Nanocomposite Strain Gauges Having Small TCRs

Usefully large gauge factors and acceptably small drifts should also be attainable.

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Ceramic strain gauges in which the strain-sensitive electrically conductive strips made from nanocomposites of noble metal and indium tin oxide (ITO) are being developed for use in gas turbine engines and other power-generation systems in which gas temperatures can exceed 1,500°F (about 816°C). In general, strain gauges exhibit spurious thermally induced components of response denoted apparent strain. When temperature varies, a strain-gauge material that has a nonzero temperature coefficient of resistance (TCR) exhibits an undesired change in electrical resistance that can be mistaken for the change in resistance caused by a change in strain. It would be desirable to formulate strain-gauge materials having TCRs as small as possible so as to minimize apparent strain.

Most metals exhibit positive TCRs, while most semiconductors, including ITO, exhibit negative TCRs. The present development is based on the idea of using the negative TCR of ITO to counter the positive TCRs of noble metals and of obtaining the benefit of the ability of both ITO and noble metals to endure high temperatures. The noble metal used in this development thus far has been platinum. Combinatorial libraries of many ceramic strain gauges containing nanocomposites of various proportions of ITO and platinum were fabricated by reactive co-sputtering from ITO and platinum targets onto alumina- and zirconia-based substrates mounted at various positions between the targets. TCR values of the sensors were determined from measurements made in thermal cycling between room...
The TCRs (slopes of electrical resistance versus temperature) of five platinum/ITO nanocomposite films having different compositions ranged from negative to near zero to slightly positive, suggesting that it should be possible to formulate platinum/ITO composites having TCRs very close to zero.

The chemical compositions of the most promising combinatorial libraries were analyzed by energy-dispersive x-ray spectrometry and scanning electron microscopy. Preliminary results (see figure) have been interpreted as indicating that TCRs near zero, from room temperature to 1,000°C, could be achieved even in non-optimized platinum/ITO nanocomposite strain gauges containing approximately 12 weight percent of ITO. For one such strain gauge, the gauge factor was found to be relatively large (≈26) and the drift rate very low (0.018 percent/h). On the basis of these and similar results, other combinatorial libraries of composites of ITO with Pd, Ni, NiCoCrAlY alloys, W, and Ir are also under consideration.

This work was done by Otto Gregory and Ximing Chen of the University of Rhode Island for 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: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18253-1.