Enhancement of Atomic Oxygen durability of 3D-Graphene infused Polyimide for long-term space application

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In this work, Polyhedral Oligomeric Silsesquioxane (POSS) nanoparticles are used to enhance the Atomic Oxygen (AO) durability of 3D-graphene infused Polyimide (3D-C/PI) composite films in low earth orbit (LEO). Recently, 3D-C was identified as an effective filler to protect the polyimide films from electrostatic discharge when used as thermal blankets for satellites.[1-3] However, the carbon-based composite film is susceptible to erosion due to long term AO exposure at LEO altitudes. [4, 5] Here, POSS is added to the composite film in three ways, and the resulting samples (3D-C-POSS/PI, 3D-C/PI-POSS and 3D-C-POSS/PI-POSS) are studied and compared to 3D-C/PI. These samples are subjected to ground-based AO exposure. Their electrical and mechanical properties are also investigated. It is seen that adding POSS to PI results in lower AO erosion yield since most of the film mass, including the top surface, is PI. The 3D-C/PI-POSS film has the lowest erosion yield of 4.67 X 10^{-25} cm^3/AO when subjected to AO fluence equivalent to 5 months at an altitude of 500 km. By adding POSS in PI, the durability of 3D-C/PI composite film has been extended beyond ten years, making it an ideal material for long term missions in LEO.

References

[1] Zhang, L.; Liu, M.; Bi, S.; Yang, L.; Roy, S.; Tang, X.-Z.; Mu, C.; Hu, X., Journal of Colloid and Interface Science, 493 (2017), 327-333.
[2] Wu, Y.; Wang, Z.; Liu, X.; Shen, X.; Zheng, Q.; Xue, Q.; Kim, J.-K., ACS Applied Materials & Interfaces,10 (2017), 9059-9069.
[3] Loeblein, M.; Bolker, A.; Tsang, S. H.; Atar, N.; Uzan-Saguy, C.; Verker, R.; Gouzman, I.; Grossman, E.; Teo, E. H. T., Small, 48 (2015), 6425-6434.
[4] Reddy, M. R., Journal of Materials Science, 2 (1995), 281-307.
[5] Iskanderova, Z. A.; Kleiman, J. I.; Gudimenko, Y.; Tennyson, R. C., Proceedings of ICPMSE-4, 4(2001); 33-50.

Figures

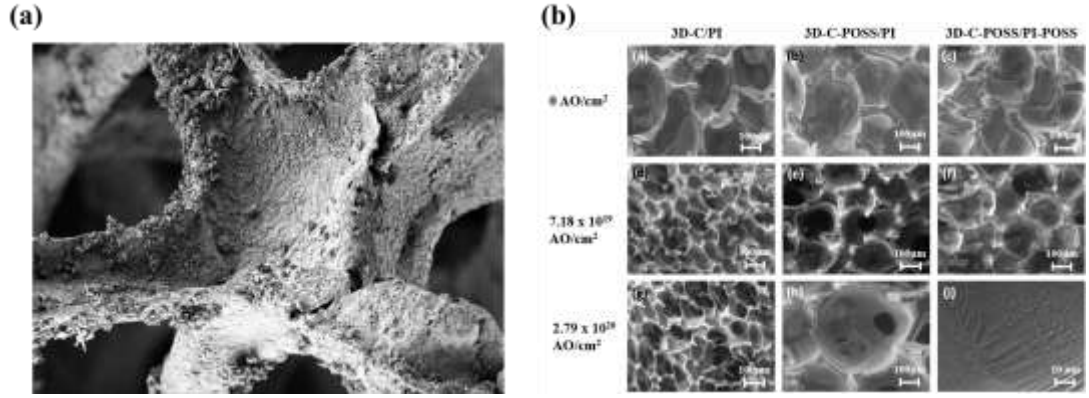

Figure 1: SEM images showing a) 3D-C with POSS nanoparticles on the foam surface; b) Composite film surface before and after AO exposure showing the effect of AO exposure.