monomer's further oxidations followed by treatment with thionyl chloride. The side-chain polyether was then formed by step-growth homogeneous solution polymerization. Its number-averaged molecular weight was 29,000 g/mol and its weight-averaged molecular weight was 44,000 g/mol. The measurement data from surface plasmon resonance spectroscopy showed the synthetic materials to have excellent protein resistance.

This carbohydrate-derived side-chain polyether material combines functionalizability, biodegradability, and protein resistance. Guan's group is now studying the influences of various structural permutations on the biocompatibility and biodegradability of this family of polymers.

YUE HU

## Mesostructured Silica Thin Films with Spherical Voids Organized in a BCC Array Achieved

In the development of the microelectronics industry, device physics is not the only limiting factor for continued performance improvements in systems. Challenges remain in carrying electric power, and distributing clock signals that control the timing and synchronize the operation. The propagation velocity of electromagnetic waves will become increasingly important due to their unyielding constraints on interconnect delay. The introduction of Cu and low-κ dielectrics has incrementally improved the situation, as compared to the conventional $Al/SiO_2$ technology, by reducing both resistivity and capacitance between wires. Silica materials composed of nanometer-scale isolated, but ordered, pores, exhibiting low dielectric constants and good mechanical properties, are highly desirable for future semiconductor devices. In the January issue of *Advanced Functional Materials* and September issues of *Langmiur*, K. Yu of the National Research Council Canada, C.J. Brinker of Sandia National Laboratories, and their colleagues have published a series of articles on the synthesis and comprehensive characterization of mesostructured methyl-silica ($CH_3$-$SiO_{3/2}$) thin-films consisting of isolated spherical voids organized in a body-centered cubic (bcc) array. The closed porosity and controlled hydrophobicity should yield low dielectric constant values for these thin film materials.

The films were synthesized on silicon substrates using solvent evaporation-induced sol-gel and self-assembly processes (EISGSA), with polystyrene-*block*-poly(ethylene oxide) (PS-*b*-PEO) as a structure-directing agent and MTES ($CH_3$-$Si(OCH_2CH_3)_3$) as the silica precursor. Afterwards, pyrolysis in argon was performed carefully to remove the template. This synthetic approach was designed to suppress the condensation of the inorganic network allowing co-self-assembly of the silica and the amphiphile PS-*b*-PEO, followed by retraction of the PEO chains from the silica matrix and matrix consolidation to occur unimpeded. The researchers proposed a solvent-mediated formation mechanism for the absence of microporosity.

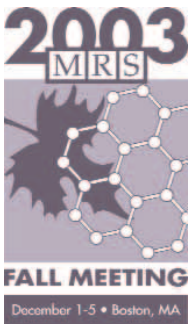
An unusual transmission electron microscopy (TEM) approach was developed to resolve the mesostructure. This approach involved sample tilting to obtain different zone axes, simulation, as well as the calculation of plane spacings and angles for comparison of the experimental values with corresponding theoretical ones. The mesostructure was conclusively found to be body-centered cubic (bcc) rather than face-centered cubic (fcc). In addition, the bcc mesostructure with a slight distortion was assigned to a body-centered tetragonal (bct) structure with $a = 13.5$ nm and $c = 13.0$ nm. Two types of dislocations were observed by TEM: an edge dislocation and a dislocation dipole. The development of the edge dislocation was argued to partially relieve the tensile strain developed during the film shrinkage in the fabrication process; the researchers proposed a new concept, namely critical mesostructure thickness for the occurrence of the stress relaxation, which was computed using an elastic strain energy argument. The bcc mesostructure was also confirmed by grazing incidence small-angle x-ray scattering (GISAXS).

In addition to the mesostructure, the researchers characterized the microstructure thoroughly, using nitrogen sorption and gas permeation measurements, in addition to TEM and GISAXS. The GISAXS study indicated that there was essentially no microporosity in the calcined film. The absence of microporosity was also in agreement with surface acoustic wave nitrogen sorption thin film measurements, a technique suitable for the characterization of pore sizes larger than 0.4 nm. Magic angle spinning solid-state $^{29}Si$ and $^{13}C$ nuclear magnetic resonance and the GISAXS experiments proved the maintenance of Si–$CH_3$ bonds in the film after pyrolysis in argon. The presence of the methyl ligands after calcination was also in agreement with the contact angle measurement of ~115°.

The self-assembled MTES-derived silica thin film with isolated bcc-arranged voids provides a conceptual route to the fabrication of materials with nanosized voids arranged in a cubic array as well as with controllable hydrophobicity. The researchers said that "concerning the utilization of porous materials as low-κ dielectric insulators, cubic arrangements of isolated spherical pores are expected to maximize the modulus for a given porosity. Thus, the PS-*b*-PEO-templated films and related ordered closed porosity films should be of general interest to the microelectronics community."

MAXIM NIKIFOROV







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