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Author: Dr. Xin Xiang Jiang
Canadian Space Agency, Canada, xin-xiang.jiang@asc-csa.gc.ca

THERMOCHROMIC COATING BASED SMART THERMAL RADIATOR FOR AUTONOMOUS SPACECRAFT THERMAL CONTROL APPLICATION

Abstract

Smart thermal radiator technology based on radiating surface of variable emissivity potentially offers many advantages for thermal control of spacecraft for future missions, particularly the missions involving micro- and nano-satellites. Because of its autonomous characteristics, such device can reduce the mass, volume and power consumption of thermal control subsystem as well as to have design simplicity. One of the most promising coating materials, key to such technology development, is the transition oxide compound of perovskite crystalline structure in the form of La1-xSrxMnO3. The material exhibits a phase transition from a ferromagnetic metal state to a paramagnetic insulator state in the temperature range between 280K and 340K, resulting in a drastic change in its emissivity. However, synthesis of such material with the desired transition characteristics in the form of coating on existing thermal radiator base plate has been a technical challenge. In this paper, deposition of La1-xSrxMnO3 coating is investigated on various types of substrates using a multi-target reactive magnetron sputtering system. Experimental results indicate that after annealing, the La1-xSrxMnO3 coating exhibits a desired polycrystalline nanostructure. Measurement of surface electrical resistivity of the coating is performed over the temperature range from -30C to 150C and results show a clear metal-insulator phase transition occurring at the temperature between 60C and 70C. The reflectance of the coatings over the spectral range from 1.6 um to 25 um was measured at different temperatures and the results indicate that the coating exhibits a clear thermochromic behavior. Further characterization of total hemispherical thermal emittances of the coatings over a temperature range between -100C and 120C was performed using calorimetric method in liquid nitrogen cooled chamber. The result shows that the transition in thermal emittance is greater than 0.35 over the temperature range between -60C and 100C, which can potentially be used for autonomous thermal control for some small- or micro-satellite missions.