NASA TECH BRIEF

Ames Research Center

Fabrication of Carbon Film Composites for High-Strength Structures

Fiber-composite materials exhibit very desirable physical and mechanical properties because fine fibers have qualities that are vastly superior to bulk material of the same composition. Similarly, thin films often exhibit properties that are substantially different from bulk material; in view of this, it has been proposed that thin films of selected materials might be used to improve the physical and mechanical properties of laminated composites.

Preliminary investigations have shown that the density, elastic modulus, and tensile strength of carbon films increase dramatically as film thickness is reduced from about 3.8 μm to 0.13μm. For example, carbon films have been prepared with an elastic modulus of 345 to 896 GN/m^2 and ultimate tensile strengths of 2.8 GN/m^2; the coefficient of thermal expansion for the carbon films has been found to be close to zero. Moreover, it has been found that the high moduli and tensile strengths are retained in multiple-layer deposits when individual carbon layers are separated by intervening films of titanium. These observations indicate attractive potential applications of carbon-film structural composites for the construction of microwave filters or optical instruments which are subject to wide temperature variations; the qualities of high strength and low density also imply applications of the composites in aerospace structures or in architectural structures where a high strength-to-weight ratio is desired. The experimental procedure used for the deposition of ultrathin films of carbon and titanium in alternating layers is described in the following paragraphs.

A substrate (e.g., inert fluorocarbon polymer) approximately 10 cm x 15 cm in area and 0.013 or 0.007 mm thick, was cleaned ultrasonically in a detergent bath, followed by rinses in acetone, isopropyl alcohol, and deionized water; then, the substrate was supported in a metal frame which kept it taut by application of a nominal longitudinal tension of 22 N. The assembly was placed in a vacuum-deposition chamber and maintained at 150° to 200°C for about 1 hour at a pressure of 2.7 x 10^{-3} N/m^2; the substrate was rotated at 60 rpm during deposition so as to form essentially equal thicknesses of film on its two sides. Electron-beam heating was used to evaporate source material; typically, the beam current was held at 150 to 200 milliamperes. Deposition rate and final thickness were controlled and monitored by means of a quartz crystal sensor and associated circuitry.

Composite films of carbon and titanium were formed by using a double-hearth system in the electron-beam deposition equipment. At preset intervals, the beam was switched for deposition of either carbon or titanium to produce the desired layered deposit.

Notes:

1. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

(continued overleaf)

Reference:
NASA CR-1972 (N72-17537), Physical Properties of Thin Films.

2. No additional documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: B72-10423

Patent status:

No patent action is contemplated by NASA.

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