Nanorod-Based Fast-Response Pressure-Sensitive Paints

Improved, nanostructured coatings could be used to measure rapid pressure fluctuations.

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A proposed program of research and development would be devoted to exploitation of nanomaterials in pressure-sensitive paints (PSPs), which are used on wind-tunnel models for mapping surface pressures associated with flow fields. Heretofore, some success has been achieved in measuring steady-state pressures by use of PSPs, but success in measuring temporally varying pressures has been elusive because of the inherent slowness of the optical responses of these materials.

A PSP contains a dye that luminesces in a suitable wavelength range in response to photoexcitation in a shorter wavelength range. The luminescence is quenched by oxygen at a rate proportional to the partial pressure of oxygen and thus proportional to the pressure of air. As a result, the intensity of luminescence varies inversely with the pressure of air.

The major problem in developing a PSP that could be easily applied to a wind-tunnel model and could be useful for measuring rapidly varying pressure is to provide very high gas diffusivity for rapid, easy transport of oxygen to and from active dye molecules. Most PSPs include polymer-base binders, which limit the penetration of oxygen to dye molecules, thereby reducing responses to pressure fluctuations. The proposed incorporation of nanomaterials (somewhat more specifically, nanorods) would result in paints having nanostructured surfaces that, relative to conventional PSP surfaces, would afford easier and more nearly complete access of oxygen molecules to dye molecules. One measure of greater access is effective surface area: For a typical PSP as proposed applied to a given solid surface, the nanometer-scale structural features would result in an exposed surface area more than 100 times that of a conventional PSP, and the mass of proposed PSP needed to cover the surface would be less than tenth of the mass of the conventional PSP.

One aspect of the proposed development would be to synthesize nanorods of Si/SiO_2, in both tangle-mat and regular-array forms, by use of chemical vapor deposition (CVD) and wet chemical processes, respectively. The rods would be coated with a PSP dye, and the resulting PSP signals would be compared with those obtained from PSP dye coats on conventional support materials.

Another aspect of the proposed development would be to seek to exploit the quantum properties of nanorods of a suitable semiconductor (possibly GaN), which would be synthesized by CVD. These quantum properties of semiconductor nanorods include narrow-wavelength-band optical absorption and emission characteristics that vary with temperature. The temperature sensitivity might enable simultaneous measurement of fluctuating temperature and pressure and to provide a temperature correction for the PSP response. [The concept of such a temperature correction was described in "Temperature Correction for Pressure-Sensitive Paint" (LEW-16915), *NASA Tech Briefs*, Vol. 24, No. 1 (January 2000) page 50.]

This work was done by Timothy Bencic of Glenn Research Center and Randall L. VanderWal of the National Center For Space Exploration Research on Fluids and Combustion, formerly the National Center for Microgravity Research on Fluids and Combustion. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17827-1.