# Solutia's infrared-absorbing solution

A supplier of automotive glass interlayer products has debuted a new technology on the **Citroën** C4. **Solutia**'s product—Vanceva solar—uses nano-particles to accomplish infrared (IR) absorption.

Infrared-absorbing polyvinyl butyral (PVB) has been bantered about as an idea since the 1960s, but "initial R&D for the Vanceva brand solar product started in 1996, with strong efforts beginning in 1998 when it was realized that advancements in IR-absorbing materials development meant that an IR-absorbing PVB could be brought to reality," said Paul Garrett, Science Fellow for Solutia.

Development of the actual formulation commercialized in the Vanceva solar product began in mid-2000. The architectural market saw the product in mid-2002, and for the 2005 model year, the automotive market sees a first-generation product. "For glazing in general, Solutia's Vanceva brand solar product is another tool for controlling solar heat load along with solar tinted glass, sputter-coated glass, sputter-coated films, and tinted window films," Garrett said.

Solutia and **Sumitomo Metal Mining** of Japan collaborated to develop a nano-particle dispersion product. "Solutia was searching intensively for IR-absorbing additives for PVB to meet the demanding requirements of solar control glazing. Sumitomo Metal Mining was simultaneously developing lanthanum hexaboride nano-particles for use as solar control coatings on PET window film," said Garrett.

"Lanthanum hexaboride is a semiconducting material that exhibits a strong absorption in the near-infrared when it is in the nanometer size regime. The absorption is due to a phenomenon called 'surface plasmon resonance' that is a result of the nano particles' optical behavior being determined by its surface electrons, which are a higher proportion than its bulk electrons when the particles are that small," explained Garrett, adding, "The nano size of the particles also ensures that light is not scattered—causing haze—in spite of the refractive index difference between the particles and the polymer matrix."

*The Citroën C4, introduced at the Paris Auto Show, features a panoramic laminated glass roof with solar-absorbing nano-particles embedded in the PVB interlayer.*

The C4 uses Vanceva solar in its panoramic glass roof to provide similar benefits associated with established technologies—such as tinted glass and coated glass—for solar control glazing. "In addition, it enhances the flexibility of glazing design by offering another solar control tool. The Vanceva solar product in its various offerings may be used to enhance tinted glass performance in high visibility glazing locations, to create dark color solar tints in combination with clear glass, or be combined with reflective films or coatings," Garrett said.

Windshield applications are possible with Vanceva solar, but "the first generation's product performance does not improve significantly [when] compared to high-performance tinted glass while remaining above required levels of visible transmission," said Garrett, who noted that bus windshields present a first-generation application opportunity since "high-performance tinted glass may not be available."

The product's research and development phase meant overcoming obstacles. "The biggest challenge was to identify IR-absorbing additives that combined

## Briefs

**Specialty Coating Systems** has opened a full-service Parylene conformal coating facility in Shanghai, China. The Shanghai staff has 20 employees. **China Assembly** will be the distributor of Specialty Coatings' Parylene deposition systems. China Assembly is part of the **Cycad** group, from which Specialty Coatings recently purchased **Cycad Specialty Coatings Technology**'s assets.

Nanotechnology is growing in importance as the automotive industry strives for materials solutions to meet stricter emissions and safety regulations, according to **Frost & Sullivan**. The company estimates that the industry spent about $1.1 billion on nanotechnology in 2004. The total penetration of nanotechnology into automotive applications is expected to be about 70% by 2015, with revenues reaching about $6.5 billion. Nanotechnology, the company adds, currently is providing novel and effective means to reduce costs in applications, particularly paints, coatings, and catalytic converters. The efficiency of a single layer of nanomaterial-based coating is comparable to that of three layers of conventional coatings, according to Frost & Sullivan. Demand will rise as end-user awareness increases.

**PPG** and **Kansei Paint** have formed an alliance to sell automotive coatings globally to OEMs. **PPG Kansai Automotive Finishes** initially will target Japanese-based automakers in North America and Europe. Future plans include establishment of sales and marketing operations in Shanghai, China, and in various Asian countries. The companies will also develop new technologies jointly.

**Ashland Composite Polymers** has signed an agreement to purchase the Derakane epoxy vinyl ester resin business (including the Derakane Momentum product line) from **Dow Chemical** for $92 million. The Derakane products are used in the production of fiber-reinforced plastics.

three attributes: 1) excellent IR-blocking performance, 2) long-term durability to UV exposure, and 3) compatibility with typical PVB processing methods and performance properties, such as adhesion to glass, impact strength, and optical clarity," said Garrett.

Dozens of candidates were screened, and many IR-absorbing additives were developed to the near-commercialization stage. "The most difficult attribute to meet was UV durability. Despite advances in the development of UV stable organic dyes, the best durability was found to be inorganic IR-absorbing nano-particles," said Garrett.

Vanceva's solar interlayer is handled and laminated to glass the same way as standard PVB, and the product is essentially no different than reflective coating on glass or PET film in terms of heat load gain when the vehicle is moving. "While parked, the heat load gain for IR-absorbing glazing will be greater than for IR-reflecting glazing using metallic substrates. The difference will depend on the exact properties of the glazing used and the vehicle's design," said Garrett.

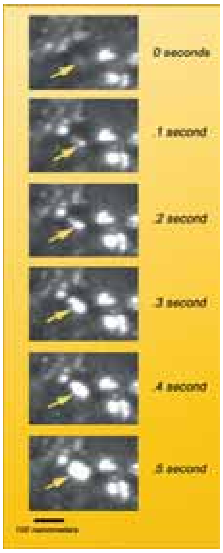
The glass for the C4 was made by **Rioglass** of Spain, and the final roof system was integrated by **Wagon**, a European supplier.

