Adaptive Thermal Control of Satellites by ElectroActive Polymeric Coating

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Abstract

The aim of this study is to design new polymer coatings able to modulate their infrared emissivity with potential applications for thermal regulation of artificial satellites. Indeed in space the thermal equilibrium of a satellite is only governed by radiative exchanges. In this context, the study focuses on the development of electroemissive devices based on an electronically conducting polymer, poly(3,4-ethylenedioxythiophene) (PEDOT). These electroemissive devices are evaluated under space-like environment.

The first part of the presentation will be devoted to the incorporation of the active layer (PEDOT) by chemical polymerization of the parent monomer EDOT within a hosting matrix.[1,2] This latter is designed on interpenetrating polymer network (IPN) architecture which includes an elastomer such as nitrile butadiene rubber (NBR) and an ionic promoter as polyethylene oxide (PEO). After swelling in oxidative medium, EDOT turns into interpenetrated PEDOT electrodes at the surface of the IPN. Once washed, swelled in pure ionic liquid like N-Ethyl-N'-Methyl Imidazolium bis-trifluoromethanesulfonyl-imide (EMITFSI) and assembled between two current collector frames (2.5x2.5cm^2), the electroemissive device (EED) is obtained (Fig. 1). The electrochemical behaviour was investigated in a primary vacuum chamber and infrared optical properties were evaluated in the 2-20µm range.

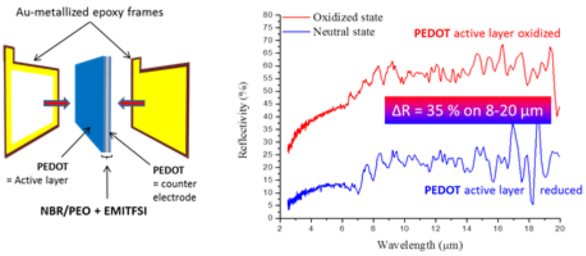

Fig. 1: (left) EED device assembled. (right) Mid-IR dynamic within the 2-20µm range

Based on these results, the main part of the presentation will concern the fabrication and evaluation of prototypes for thermal control application at Thales Alenia Space (TAS). Basically they consist in the assembly of 16 single PEDOT/NBR/PEO IPNs membranes (previously swollen by EMITFSI in a 4x4 matrix) on aluminum plate equipped with thermocouples (Fig. 2). A top frame is added to ensure the electrical contact with the 16 active layers ; finally all active layers and counter electrodes are in parallel configuration so that the radiator exhibits an active surface of *c.a.* 82cm^2.

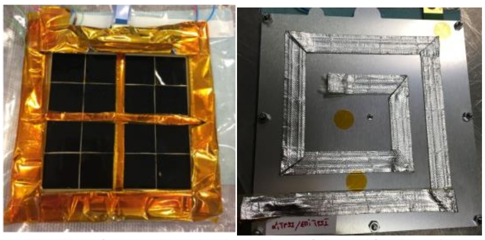

Fig. 2: Electroemissive Radiator front (left) and back (right)

Once covered by Kapton® the radiators were placed into a vacuum chamber and tested under thermal conditions close to the space environment (10^{-6}mbar, -60°C). Their thermal behaviours (without taken into account the solar flux) were compared to that of passive technology currently used on artificial satellites *i.e.* optical solar reflectors (OSR). During the commutation between variable thermal conditions the electroemissive radiators proved better ability than OSR to preserve heat inside the satellite during cold environments while under "hot" environment, the heat rejection was at the same level as the OSR one, proving the relevance of this type of system for the thermal regulation of satellites. In addition, a low energy consumption of these systems was highlighted during these tests. Associated to a reduced on-board weight, the electroemissive devices designed by LPPI and TAS have thus a double interest for the intended application with respect to the current technology.

References

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