It is difficult to make large glass sheets having thicknesses less than 3 mm, and 3-mm-thick glass sheets are too stiff to be deformable to the shapes typically required for correction of wavefronts of light that has traversed the terrestrial atmosphere. Moreover, the primary commercially produced candidate low-thermal-expansion glass is easily fractured when in the form of thin face sheets.

Graphite-filled cyanate ester has relevant properties similar to those of the low-expansion glasses. These properties include a coefficient of thermal expansion (CTE) of the order of a hundredth of the CTEs of other typical mirror materials. The Young's modulus (which quantifies stiffness in tension and compression) of graphite-filled cyanate ester is also similar to the Young's moduli of low-thermal-expansion glasses. However, the fracture toughness of graphite-filled cyanate ester is much greater than that of the primary candidate low-thermal-expansion glass. Therefore, graphite-filled cyanate ester could be made into nearly unbreakable face sheets, having maximum linear dimensions greater than a meter and thicknesses of the order of a millimeter, that would satisfy the requirements for use in adaptive optics.

This work was done by Harold Bennett and Joseph Shaffer of Bennett Optical Research, Inc. and Robert Romeo of Composite Mirror Applications, Inc. for Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32337-1.

Atomized BaF_2-CaF_2 for Better-Flowing Plasma-Spray Feedstock

Water atomization is better suited to high-volume production of metal fluoride than conventional methods.

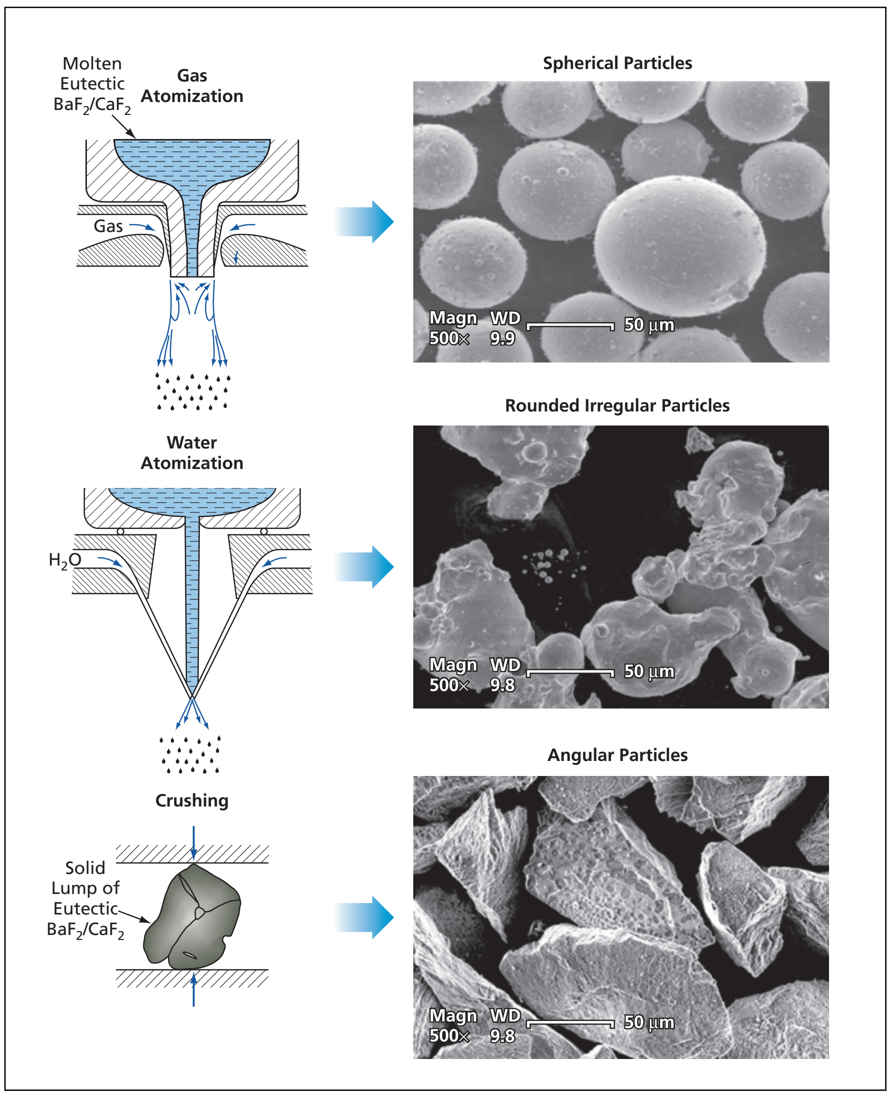
John H. Glenn Research Center, Cleveland, Ohio

Atomization of a molten mixture of BaF_2 and CaF_2 has been found to be superior to crushing of bulk solid BaF_2-CaF_2 as a means of producing eutectic BaF_2-CaF_2 powder for use as an ingredient of the powder feedstock of a high-temperature solid lubricant material known as PS304. Developed to reduce friction and wear in turbomachines that incorporate foil air bearings, PS304 is applied to metal substrates by plasma spraying. The constituents of PS304 are:

- An alloy of 80 weight percent Ni and 20 weight percent Cr,
- Cr_2O_3,
- Ag, and
- The BaF_2-CaF_2 eutectic — specifically, 62 weight percent BaF_2 and 38 weight percent CaF_2.

