### Candidates for Space Observatory Optics: Pyrex and ULE Glasses Withstand Greater Force in Vacuum than Air

Imagine delicate glass discs two meters in diameter floating with the ease of soap bubbles gliding in air. The unencumbered vacuum of outer space may provide just the hospitable environment needed to manufacture sensitive optics for a giant space surveillance observatory. T.A. Manning and D.A. Gregory from the University of Alabama in Huntsville in collaboration with D.S. Tucker and K.A. Herren of NASA Marshall Space Flight Center investigated the strength of Pyrex and Ultra Low Expansion (ULE) glasses in vacuum conditions. In the October issue of the *Journal of the American Ceramic Society* (p. 3318; DOI: 10.1111/j.1551-2916.2007.01872.x), the researchers report that at room temperature, Pyrex and ULE glass discs showed 54% and 82% greater average strength, respectively, in vacuum over discs tested in 1 atm air pressure.

To accomplish the strength tests, the researchers designed and built a strength-testing device inside a vacuum chamber. During a test, a thin glass disc sample rested flat on three points while a spherical contact applied a downward load to the top disc surface. The researchers attribute part of the observed increase in strength of the materials in vacuum to the absence of subcritical crack growth commonly caused by water vapor.

Manning and colleagues also examined the impact of mild heat treatment on glass strength in vacuum. They held 12 samples of both materials at 200°C for 24 h in vacuum and then strength tested samples in vacuum at 50°C. The glass transition temperature of Pyrex is 560°C and of ULE is 1000°C. Heat treatment did not cause a statistically significant change in the strength of either material in vacuum.

The researchers look forward to learning whether the theoretical strength of the glasses can be obtained in space. "The logical and more ambitious extension of this experiment would be to actually melt glass under vacuum, shape and cool it to form glass discs, and then measure the strength of those discs *in situ*," they stated.

ASHLEY PREDITH

### Yb:YAG Ceramic Laser Produced by Solid-State Reactive Sintering

Recent advances in high-performance InGaAs laser diodes emitting in the 0.9–1.1 μm range have stimulated the interest in developing diode-pumped $Yb^{3+}$ ceramic lasers. A team of researchers associated with the Chinese Academy of Sciences (Y. Wu, J. Li, Y. Pan, and J. Guo from the Shanghai Institute of Ceramics, in collaboration with B. Jiang, Y. Xu, and J. Xu from the Shanghai Institute of Optics and Fine Mechanics) have fabricated fully transparent Yb:YAG ceramics by a simple solid-state reaction, as they reported in the October issue of the *Journal of the American Ceramic Society* (p. 3334; DOI: 10.1111/j.1551-2916.2007.01885.x).

The researchers used high-purity commercially available α-$Al_2O_3$, $Y_2O_3$, and $Yb_2O_3$ powders that weighed in proportion to the stoichiometry of 1 at.% Yb:YAG. They mixed these reagents by ball milling in anhydrous alcohol for 12 h, adding a binder, dispersion medium, and 0.5 wt% tetraethyl orthosilicate as a sintering aid. The speed of the ball-milling machine was controlled to mix the powders evenly, but to avoid crushing the particles into smaller sizes, which could incorporate impurities. The research team dried and sieved the mixtures, and dry pressed them at 100 MPa into 20 mm diameter disks. They then cold isostatically pressed the mixtures at 250 MPa, and removed organic components by calcining at 1000ºC. The material was vacuum sintered at 1730ºC for 10 h and then annealed at 1450ºC for 20 h in air. The researchers obtained highly transparent 1% Yb:YAG ceramics with a uniform grain size of <10 μm, and a transmittance of about 80% in the visible and the near-IR regions. They observed that the phase of sintering from 1500ºC to 1700ºC had to be controlled for efficient grain growth without encapsulating the pores.

After annealing, the samples showed three strong absorption peaks centered at 916 nm, 941 nm, and 968 nm corresponding to the $^2F_{7/2} \rightarrow {}^2F_{5/2}$ transition of $Yb^{3+}$, and a weak absorption peak at 1030 nm attributed to the fluorescent effect of $Yb^{3+}$. For laser experiments, the Yb:YAG ceramics were mirror polished on both surfaces. The input face was coated to be accessed by light from the 940 nm pump fiber-coupled laser diode while the output face was coated to allow a high transmission of the generated light at 1030 nm. The laser cavity consisted of an input coupler flat dichroic mirror coated for antireflection at 940 nm and high reflection at 1030 nm, and a concave mirror (R = 300 mm) with different transmissions, as the output coupler (OC). The laser threshold increased from 1.8 W to 2.1 W as the OC transmission increased from 4% to 10%. The maximum output power (1.02 W) was obtained with a slope efficiency of 25% and an optical-to-optical efficiency of 15.4% when the transmission was 10%. The output power increased linearly with an increase of input power.

