vises. “The front desk and the furniture in the hotel’s architecture is outstanding — but I really would have liked to have shown you our rail shuttle. The high-tech systems department at Siemens Corporate Technologies received an environmental design award. But since we’re fully booked, I’m sure it uses a lot of electricity… “We have a sophisticated and extremely energy-efficient system here that consists of energy-saving lighting, low-emitting diodes, sensors, and high-tech electronics. All of this has reduced energy consumption by nearly 80 percent compared to what was used to be the norm. All corridors and rooms have motion detectors, and we also mix natural and artificial light, which not only makes for a more natural lighting atmosphere, but also conserves energy. Anybody suffring from jet lag — that is almost everybody these days — can recuperate with a light-pulse shower in our Roman thermal baths.” Hey, and they even have splashing water, dim lights, carafes with wine, scented oils, a massage table — oh, I almost tripped into a fountain over there. What’s that strange vibration under my feet? The hotel manager grins. “You’re lucky! Anyone who gets too close to our fountain of youth, as we call it, gets a warning from vibration sensors integrated into the floor.” I look down and see a beautiful ancient Roman mosaic floor. “The mosaic in the lobby, as well as the furniture are sealed with a dirt-repellent nano-coating,” the manager continues. “The use of plastics produced by bacteria should shields fulfill the same function in the annular combustion chambers of gas turbines (p. 53). Additional existing enhanced efficiency systems technologies include light-emitting diodes (LEDs), which are destined to become one of the most environmentally compatible forms of lighting around. They consume around 80 per- cent less electricity than conventional incan- descent lamps and also last as much as 50 times longer. Their use will help make rail systems more environmentally compatible thanks to the use of new materials. They use a third less power than their conventional counterparts. Below 150 nanometers — a nanometer is one billionth of a meter — particles are freed-up, so to speak, after which decomposition products are non-toxic as well. “No fun for graffiti artists here. “Oh no! I just got that car three months ago! I better go take a look. Luckily, it turns out to be only a small scratch that’ll heal by itself, because in just a few minutes the nano-based body paint will re- generate. So no need to go to the repair shop. And at least the car’s been broken in now. O.K., let me get back to the tour; it’s really exciting. “And speaking of energy supplies, if you’ve got some time later, you should have a look at our combined cycle power plant, which is right nearby. As a lover of art, I have to say I think the facility’s architecture is outstanding — but those of you who are more interested in technology will find it fascinating too. So take a look, and make sure the technicians there tell you about some of the secrets of nano-coatings. "Now please follow me into the lobby. “As it turns out, the lobby is a lighting paradise, and I’m sure it uses a lot of electricity… “We have a sophisticated and extremely energy-efficient system here that consists of energy-saving lighting, low-emitting diodes, sensors, and high-tech electronics. All of this has reduced energy consumption by nearly 80 percent compared to what was used to be the norm. All corridors and rooms have motion detectors, and we also mix natural and artificial light, which not only makes for a more natural lighting atmosphere, but also conserves energy. Anybody suffering from jet lag — that is almost everybody these days — can recuperate with a light-pulse shower in our Roman thermal baths.” Hey, and they even have splashing water, dim lights, carafes with wine, scented oils, a massage table — oh, I almost tripped into a fountain over there. What’s that strange vibration under my feet? The hotel manager grins. “You’re lucky! Anyone who gets too close to our fountain of youth, as we call it, gets a warning from vibration sensors integrated into the floor.” I look down and see a beautiful ancient Roman mosaic floor. “The mosaic in the lobby, as well as the furniture are sealed with a dirt-repellent nano-coating,” the manager continues. “The use of plastics produced by bacteria should...
sorber of UV light, which is why nanotechnol-
ogy is even impacting products such as cosmet-
ics (sunscreen lotions). Another example is gold.
Although known for being extremely inert and
difficult to corrode, it is therefore a favored anticorrosion agent for high-grade components, gold as a nanoparticle is in fact extremely reactive — a new material property which is now being exploited in the development of new catalysts.

Once again, the reason for this is the differ-
ence between a nanoparticle’s surface area and its volume. Whereas a solid cube of one cubic centimeter has a surface area of six square centimeters, the same-sized cube filled with particles each 10 nanometers in diameter has a surface area of around 450 square meters — some 740,000 times as much. “The great thing is that each element and each structure can in principle be reduced to the nanoscale, where it then exhibit completely different properties,” says Grönke.

Nanotechnology opens the door to a host of materials with new properties.

Better Cabin Air. Siemens’ research for the NanoBase project is also focusing on highly active catalytic coatings, which — when incor-
porated in an appropriate catalytic system — will be able, for example, to decompose ozone in surrounding air. “These ozone converters could be used in aircraft air conditioning units,” Jensen explains.

At an altitude of 10,000 meters the air con-
tains about 550 ppb of ozone per cubic meter, which means it must be treated before being fed into the cabin. That’s because ozone is an aggressive and noxious gas. Regulations stipu-
late a maximum permissible volume of 100 ppb over a three-hour period. Current aircraft

air conditioning systems transform ozone into oxygen, but only at temperatures of between 150 and 200 degrees Celsius before cooling it to cabin temperature. At these high tem-
peratures, catalytic converters using precious metals can efficiently decompose ozone into oxygen.

