NASA TECH BRIEF

Lewis Research Center

Nonmetallic Impurities Improve Mechanical Properties of Vapor-Deposited Tungsten

Certain mechanical properties of vapor-deposited tungsten can be improved by the selective incorporation of various nonmetallic impurities. The addition of trace quantities of carbon, nitrogen, or oxygen can significantly increase both the low- and high-temperature yield strength without greatly affecting the ductile-to-brittle transition temperature (DBTT).

These results represent the basic findings of a study aimed at achieving greater control of the properties of vapor-deposited tungsten. Specifically, it was found that the addition of carbon in concentrations of from 250 to 300 ppm raised the low-temperature yield strength from 345×10^6 N/m^2 (50 ksi) to nearly 1380×10^6 N/m^2 (200 ksi) and the yield strength at 1800°C from less than 27.6×10^6 N/m^2 (4 ksi) to about 62.1×10^6 N/m^2 (9 ksi), while the DBTT stayed below 200°C. Nitrogen additions within the additive range studied were equivalent to carbon in producing strength increases. The effect of oxygen on high- and low-temperature yield strengths was somewhat less.

Two principal techniques were used to add the desired impurity: One involved gas-metal reactions to introduce an impurity into previously deposited tungsten; the other involved the codeposition of the impurity with the tungsten. In the case of carbon, the first technique was performed by immersing vapor-deposited tungsten specimens in a rich mixture of methane in hydrogen gas at about 1650°C, to form a carbon-rich surface layer. The specimen was then annealed at a higher temperature to establish an equilibrium solid solution in the metal, and the remaining carbide layer was machined from the surface before any property measurements were made. The second technique entailed adding methane to the hydrogen and tungsten hexafluoride gas mixture normally used in tungsten vapor deposition.

These two techniques were selected in order to separate the effect of the additive from that caused by any alteration introduced by second-phase nucleation if the additive is incorporated during deposition.

Notes:

1. Background information on the process of tungsten vapor deposition is presented in NASA Tech Brief 67-10232. A practical application of this process in forming large mechanical structures from refractory metals is presented in NASA Tech Brief 71-10212.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10454

Patent status:

No patent action is contemplated by NASA.

Source: J. Chin, A. F. Weinberg, and
J. R. Lindgren of
Gulf General Atomic
under contract to
Lewis Research Center
(LEW-10800)

Category 04