*Kami Buchholz*

# Changing metal shapes at nanometer level

A nanocrystalline metal has an average grain size measured in billionths of a meter, according to researchers at the National Center for Electron Microscopy (NCEM), **Department of Energy**'s **Lawrence Berkeley National Laboratory**. This is a much smaller size than in most ordinary metals.

As the grain size of a metal shrinks, it can become stronger. The downside is that the metal also usually loses ductility. To take advantage of increasing strength with decreasing grain size, researchers must first understand a fundamental problem: by what processes do nanosized crystals of metal stretch, bend, or otherwise deform under strain?




*Frames from a dark-field TEM video of nanocrystalline nickel under strain show rapid aggregation of a group of grains.*

A team of researchers headed by Scott X. Mao of the **University of Pittsburgh**'s Mechanical Engineering Department, working at the NCEM and using high-quality samples of nickel prepared at DOE's **Sandia National Laboratories**, has identified a prominent way in which nanocrystalline metals deform.

Ordinary coarse-grained metals deform when parts of a grain slip past one another as extra planes of atoms, called dislocations, move through the material. The process has been compared to moving a rug by flapping one end of it to create a wave, causing the rug to inch along bit by bit. But the trick won't work if the rug is too short; likewise, if the dimensions of the crystal grains are too small, dislocations can't be created or glide through the grain to allow deformation.

Theorists have proposed that when grain sizes are too small for dislocations, a different mode of deformation comes into play: The grain boundaries themselves move, sliding past one another and allowing the grains to rotate to find new ways of fitting together.

"It's a simple idea," said Zhiwei Shan of Mao's laboratory at Pitt,"and many groups have researched aspects of it, but no one has reported direct evidence of a shift from dislocation-mediated deformation to grain-boundary-mediated deformation." Until

*Zhiwei Shan (sitting) of the University of Pittsburgh works with Eric Stach of Berkeley Lab at the National Center for Electron Microscopy's In-Situ Microscope.*

now, no one was even sure where to look for the transition from one mode of deformation to the other. "When the grains were reduced to 20 nm across? 10? Perhaps as small as 5?"

To search for the effect, Shan used NCEM's In-Situ Microscope. NCEM's Eric Stach explained that what makes the In-Situ's otherwise standard transmission electron microscope unique is that it combines a stage area in which samples can be stressed or manipulated in other ways—and meanwhile videotaped—with a high-voltage, 300-kV electron beam that can penetrate thick samples and yield 0.2 nm resolution.

The nanocrystalline nickel samples were mounted in a probe that placed them under load—stretched them—while images of small regions of the sample were captured on videotape at the standard rate of 30 ft/s (9.1 m/s).

But besides having an excellent instrument, Shan made a crucial observation. An effect that was far from obvious in the most common TEM imaging method, called bright-field imaging, stood out clearly with the different technique of dark-field imaging.

"As the TEM's electron beam passes through a sample, some of the electrons are diffracted," Stach explained. "Bright-field images are constructed using the direct electrons, while dark-field images use the diffracted electrons. In bright-field imaging, regions of the sample that scatter a lot of electrons, like defects such as dislocations, look darker. With dark-field images, strongly diffracting regions look brighter."

Shan concluded that dark-field imaging was critical to the result. When he viewed videotapes of the nickel sample under strain, he saw small regions rapidly brightening and growing larger—direct confirmation of grains sliding and rotating into positions of strong diffraction.

In a bright-field image, these grain-boundary processes would have been impossible to distinguish from lattice dislocations, which in prior attempts is what other groups assumed they were seeing. It took dark-field observations to confirm that below a certain size, grain-boundary rotation indeed becomes prominent. The cut-off isn't sharp, however.

"It's continuous, not a sharp change," Shan said. "In describing grain-boundary deformations we chose the word 'prominent' carefully, because even in nanocrystalline metal, dislocations still play a role." Trapped dislocations in the crystal lattice were observed even when the average grain size was as small as 10 nm.

"The material always chooses the easiest pathway to deform, and that can differ through a range of sizes," said Stach. Although the In-Situ Microscope observations confirm the grain-boundary model of nanocrystalline deformation, whichever process predominates at a given grain size depends on a variety of conditions.

*Patrick Ponticel*

# VW gives Bayer polycarbonate ringing endorsement

Innovation in the application of a **Bayer MaterialScience** polycarbonate, Makrofol DE 1-4, gives the **VW** Golf speedometer the appearance of having an aluminum decorative ring.

Working with speedometer provider **Siemens VDO Automotive** to develop the component, Bayer employed a proprietary process in which the polycarbonate used for the speedometer dial itself is pressure-formed so its circumference is lent a matte metallic appearance. The matte appearance is retained because the film can be formed with great precision significantly below the $T_G$ (glass temperature) of the polycarbonate.


*The dial ring looks like aluminum, but it is really a Bayer polycarbonate formed to look metallic.*

The process eliminates several steps otherwise necessary, including electroplating.

The film is 375 µm (0.015 in) thick and is printed on both sides with more than 10 layers of ink using the screen-printing method. The translucent symbols are gray and are backlit by colored LEDs.

Bayer currently is developing new materials and processes to give dial designers more creative freedom and to make the manufacturing process more cost-effective.

*Patrick Ponticel*