August 1969

Brief 69-10266

NASA TECH BRIEF

Improved High-Temperature Silicide Coatings

A special technique for applying silicide coatings to refractory metal alloys substantially improves their high-temperature protective capability.

Alloys of the refractory metals (columbium, molybdenum, tantalum or, tungsten) are being used in advanced engines, and spacecraft operating at temperatures approaching 3500°F. To protect these parts from cyclic oxidation, which rapidly degrades their structural integrity, they must be protectively coated. Silicide coatings have been used with fair results. Conventionally, silicide coatings have been produced by the chemical reaction of the refractory metal parts with a silicon halide vapor. A metal silicide coating is formed. However, such coatings provide limited protection under varying operating conditions because they are thin and variation of the chemical composition of the coating is not feasible.

This new technique for producing silicide coatings, developed by a NASA contractor (see source No. 1), involves two steps. First, a slurry of selected refractory metal powders mixed with an organic binder is applied to the surfaces to be coated. The binder is baked-out and the coating is sintered in a vacuum to produce a porous layer of alloy on the surface. Second, this porous surface layer is exposed to hot silicon or silicon halide vapor which reacts with the porous alloy and converts part or all of it to a silicide. The final result is a silicide coating of predetermined depth and selected composition which provides improved protection to the original metal substrate over a wide range of operating temperatures.

Using this technique, the contractor developed highly alloyed silicide coatings for tantalum alloys. These coatings consist of varying proportions of tungsten (W), molybdenum (Mo), titanium (Ti), and vanadium (V). A 50 W–20 Mo–15 Ti–15 V (weight percent) composition gave the best performance for tantalum for 800 hours, at temperatures up to 2400°F. Similar coatings with less vanadium and titanium have survived more than four hours at 3500°F, but are not as protective for tantalum at lower temperatures.

Tests have shown that this technique provides coatings that protect both tantalum and columbium alloys at temperatures to 2400°F for up to four times as long as conventional silicide coatings, including in the critical intermediate temperature range between 1450° and 1800°F where simple silicide coatings usually tend to fail catastrophically.

Research conducted at the NASA Lewis Research Center (see source No. 2) has resulted in greatly improved silicide coatings for chromium alloys. The slurry-plus-silicide technique allowed investigation of a large number of modifying combinations. A silicide coating modified with iron significantly protects chromium from high-temperature embrittlement by nitrogen.

Studies are continuing of these modified silicide-coating techniques for metal alloys to optimize coating compositions, to extend the range of protection to higher temperatures, to increase their durability, and to improve their impact resistance.

Notes:

1. Documentation is available from:
   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10266

(continued overleaf)

2. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B69-10266

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: (1) R. T. Wimber and A. R. Stetson of
International Harvester Company
under contract to
Lewis Research Center
(2) J. R. Stephens and W. D. Klopp
Lewis Research Center
(LEW-10817)