JOAN J. CARVAJAL

### Carbon Nanocubes Display Cubic Mesoporosity

Nanoparticles with well-defined mesoporosities are currently of interest for applications involving adsorption, such as controlled drug release, energy storage, chromatography, and catalysis, because of their increased surface areas compared to bulk materials. Mesoporous silica spheres, fabricated using mature sol-gel chemistry, have been studied at length but mesoporous carbon particles are appealing due to their electrical conductivity and chemical inertness. In particular, the development of fuel cells, which rely on facile mass transport, would benefit from ordered mesoporous carbon particles with dimensions ~100 nm. The nanocasting approaches typically employed to prepare mesoporous carbon particles use as hard templates mesoporous silica particles, the removal of which requires either HF or strong bases. A newer, aerosol-based, self-assembly technique produces either polydisperse carbon spheres with disordered mesopores or fairly monodisperse carbon microspheres with ordered porosity. More recently, however, Z. Wang, F. Li, and A. Stein of the University of Minnesota developed a facile method for the direct synthesis of monodisperse carbon nanoparticles with ordered mesoporosity in high yield. The method involves copolymer templating within the confinement of a colloidal crystal and does not use HF or strong bases.

As reported in the October issue of *Nano Letters* (p. 3223; DOI: 10.1021/nl072068j), the researchers infiltrated until fully wetted monolithic colloidal crystal templates composed of poly(methyl methacrylate) (PMMA) spheres (diameter = 416±11 nm) with a homogeneous precursor solution (Pluronic F127—a triblock polymer surfactant [$EO_{97}PO_{69}EO_{97}$, BASF]—added to a mixture of phenolic resin, ethanol, and aqueous HCl and stirred for 6 h). After removing the solvent by exposure to reduced pressure (0.5 mm Hg) for 3 h, the monoliths were thermally polymerized within a closed container at 100˚C for 48 h. Heating under flowing $N_2$ at 400˚C for 3 h and then at 900˚C for 2 h yielded carbonaceous samples, which the researchers designated MSP-3. Assuming a fully crosslinked phenolic resin, the carbon yield was 94 wt%.

The researchers used scanning electron microscopy to show that the pyrolized products contain nanoparticles with a bimodal size distribution: nanocubes with

edge lengths of 150 nm ± 5 nm and nanospheres with diameters of 67 nm ± 9 nm. The researchers said that the ratio of cubes to spheres is close to the theoretical ratio (1:2) of the number of holes with octahedral and tetrahedral symmetry, respectively, in the face-centered cubic colloidal crystal template. Using transmission electron microscopy on a single nanocube, the mesopore symmetry was shown to be cubic, pore diameters were estimated at 2.4 nm, and the average unit cell length was determined to be 18.4 nm ± 0.8 nm. Ordered mesopores could not be observed in the nanospheres. The symmetry axis of the nanocubes coincided with the cubic mesopore arrays, suggesting to the researchers that the confinement by the colloidal crystal template influenced the arrangement of the surfactant micelles. Overall mesostructural ordering was verified with small-angle x-ray scattering but detailed information was obtained from nitrogen sorption measurements, which showed that the entire pore system is accessible to guest molecules, which, the researchers said, "lends itself to a wide range of applications involving host-guest interactions where guests are separated by predefined distances." They said, "[T]he nanoparticle architecture has an advantage over larger mesostructures in that guests are confined to a countable number of cages limited by the 3D volume of the nanoparticle."

STEVEN TROHALAKI

### Machinable $Ti_3SiC_2$/Hydroxyapatite Bioceramic Composites Prepared by Spark Plasma Sintering

Hydroxyapatite (HAp) is a well known biomaterial for its excellent biocompatibility and ability to bond chemically with host bones. However, the poor mechanical properties of HAp prevent its wide application for load-bearing implants. Researchers at Tsinghua University in China have reported a $Ti_3SiC_2$/HAp composite with a significant improvement of bending strength and fracture toughness compared with those of monolithic HAp.

As described in the October issue of the *Journal of the American Ceramic Society* (p. 3331; DOI: 10.1111/j.1551-2916.2007.01882.x), S.L. Shi and W. Pan prepared $Ti_3SiC_2$/ $(Ca_{10}(PO_4)_6(OH)_2)$ composites using spark plasma sintering.

