($L^{3+}_{1-x}B^{2+}_x$) as well as B-site substitutions with Ga (for Mn). In this presentation, we discuss how the transition temperature of MIT ($T_c$), the electric resistivity, and $\varepsilon$ are related to each other and how we can design an improved SRD. And then, we report the results of our compositional survey.