The superiority of atomization as a means of producing the eutectic BaF_2-CaF_2 powder lies in (1) the shapes of the BaF_2-CaF_2 particles produced and (2) the resulting flow properties of the PS304 feedstock powder: The particles produced through crushing are angular, whereas those produced through atomization are more rounded. PS304 feedstock powder containing the more rounded BaF_2-CaF_2 particles flows more freely and more predictably, as is preferable for plasma spraying.

Two well-known atomization processes (gas atomization and water atomization) have been investigated, in comparison with crushing, as means of producing eutectic BaF_2-CaF_2 powders (see figure). The particles produced by gas atomization are the most nearly spherical, but each batch contains only a small proportion of particles in the



Water Atomization produces particles intermediate in shape to those produced by gas atomization and crushing. Water atomization may be economically the most advantageous of the three techniques.

size range (20 to 100 µm) suitable for plasma spraying and a much larger proportion of undesired finer particles. Water atomization yields particles that are less spherical in character but still more rounded than those produced by crushing, and yields a greater proportion of usable particles.

As one might expect from the intermediate nature of the shapes of water-atomized BaF_2-CaF_2 particle shapes, the flow properties of PS304 powders containing water-atomized BaF_2-CaF_2 are intermediate to those of PS304 powders containing equal proportions of gas-atomized BaF_2-CaF_2 and those containing equal proportions of crushed BaF_2-CaF_2. Inasmuch as water atomization tends to be less expensive and better suited to high-volume production than is gas atomization, water atomization could be preferable for applications in which the shapes of the eutectic BaF_2-CaF_2 particles are not required to closely approximate spheres and the intermediate flow properties are acceptable.

This work was done by Christopher DellaCorte of Glenn Research Center and Malcolm K. Stanford of the University of Dayton. 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-17709-1.

Nanophase Nickel-Zirconium Alloys for Fuel Cells

Corrosion resistance can be achieved at lower cost.

NASA's Jet Propulsion Laboratory, Pasadena, California

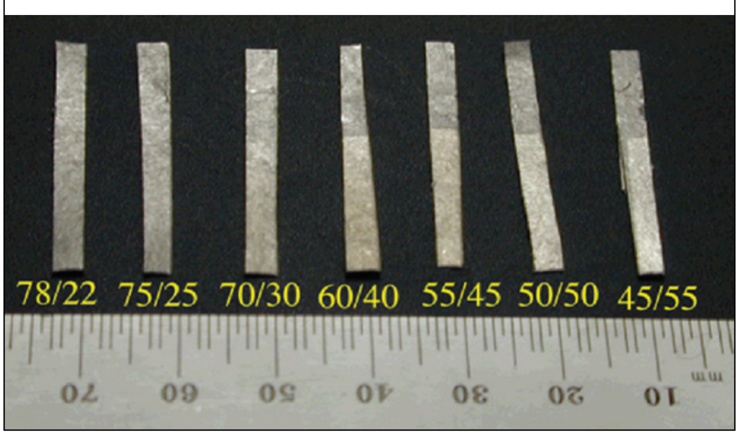
Nanophase nickel-zirconium alloys have been investigated for use as electrically conductive coatings and catalyst supports in fuel cells. Heretofore, noble metals have been used because they resist corrosion in the harsh, acidic fuel-cell interior environments. However, the high cost of noble metals has prompted a search for less-costly substitutes.

Nickel-zirconium alloys belong to a class of base metal alloys formed from transition elements of widely different d-electron configurations. These alloys generally exhibit unique physical, chemical, and metallurgical properties that can include corrosion resistance. Inasmuch as corrosion is accelerated by free-energy differences between bulk material and grain boundaries, it was conjectured that amorphous (glassy) and nanophase forms of these alloys could offer the desired corrosion resistance.

For experiments to test the conjecture, thin alloy films containing various proportions of nickel and zirconium were deposited by magnetron and radio-frequency co-sputtering of nickel and zirconium. The results of x-ray diffraction studies of the deposited films suggested that the films had a nanophase and nearly amorphous character.

For tests of corrosion resistance, films of these alloys were deposited on graphite foils to form working electrodes. In each test, the working electrode was immersed in a 2 N sulfuric acid solution and polarized at a succession of potentials in range of 0.05 to 0.75 V versus a normal hydrogen electrode. The steady-state current sustained by the working electrode was monitored at each applied potential. For the alloys containing less than 70 atomic percent nickel, the steady-state current densities were less than 1 nA/cm^2. Inasmuch as current densities less than 100 nA/cm^2 are generally considered indicative of good corrosion resistance, these measurements can be interpreted as indicating excellent corrosion resistance. There was also visual evidence of excellent corrosion resistance (see figure).

Samples With Different Ni/Zr Ratio



Samples of Thin Films of Ni/Zr Alloys were photographed after corrosion testing in sulfuric acid. The numbers next to the strips indicate the alloy compositions in atomic percent of Ni/atomic percent of Zr.

One alloy, comprising 55 atomic percent nickel and 45 atomic percent zirconium, was selected for further tests. In one test, part of a nickel foil was coated with this alloy, then the foil was immersed in sulfuric acid for 48 hours. At the end of the test, the alloy coat remained shiny, while the uncoated part of the foil had become corroded. For another test, a thin film of the alloy was incorporated as a catalyst-support layer in an anode in a fuel cell. The fuel cell was then operated at a temperature of 90 °C for several tens of hours. The fuel cell exhibited stable current densities, indicating that the alloy is stable under fuel-cell operating conditions.

This work was done by Sekharipuram Narayanan, Jay Whitacre, and Thomas Valdez of for Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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