The mechanical properties of the fabricated $Ti_3SiC_2$/HAp were examined using the three-point bending test and the Vickers hardness test. The bending strength and fracture toughness of the composites were improved significantly with adding $Ti_3SiC_2$. With 50 vol% $Ti_3SiC_2$, maximum bending strength and fracture toughness values were achieved with 250 MPa ± 10 MPa and 3.9 MPa·$m^{1/2}$ ± 0.1 MPa·$m^{1/2}$, respectively. The bending strength and fracture toughness were two to three times and two to five times higher than that of monolithic HAp. The researchers attribute the increase of bending strength to matrix strengthening. They also attribute the enhancement of fracture toughness to the synergistic effect of matrix strengthening and energy-absorbing mechanisms of individual grains of $Ti_3SiC_2$ platelets.

To characterize the machinability of the composites, the specimen was tested using cemented carbide drills. No evidence of large-scale cracking or chipping was seen in the drilled hole when the $Ti_3SiC_2$ content was higher than 20 vol%, suggesting an excellent machinability according to the researchers. The brittleness index (ratio of the Vickers hardness to the fracture toughness) of the composites decreases with increasing $Ti_3SiC_2$ content. The researchers conclude that $Ti_3SiC_2$/HAp composites have excellent mechanical properties and machinability, and "may be attractive for practical applications of novel bone repair and replacement materials."

JING ZHANG

## News of MRS Members/Materials Researchers

**Joanna Aizenberg** has been appointed Gordon McKay Professor of Materials Science in Harvard University's Faculty of Arts and Sciences and its School of Engineering and Applied Sciences (SEAS).

**Lilac Amirav** of the Technion, Haifa, received the **Sara Lee Schupf Postdoctoral Award** by Weizmann Institute of Science to conduct her postdoctoral research on "Improved Solar Energy Harvesting with a Semiconductor-Metal Nanorod Photocatalyst" at the University of California, Berkeley.

**V.S. Arunachalam** of the Center for Study of Science, Technology & Policy in Bangalore, Distinguished Services Professor at Carnegie Mellon University in Pittsburgh, and former Scientific Adviser to India's Defence Minister & Secretary received the **Lifetime Achievement Award** from the Indian Institute of Metals.

**Jacques Aschenbroich** has been named President and CEO of Saint-Gobain Corporation (Valley Forge, Pa.).

**Anna C. Balazs**, Distinguished Professor of Chemical and Petroleum Engineering and Robert Von der Luft Professor in the University of Pittsburgh's chemical and petroleum engineering department, received a **Women in the Material World Award** from the Women and Girls Foundation of Southwest Pennsylvania for her work in determining how building and manufacturing materials interact at the molecular level.

**James L. Dowey** has been named Vice President and Managing Director of Smithers Rapra Technology—formerly Rapra Technology (Shropshire, U.K.).

**Mildred Dresselhaus**, Institute Professor of Electrical Engineering and Physics at the Massachusetts Institute of Technology, has been selected as the North American recipient of a **2007 L'Oréal-UNESCO Award for Women in Science** for "conceptualizing the creation of carbon nanotubes."

**Paul Drzaic** has been appointed Chief Technology Officer at Unidym, Inc. (Menlo Park, Calif.), a majority-owned subsidiary of Arrowhead Research Corporation.

**Rodney Ewing** of the University of Michigan received the **2006 Lomonosov Gold Medal** from the Russian Academy of Sciences in recognition of outstanding achievements in the natural sciences and humanities.

**Daryush Ila**, head of the Alabama A&M University Research Institute, has been elected to serve as the Executive Director of the Alabama Experimental Program to Stimulate Competitive Research (EPSCoR) Steering Committee.

**Himanshu Jain** of Lehigh University has received the **2007 Otto Schott Research Award** for his outstanding work in advancing the understanding of the movement of atoms inside glass.

**Marshall G. Jones** of General Electric's Global Research Center has been named to receive the **2007 Arthur L. Schawlow Award** by the Laser Institute of America.

**Alexander King** has been named the new director of the U.S. Department of Energy's Ames Laboratory at Iowa State University. The appointment is effective January 1, 2008.

**Walter Kob** of the Université Montpellier, France has received the **2007 Otto Schott Research Award** in acknowledgement of his research in the static and dynamic properties of glasses and supercooled liquids with the help of computer simulations.

**Jennifer A. Lewis**, the Hans Thurnauer Professor of Materials Science and Engineering and Willett Faculty Scholar of