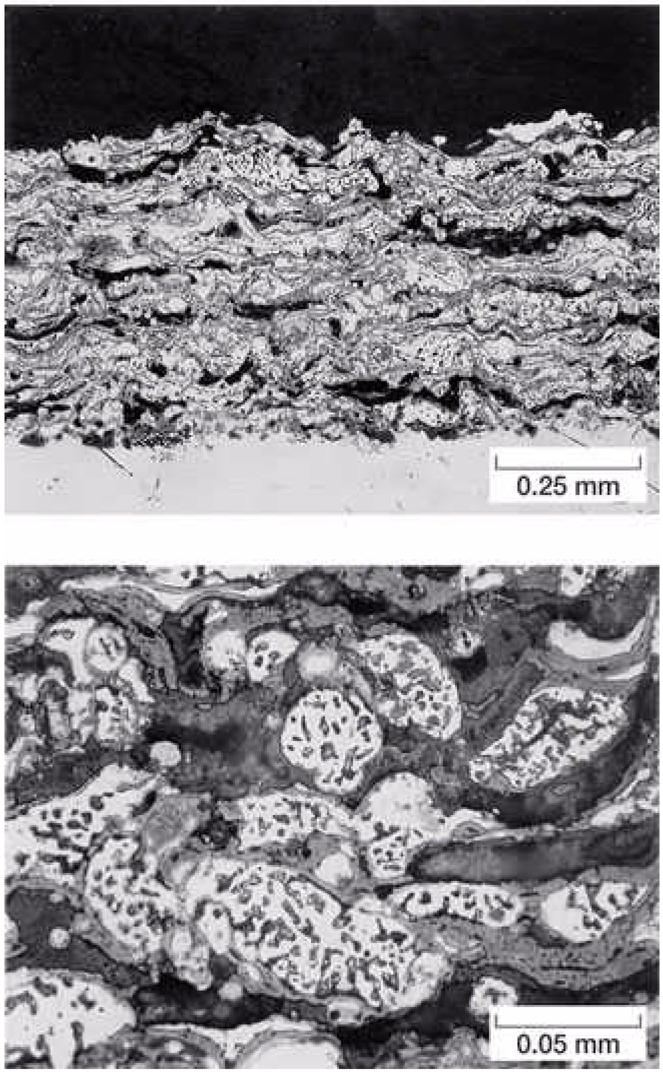
# Heat Treatment Used to Strengthen Enabling Coating Technology for Oil-Free Turbomachinery




*Cross section of PS304 coating following heat treatment in air at 650 °C showing the second-phase precipitate that forms in the nickel chrome binder phase.*

Long description: One can readily see the formation of a new precipitated phase within the nichrome binder particles. These precipitates result in a significant adhesion strength improvement and a slight, one time, volume expansion.

The PS304 high-temperature solid lubricant coating is a key enabling technology for Oil-Free turbomachinery propulsion and power systems. Breakthroughs in the performance of advanced foil air bearings and improvements in computer-based finite element modeling techniques are the key technologies enabling the development of Oil-Free aircraft engines being pursued by the Oil-Free Turbomachinery team at the NASA Glenn Research Center. PS304 is a plasma spray coating applied to the surface of shafts operating against foil air bearings or in any other component requiring solid lubrication at high temperatures, where conventional materials such as graphite cannot function.

The PS304 patented coating is a composite made from a nickel chromium binder, chrome oxide hardener, and solid lubricant additives silver and barium/calcium fluoride eutectic. This coating provides low friction and wear to sliding contacts in oxidizing and reducing atmospheres from cryogenic temperatures to over 650 °C. Recent experimental results indicate that the coating's adhesive and cohesive strengths improve by at least a factor of two following exposure to high-temperature air. Measured adhesive pulloff strength for the as-deposited coating is typically 17 MPa but rises to over 35 MPa after a 24-hr heat treatment at 532 °C. The exact strength of the heat-treated coating remains unknown because its strength exceeds that of the epoxy used in these tests to make the adhesion measurement. The heat treatment also results in a one-time coating thickness expansion of about 5 percent.

Cross-section metallographic analyses show that the binder phase has been altered by the heat treatment. As the photomicrographs show, the nickel chrome binder phase, which originally was uniform and gray, now has distinct second-phase precipitates. These precipitates have been found to contain high levels of chromium, oxygen, and other trace elements (like silicon) when examined using scanning electron microscopy x-ray techniques. The exact nature and structure of the second phase is under continued study, but this doesn't seem to create any negative performance or durability issues. As a result of this work, a postdeposition heat treatment has been implemented for the PS304 coating, further assisting its commercial application in Oil-Free turbomachinery and other high-temperature systems.

**Find out more about this research http://www.grc.nasa.gov/WWW/Oilfree/.**

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