INVESTIGATION OF INTERACTION OF SPACECRAFT MATERIALS WITH HIGH-VELOCITY SPACE DUST STREAMS

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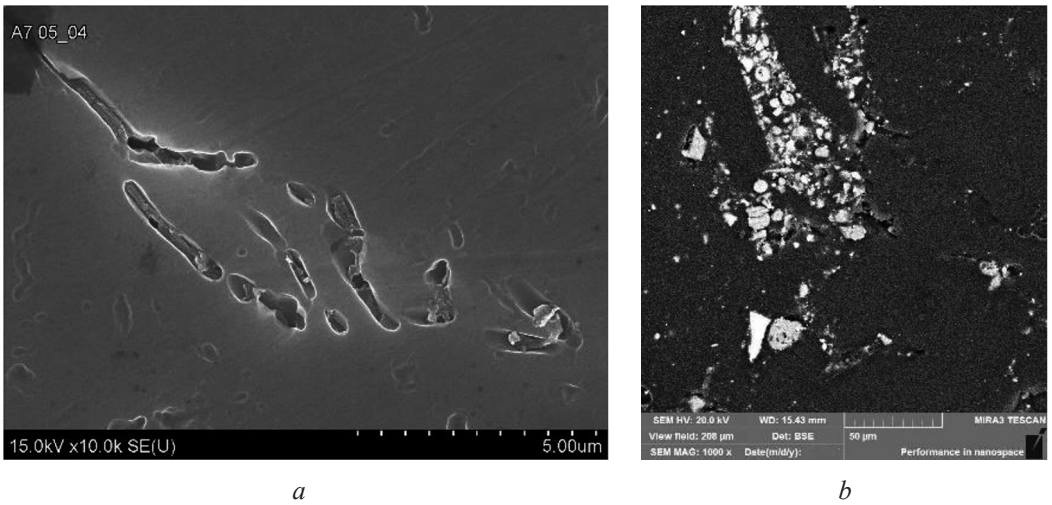
Collisions of spacecraft with solids of natural and artificial origin are among the most important factors causing damage and destruction of spacecrafts. Collision velocities of spacecraft with meteor bodies and space debris objects are in the range of 1–70 km/s. Solid particles with transverse dimensions less than 1 mm (cosmic dust) can be considered as a factor constantly affecting spacecraft, characterized by their flux density. Previous studies have shown that at such collision speeds intense energy release occurs in a limited volume of the substance, accompanied by the formation of shock waves with subsequent mechanical damage, melting, evaporation and plasma formation, appearance of electromagnetic radiation that can turn off nearby electrical equipment. Existing spacecraft shields do not provide reliable protection cause for a long time, the collisions of streams of dust particles with metal modules of spacecraft were considered only from the position of erosion of the outer surface. However, studies show that this is not the case [3, 4]. An expensive task is to conduct field tests of the protective properties of various materials; therefore, computer simulation is often used which cannot always ensure full compliance with real conditions.

Using the method of dynamic loading of a material with a high-speed stream of powder particles (in SDP mode) provide a simple and effective way to test the behavior of materials and electronic systems in ground-based conditions. Super-deep penetration (SDP) is a complex physical phenomenon, when in a split second stream of powder particles with a fraction less than 200 microns, accelerated to speeds of 700–3000 m/s, penetrates into the solid metal body at depth in tens, hundreds mm. Experimental data obtained by the SDP method in terrestrial conditions show that the proposed method allows one to perform a preliminary assessment of the effect of high-speed flow on various materials. The study of the structure and properties of materials (steels, aluminum, polymers) subjected to high-speed loading in the SDP mode shows that the structure of materials, in contrast to the standard concept of crater formation, remains integral (no through holes or craters are formed) undergoes significant changes. A greater risk is a change in the structure, accordingly, the properties of materials and structures. It was shown, that such properties as hardness, electrical conductivity and electron work function is changed. Such influence can lead to accelerated degradation of materials and structures, impact the operation of control and monitoring systems. Based on the experimental data obtained on the change in the structure and properties of materials under the influence of high-velocity particle streams,



a *b*

Fig. 1. *a* – Structure of Al99.7 % (A7) after processing in SDP mode by SiC particle stream; *b* – The structural element of powder stream residues (SiC+Al) in a polymer matrix

it can be concluded that such constant flows of cosmic dust have a significant effect on materials, structures, and the control system of spacecraft.

References

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