Rare-earth Information Center

Insight

Center for Rare Earths and Magnetics
Ames Laboratory
Institute for Physical Research and Technology
Iowa State University, Ames, Iowa 50011-3020 U.S.A.

Volume 12 | July 1, 1999 | No. 7

Fiber-optic Temperature Sensor

The accurate measurement of process temperatures is extremely important to the processing of the state-of-the-art materials. Typically, thermocouples are used, but they have a number of problems. Many of the commonly used thermocouples are prone to drift with time, and their calibration may change if the temperature gradient along the thermocouple changes. While thermocouples with good long-term stability exist, they tend to have low sensitivity. Thermocouples are, of course, susceptible to RF noise, and are unsuitable for use in many environments, particularly those used for processing semiconductors. As a result, there is considerable interest in fiber optic methods of measuring temperature. Fiber optic optical pyrometers have existed for some time, but their calibration is dependent on often-unknown emissivities. Recently, D. M. Henry et al. {*Appl. Phys. Lett.* 74, [23], 3447-9 (1999)} have demonstrated a fiber optic temperature sensor that will measure temperatures up to 1520 K, using fluorescence decay of the 1.6 μm transition in Er:$Y_3Al_5O_{12}$ (Er:YAG). The temperature-sensing element was grown as the tip of a single crystal YAG fiber. At high temperature, the fluorescence decay is dominated by multiphonon relaxation, which has a strong temperature dependence. The authors estimate that a 1 K-temperature resolution is possible. They also demonstrated that the probe functioned unharmed when immersed directly in a molten aluminum bath.

Al_2O_3-Y_2O_3 Sintering Aid for SiC

SiC has long been considered an outstanding candidate for use as a high temperature structural ceramic. However, for it to be widely used, strong dense pressureless-sintered ceramics are required. While small additions of B and C enhance the densification of SiC via a solid state sintering mechanism, liquid phase sintering is required to produce truly high-density strong ceramics. The Al_2O_3-Y_2O_3 system has what ceramists consider a low eutectic, 1850-2000°C, and it has been used as a sintering aid for SiC. J. H. She and K. Ueno {*Mater. Chem. Phys.*, **59**, 139-42 (1999)} have performed a detailed study of the Al_2O_3+Y_2O_3 additives on the densification behavior and mechanical properties of pressureless-sintered μSiC ceramics. A density of 98% was obtained sintering at 1950°C. The densification was achieved without exaggerated grain growth, resulting in improved mechanical properties.

Production of Nanostructure Yttria Powders

Ceramic powders are extensively used in catalysis. In some applications, such as the use of ceria in automotive catalyst, the ceramic plays an active role while in others it serves as a support for noble metal catalysts. In both cases, a very high surface area per unit volume is required. Thus, ceramic nanoparticles are of considerable interest. While many ceramic particles can be easily made by precipitation, sol-gel

-over-

routes may yield finer particles. S. Roy et al. {*J. Mater. Res.,* 14, [14], 1524-31 (1999)} have discussed making nanostructure yttria powders by preparing a sol, which then undergoes combustion synthesis. In combustion synthesis, the precursors are chosen such that an exothermic reaction results in the formation of the desired phase and some waste gas. In the case described in the paper, mixing yttrium nitrate with citric acid while heating in water forms a gel. As the water is driven off a transparent gel is formed. Further heating precipitate is formed and then the gel combusts. The paper deals extensively with the combustion process as a function of the reductant / oxidant ratio. As with the fuel / air ratio in any burning process, the resultant product is strongly correlated to this ratio. Some products require further calcination to produce pure Y_2O_3. The process occurs at relatively low temperatures allowing the production of nanoparticles though there is some tendency for the particles to coarsen if they must be calcined.

Magnetism and High T_c Superconductivity

When high temperature superconductors were discovered, there were all kinds of speculations about the origin of the phenomena. Initially, many of the fundamental measurements gave results that deviated significantly from what the BCS theory of superconductivity predicts based on the pairing of conduction electrons below T_c. However, as sample quality improved, the values of these properties settled in close to the BCS values, showing that pairing was indeed the origin of the superconducting properties even though the symmetry of the pairs was more exotic. The question that still remains is what is the origin of the pairing. In low temperature superconductors, a phonon pairing mechanism is active, but it is widely accepted that this interaction is not strong enough to account for the observed T_c's. It has long been speculated that some type of magnetic pairing mechanism exists. This viewpoint has received added support from recent inelastic neutron scattering measurements of the magnetic fluctuations in single crystal $YBa_2Cu_3O_7$. A strong correlation is found between the exchange energy associated with the formation of resonance in the magnetic excitations and the electronic specific heat near T_c.

Short Notes:

Sumitomo Special Metals Company Ltd. is reported to have achieved an energy product of 55.8MGOe with a Nd-Fe-B sintered magnet. The high energy product was achieved by enhancing the degree of crystalline alignment and reducing the second phase content while maintaining a 99 % density. {*Jpn. New Mater. Rpt.,* **XIV**, [1], 2 (1999)}

Tokyo Gas company has demonstrated thermoelectric elements with sodium cobalt oxide / zirconium doped neodymium copper oxide couples. Because of the fact that they are oxide based, the new couples can be used to 800°C as compared to 200°C for typical bismuth tellurium couples. Thermoelectric elements are too inefficient to be used for general-purpose power generation, but have potential for turning waste heat into electricity. {*Jpn. New Mater. Rpt.,* **XIV**, [2], 10-11 (1999)}

Researchers at Oita University's Faculty of Engineering (Japan) are using lanthanum gallium oxide as a solid electrolyte for fuel cells. Solid electrolyte fuel cells typically operate at temperatures around 1000°C causing problems with materials. The La-Ga-O material allows operation at 600°C. {*Jpn. New Mater. Rpt.,* **XIV**, [2], 11-12 (1999)}

R. W. McCallum
Director CREM/RIC