Materials & Coatings

Temperature-Sensitive Coating Sensor Based on Hematite

This inexpensive, robust sensor system enables easier measurement and interpretation for optical detection.

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A temperature-sensitive coating, based on hematite (iron III oxide), has been developed to measure surface temperature using spectral techniques. The hematite powder is added to a binder that allows the mixture to be painted on the surface of a test specimen. The coating dynamically changes its relative spectral makeup or color with changes in temperature. The color changes from a reddish-brown appearance at room temperature (25 °C) to a black-gray appearance at temperatures around 600 °C. The color change is reversible and repeatable with temperature cycling from low to high and back to low temperatures. Detection of the spectral changes can be recorded by different sensors, including spectrometers, photodiodes, and cameras. Using a-priori information obtained through calibration experiments in known thermal environments, the color change can then be calibrated to yield accurate quantitative temperature information. Temperature information can be obtained at a point, or over an entire surface, depending on the type of equipment used for data acquisition.

Because this innovation uses spectrophotometry principles of operation, rather than the current methods, which use photoluminescence principles, white light can be used for illumination rather than high-intensity short wavelength excitation. The generation of high-intensity white (or potentially filtered long wavelength light) is much easier, and is used more prevalently for photography and video technologies. In outdoor tests, the Sun can be used for short durations as an illumination source as long as the amplitude remains relatively constant. The reflected light is also much higher in intensity than the emitted light from the inefficient current methods. Having a much brighter surface allows a wider array of detection schemes and devices. Because color change is the principle of operation, the development of high-quality, lower-cost digital cameras can be used for detection, as opposed to the high-cost imagers needed for intensity measurements with the current methods.

Alternative methods of detection are possible to increase the measurement sensitivity. For example, a monochrome camera can be used with an appropriate filter and a radiometric measurement of normalized intensity change that is proportional to the change coating temperature. Using different spectral regions yields different sensitivities and calibration curves for converting intensity change to temperature units. Alternatively, using a color camera, a ratio of the standard red, green, and blue outputs can be used as a self-referenced change. The blue region (<500 nm) does not change nearly as much as the red region (>575 nm), so a ratio of color intensities will yield a calibrated temperature image.

The new temperature sensor coating is easy to apply, is inexpensive, can contour complex shape surfaces, and can be a global surface measurement system based on spectrophotometry. The color change, or relative intensity change, at different colors makes the optical detection under white light illumination, and associated interpretation, much easier to measure and interpret than in the detection systems of the current methods.

This work was done by Timothy J. Bencic of Glenn Research Center. 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: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18761-1.

Standardization of a Volumetric Displacement Measurement for Two-Body Abrasion Scratch Test Data Analysis

A more robust method is proposed that takes into account the full three-dimensional profile of the displaced material.

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A limitation has been identified in the existing test standards used for making controlled, two-body abrasion scratch measurements based solely on the width of the resultant score on the surface of the material. A new, more robust method is proposed for analyzing a surface scratch that takes into account the full three-dimensional profile of the displaced material. To accomplish this, a set of four volume-displacement metrics was systematically defined by normalizing the overall surface profile to denote statistically the area of relevance, termed the Zone of Interaction. From this baseline, depth of the trough and height of the plowed material are factored into the overall deformation assessment. Proof-of-concept data were collected and analyzed to demonstrate the performance of this proposed methodology. This technique takes advantage of advanced imaging capabilities that allow resolution of the scratched surface to be quantified in greater detail than was previously achievable.

When reviewing existing data analysis techniques for conducting two-body