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ENHANCED ORBITAL DEBRIS SHIELDING STRUCTURE WITH IMPEDANCE-GRADED MATERIALS

Abstract

It is believed that the bumper of spacecraft Meteorids/Debris shielding structure is the key element because it determines the projectile fragments after initial impact. In this paper, an enhanced shielding structure using impedance-graded materials (IGM) bumper is presented. Three types of IGM bumper have been designed and prepared, which is composed of titanium alloy, aluminum alloy and magnesium alloy. A series of experiments had been performed on two-stage light-gas gun to impact IGM and aluminum alloy Whipple shield by aluminum spheres between 3.5 km/s to 6.5 km/s, and a high-speed camera was employed to record impact process. The impact characteristics including penetration hole, debris cloud and damage pattern on the rear wall have been studied, and regular results have been gained. The results show that the shielding capability of the IGM shields is greater than that of aluminum Whipple shield with the same bumper areal density. To explore the reason why the shielding capability of the IGM shields is better than an aluminum alloy Whipple shield, SPH simulations by using the hydrocodes AUTODYN 3D simulator were carried out. On the other hand, some theoretical analysis according to the theory of shock waves is carried out to investigate the wave characteristic and conversion of energy. The results show that the IGM bumper can breakups the projectile into smaller and more homogeneous, due to the particular wave propagation path on IGM, in addition, the shock heating effect for IMG bumper plays an important role in shield protection capability, which making a sharp increase in protective capability for spacecraft meteoroids/debris shielding.