Very High Output Thermoelectric Devices Based on ITO Nanocomposites

Thermocouples based on this material perform better than precious-metal thermocouples.

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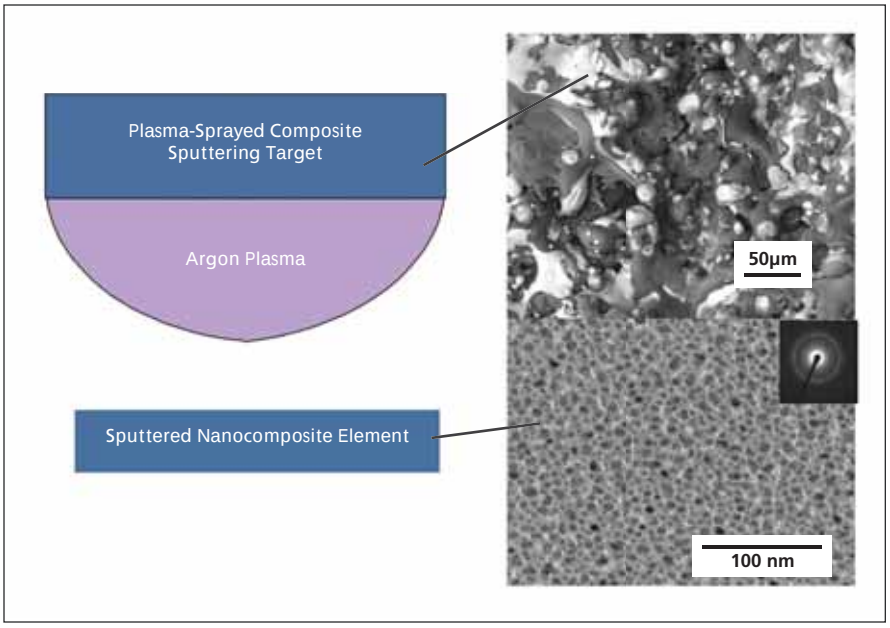
A material having useful thermoelectric properties was synthesized by combining indium-tin-oxide (ITO) with a NiCoCrAlY alloy/alumina cermet. This material had a very large Seebeck coefficient with electromotive-force-versus-temperature behavior that is considered to be excellent with respect to utility in thermocouples and other thermoelectric devices. When deposited in thin-film form, ceramic thermocouples offer advantages over precious-metal (based, variously, on platinum or rhodium) thermocouples that are typically used in gas turbines. Ceramic thermocouples exhibit high melting temperatures, chemical stability at high temperatures, and little or no electromigration. Oxide ceramics also resist oxidation better than metal thermocouples, cost substantially less than precious-metal thermocouples, and, unlike precious-metal thermocouples, do not exert catalytic effects.

Ceramic thermocouples based on the present indium-tin-oxide/(NiCoCrAlY-alloy/alumina nanocomposite) combination were demonstrated at temperatures up to 1,200 °C. An SEM (scanning electron microscope) micrograph of the starting NiCoCrAlY-alloy/alumina composite material and resulting NiCoCrAlY-alloy/alumina nanocomposite produced by sputtering is shown in the figure.

In other tests, thin-film thermocouples were synthesized by directly combining indium-tin-oxide and a NiCoCrAlY alloy at small length scales to form "n-type" and "p-type" nanocomposites. These indium-tin-oxide/NiCoCrAlY nanocomposites exhibited extremely large and stable Seebeck coefficients (S> 2000 μV/K) when thermally cycled between room temperature and 1,500 °C. From observations made in these tests, it was concluded that the sensitivity and other aspects of performance of these thermocouples are large enough to be considered for energy harvesting applications and superior to those of precious-metal thermocouples.



SEM Micrograph is shown of the starting NiCoCrAlY-alloy/alumina composite material and resulting NiCoCrAlY-alloy/alumina nanocomposite produced by sputtering. Note the distribution of phases at small length scales in the nanocomposite (TEM in lower right).

This work was done by Otto J. Gregory of the University of Rhode Island and Gustave Fralick of the Glenn Research Center.

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-18120-1.