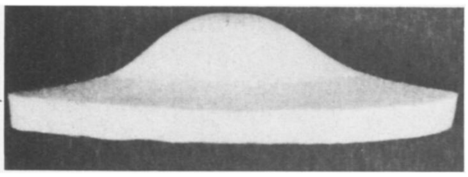
Materials Science

Elizabeth Pennisi reports from Boston at a meeting of the Materials Research Society

Ever-finer powders for improved ceramics

Many materials stretch like taffy: They get weaker as they are pulled and eventually break. But some metals and a few ceramics are "superplastic": They can deform quite a bit before losing any of their integrity. This means that scientists or manufacturers can mold these materials into desired shapes, something they have difficulty doing with most ceramics.



Wilkinson/McMaster

Deformation did not weaken this superplastic ceramic.

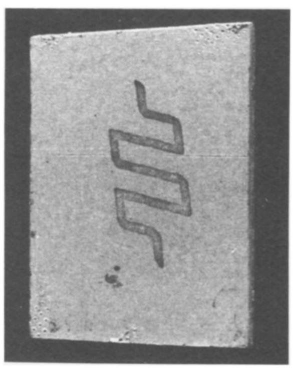
Canadian scientists have now worked out a way to create new superplastic ceramics by using much finer starting materials than those typically used. The finer the starting powder, the finer the grain in the finished ceramic and the more likely it is to be superplastic, explains David S. Wilkinson, a materials engineer at McMaster University in Hamilton, Ontario.

In a process known as tape-casting, he and his colleagues use a slurry of aluminum powder to make a thin film. In order for this process to work, the researchers first had to figure out how to make the slurry liquid enough to pour on a plate, where the film then forms, Wilkinson says. They also add zirconium to help prevent clumping of the powder grains. To make the finished material, they then stack layers of film.

Tape-cast superplastic ceramics may prove useful for making wear-resistant coatings or cutting tools, Wilkinson says.

Cooking up copper devices with Teflon

Materials scientists have developed a simple procedure for making electronic devices such as circuit boards out of copper and (poly)tetrafluoroethylene — better known by its trade name, Teflon. The faster and more compact computers become, the more engineers want to use Teflon-based components because Teflon isolates closely spaced circuits better than most other materials, says Robert R. Rye of Sandia National Laboratories in Albuquerque, N.M. Until now, however, Teflon's inert nature meant the material required eight processing steps before it could be used in these components.



Gerry Fowler/Sandia

Simple technique yields patterns in copper-coated Teflon.

Rye and colleagues from the University of New Mexico in Albuquerque form a patterned copper coating on Teflon in three steps. First, they use X-rays aimed through a mask or a beam of electrons to trace a pattern on the Teflon. To the naked eye, the irradiated Teflon appears unaffected, but spectroscopic studies indicate that its surface chemistry does change, Rye says. The ends of the molecules open and then link with each other. "It makes the surface of the Teflon stiff, because you've tied up everything," he notes.

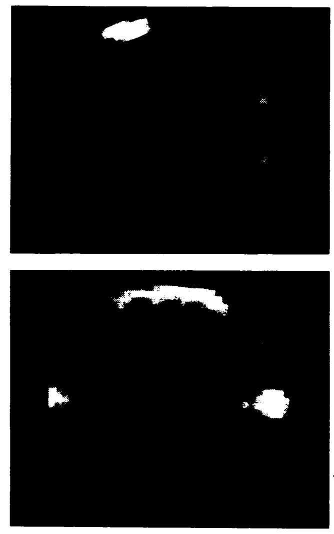
The researchers then etch the unaltered areas with a sodium solution to make it receptive to copper atoms, says Rye. Finally, they lay down copper in those areas, using a newly developed starting compound and a process called chemical vapor deposition.

The scientists say they can vary the width of the pattern lines by changing the width of the X-ray or electron beam used, and they expect to make pattern lines thinner than 30 angstroms.

Space Science

Jupiter and Earth: Something in the air

Diminutive Earth and giant Jupiter appear about as twinlike as Danny DeVito and Arnold Schwarzenegger. But the upper atmosphere of these seemingly disparate planets may have more in common than meets the eye.



Friedson and Orton, JPL/NASA

Infrared images of Jupiter taken in 1987 and 1990 reveal stratospheric warming (indicated by lighter color in bottom photo) along the equatorial band.

When Glenn S. Orton and A. James Friedson began studying heat emissions from Jupiter's stratosphere 11 years ago, they weren't looking for similarities in the Jovian and terrestrial atmospheres. Rather, these scientists at the Jet Propulsion Laboratory in Pasadena, Calif., and their colleagues wanted to learn more about storms deep within the Jovian atmosphere by studying temperature fluctuations at higher altitudes.

Using NASA's Infrared Telescope Facility atop Mauna Kea in Hawaii, the researchers found that heat emissions from methane over Jupiter's equator wax and wane in a four- to six-year cycle. Since Jupiter's stratospheric methane levels remain relatively constant, the researchers interpreted their results as direct evidence that the planet's equatorial stratosphere alternates between warm and cold periods. Orton and Friedson's team unveiled these findings in the April 26, 1991 SCIENCE.

That report captured the interest of Conway B. Leovy at the University of Washington in Seattle. He recognized that the Jovian findings resemble periodically alternating wind patterns over Earth's equator. Upper stratospheric winds switch direction about once every six months; winds in the lower stratosphere reverse roughly every two years, an effect called the Quasi-Biennial Oscillation (QBO).

Scientists trace the semi-annual wind switch above Earth to seasonal sunlight-related differences that have no apparent parallel on Jupiter. But the detailed pattern and location of QBOs bear a strong similarity to the periodic temperature fluctuations in Jupiter's atmosphere — and might also resemble features of other planets' atmospheres, Leovy asserts.

Indeed, Leovy suspects that temperature changes in Jupiter's stratosphere may create a longer-period, QBO-like wind system. Moreover, notes Leovy, the phenomenon underlying the shift in Jovian winds may resemble the terrestrial one: Storms that arise in lower layers of the atmosphere and transport heat upward act like a hammer on the stable stratosphere, generating atmospheric waves that alter wind patterns. The high rotation rates of both planets confine such waves to the equator.

While the sun drives QBOs on Earth, Leovy suspects that the small amount of heat left over from Jupiter's formation drives the fluctuations on the giant planet — possibly accounting for their longer period. Leovy, Friedson and Orton detail their comparative study in the Dec. 5 NATURE.

Further studies of Jupiter, Leovy notes, may help elucidate how different layers of Earth's atmosphere interact. The work, he says, also suggests that other planets that rotate rapidly and vigorously transport heat upward may exhibit similar variations in temperature and wind speed.