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Iridium Protects Rocket Thrusters

The efficiency of spacecraft thruster engines, used for orbit insertion and altitude control, will be improved if their operating temperatures can be increased. As the fuel comprises the bulk of the mass of a satellite any reduction in requirement permits an increase in payload and hence an enhancement of the mission. The limitation on the efficiency of rocket engines may, however, be the ability of the materials they are made from to withstand the arduous conditions encountered in service.

Materials for radiation-cooled rocket thrusters must be capable of providing both mechanical strength and oxidation resistance at the high operating temperatures demanded by engine efficiency, but no single material has the necessary combination of properties. Rhenium, with a melting point of 3180°C, has suitable mechanical properties but under the oxidising conditions encountered in thruster chambers rapid loss of material occurs. This can be prevented by coating the surface of the rhenium which will be exposed to hot combustion gases with iridium. This does not form a eutectic with rhenium, has suitable thermal expansion and is reasonably resistant to oxidation at temperatures up to 2410°C – its melting point.

In order to be able to predict the lifetime of iridium-coated rhenium thrusters investigators with the Sandia National Laboratories, Livermore, and with the Aerojet Propulsion Division, Sacramento, have studied samples cut from a thruster end ring. This had been manufactured by chemical vapour deposition, involving the deposition onto a molybdenum mandrel of a layer of iridium approximately 50μm thick which was then overlain with 2 mm of rhenium before the molybdenum was removed by chemical etching. As deposition of the rhenium takes place at 1200°C some interaction takes place during this process. It is suggested that failure of such components could involve the diffusion of rhenium through the iridium and the subsequent removal of rhenium by oxidation; hence the need for accurate diffusion data. ("Diffusion Mechanisms in Chemical Vapor-Deposited Iridium Coated on Chemical Vapor-Deposited Rhenium", J. C. Hamilton, N. Y. C. Yang, W. M. Clift, D. R. Boehme, K. F. McCarty and J. E. Franklin, *Met. Trans.*, 1992, **23A**, (3), 851–855).

Diffusion mechanisms and rates are critically affected by the grain size and morphology of the materials, and these were determined by electron microprobe analysis of a control sample and three others which had been annealed in vacuum for specified times at temperatures slightly below rocket thruster operating temperatures.

The evidence showed that for these chemical vapour-deposited materials grain-boundary diffusion was the dominate diffusion mechanism and the diffusion rate showed a Arrhenius-type dependence on temperature, enabling operating lifetimes to be predicted.