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STRUCTURED MULTILAYERED COMPOSITE MATERIALS BY SHS METHOD: EXPERIMENTAL STUDY*

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Design of materials that combine properties of ceramics and metals, such as hardness, strength, heat resistance, high-temperature strength, wear resistance, and ductility is a popular trend in materials research and design. Layered composite materials (cermets) that combine the properties of metals (ductility, heat resistance, and thermal conductivity) and ceramics (hardness, corrosion resistance, high-temperature strength, and low thermal conductivity) find wide application in different areas of aerospace industry, mechanical engineering, power engineering, etc. Meanwhile, the fabrication of multilayer composite materials encounters serious difficulties caused by strongly different mechanochemical parameters of metals and ceramics to be joined. Joining of metals with ceramic is a complicate issue due to strongly difficult physical properties of these dissimilar materials. The quality of joining is governed by the following two factors: (a) the fit of thermal expansion and (b) the formation of undesired interfacial layers [1]. The problem of joining dissimilar materials still remains to be of current importance despite of huge number of publications in the field.

Self-propagating high-temperature synthesis (SHS) is a advance technique for the synthesis of materials and deposition of coatings which is attractive due to a wide range of suitable reagents, relatively simple facilities, and high combustion temperatures developed during combustion reaction [2]. SHS method was found applicable to joining such dissimilar materials as ceramics, metals, and carbon materials [3].

In this work, we report on the SHS-assisted joining between Ti, Hf, Ta foils and ceramic layers SHS-produced in situ from reactive Ti–B, Ti–C, and Ti–Si tapes. According to [4], the reactive cold-rolled Ti–B tapes 100–300 μm thick are capable of rapid burning at a high rate of heat release. The choice of individual layers for compiling green sandwich-like multilayer assemblies was done with due regard for key thermophysical parameters of foils and rolled reactive tapes. The samples comprised of metal foils and reactive ceramic-generating tapes were ignited in a combustion chamber under Ar. The combustion process was monitored with set of thermocouples. Combustion-synthesized composites were characterized by SEM, EDX and XRD. Thermomechanical behavior of synthesized samples was determined by three-point loading at 25°C and 1100°C under Ar using a modified testing machine Instron-1195.

Lightweight Ti–Hf–ceramic and Ti–Hf–Ta–ceramic layered composite platelets 2–3 mm thick can be prepared via a short-term (around 0.2–0.6 s) combustion of preliminary sandwich-like stacks of metal foils and reactive tapes. Good joining of Ti with Hf and Ta was achieved due to SHS reactions in reactive tapes yielding ceramics and reaction heat. Layered composite material is formed as a result of mutual impregnation, interdiffusion, and chemical reactions. In contrast to the technique of ceramic–metal diffusion bonding, our combustion-aided process affords for joining dissimilar materials in short processing time without using complicate facilities. Good joining between metals and ceramics is reached due to the formation of interfacial layers in the form of cermets and eutectic solutions.

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