Computational Modelling of Epoxy-Graphene Composite Adhesive towards the Development of Cryosorption Pump

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Abstract : Cryosorption pump is the best solution to achieve clean, vibration free ultra-high vacuum. Furthermore, the operation of cryosorption pump is free from the influence of electric and magnetic fields. Due to these attributes, this pump is used in the space simulation chamber to create the ultra-high vacuum. The cryosorption pump comprises of three parts (a) panel which is cooled with the help of cryogen or cryocooler, (b) an adsorbent which is used to adsorb the gas molecules, (c) an epoxy which holds the adsorbent and the panel together thereby aiding in heat transfer from adsorbent to the panel. The performance of cryosorption pump depends on the temperature of the adsorbent and hence, on the thermal conductivity of the epoxy. Therefore we have made an attempt to increase the thermal conductivity of epoxy adhesive by mixing nano-sized graphene filler particles. The thermal conductivity of epoxy-graphene composite adhesive is measured with the help of indigenously developed experimental setup in the temperature range from 4.5 K to 7 K, which is generally the operating temperature range of cryosorption pump for efficiently pumping of hydrogen and helium gas. In this article, we have presented the experimental results of epoxy-graphene composite adhesive in the temperature range from 4.5 K to 7 K. We have also proposed an analytical heat conduction model to find the thermal conductivity of the composite. In this case, the filler particles, such as graphene, are randomly distributed in a base matrix of epoxy. The developed model considers the complete spatial random distribution of filler particles and this distribution is explained by Binomial distribution. The results obtained by the model have been compared with the experimental results as well as with the other established models. The developed model is able to predict the thermal conductivity in both isotropic regions as well as in anisotropic region over the required temperature range from 4.5 K to 7 K. Due to the non-empirical nature of the proposed model, it will be useful for the prediction of other properties of composite materials involving the filler in a base matrix. The present studies will aid in the understanding of low temperature heat transfer which in turn will be useful towards the development of high performance cryosorption pump.

Keywords : composite adhesive, computational modelling, cryosorption pump, thermal conductivity
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