The goal of Germany’s NanoBase project is to develop materials that will support the trans-
formation of ozone into oxygen without the use of precious metals and at temperatures well under 100 degrees Celsius. This would give more flexibility to aircraft air conditioning designs since converters would no longer be dependent on the use of high temperatures. This will be particularly important for planes that, for example, use electric compressors to achieve cabin pressure using external air. Such planes will no longer need to use air that has been heated by the engines in order to reach catalytic temperatures.

Although this goal is still a long way from being fully achieved, an initial demonstration model should be ready within two years. This will be able to convert ozone at well under 100 degrees Celsius. “We’re now developing this prototype for the NanoBase project in coopera-
tion with EADS and other partners,” says Jensen. “We’re combining a method introduced in the late 1960s — the so-called chemical nickel process — with nanotechnology.” As a rule, such chemical nickel coatings consist of nickel-phosphorus alloys that are deposited on a base metal — mainly metallic but increasing by plastics and glass as well — to pro-
tect them against wear and corrosion. This process involves immersing the base material in a dip tank. On its own, however, the nickel alloy is a poor catalyst. “But if we evenly embed nanoparticles of metal or metal oxide in the topmost layer of the alloy, this creates so-called nanocomposite coatings with highly catalytic properties,” explains Jensen.

These modified coatings decompose ozone at much lower temperatures and also work much faster than is the case with conventional converters. Siemens researchers are currently refining the deposition process and testing a wide range of nanoparticles, which is a very time-consuming task. “Just to keep the nanoparticles stable and make sure they don’t clump together in the dip tank and sink to the bottom is a science in itself,” Jensen says. “Another major challenge is to ensure that they are evenly embedded in the nickel alloy. It takes all our know-how, our know-how and experience, and we still learn something new every day.”

But it’s not just the aerospace industry that is interested in these high-tech catalysts. “In just a few years we could well see our nanocomposite coatings in high-speed trains and in cars. It’s a huge market,” says Jensen. “In railcars, for example, they could be used not only for air conditioning but also to keep vehi-
cles clean. As small, actively self-cleaning, self-cleaning surfaces would also be im-
pervious to graffiti.”

This would represent a major benefit for rail operators, who today spend a huge amount of time and money on removing spray paint. It takes two to three employees a whole working day to clean a suburban train, for example. Of-
ten the graffiti can only be removed with the help of powerful chemicals that get rid of not only the scribbles and scrawls but also the paint and coatings underneath.

“Deutsche Bahn alone could save tens of millions of euros in this area every year,” says Jensen. “Alternatively, nanocomposite coatings can also be used in filter elements for water treatment systems. Furthermore, they can in-
crease the sensitivity of the chemical sensors used for quick and easy detection of drugs or explosives,” explains Göppel.

Future catalysts will function faster and more efficiently while using less energy.

Withstanding the Elements. Aside from the development of highly active catalytic coat-
ings, the NanoBase project is also looking at improved protective coatings for products used for electrical engineering and transportation. Today, plastic sheeting is nor-
malized to protect electronic components and systems against the elements. Yet this is not always sufficient, especially when compo-
nents are exposed to rough conditions, such as those in vehicle engine compartments and in-
dustrial machinery.

Molecules of water, air, or, harmful gases can penetrate the plastic and cause electronic component inside to fail. “This can even knock out complete industrial plants or traffic guid-
es, sometimes with serious conse-
quences for human safety and the environ-
ment, not to mention the financial impact,” says Dr. Peter Göppel, a chemist at Siemens CT in Erlangen.

Likewise, the service life of organic LEDs de-
creases markedly when they are exposed to
dampness and oxygen. Göppel is therefore working on new nanocomposites and adhesives that offer a radically improved barrier effect. “In our labs here in Erlangen we’re synthesizing nanocomposites on the basis of modified sheet silicates. These consist of nanoparticles with a thickness of one nanometer and a length and breadth of 500 nanometers. These dimensions generate the desired barrier effect. Just to give you an example, it takes water molecules about ten times as long to penetrate this coat-
ing compared with conventional protective paints,” explains Göppel.

What’s more, conventional protective paints have an additional disadvantage. In many cases they contain organic solvents that are harmful to the environment. “In the NanoBase project, our target for 2009 is to develop a solu-
vent-free, water-based protective nanocomposite that also possesses greatly enhanced product properties,” states Göppel.

Visionaries in the nanotechnology field are already dreaming of developing a self-repairing paint. People would never have to worry again about getting minor scratches on their cars. In-
stead, nanocapsules in the paint would open at the edge of a scratch, releasing a catalyst that would react with other components in the paint. Such components might contain tiny metal crystals that would react with oxygen or water. These would fill and seal the scratch before the metal underneath could begin to corrode, with the result that the vehicle would once again look as good as new.

Ulrike Zechbauer