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RESEARCH NEWS

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1 Reveal-all-scanner for works of art

Painted-over murals were thought to be irretrievably lost because conventional methods are seldom suitable to rendering the hidden works visible without causing damage. Research scientists now aim to reveal the secrets of these paintings non-destructively using terahertz beams.

2 Sunlight with cooling factor

Although it sounds like a contradiction in terms, using the power of the sun for refrigeration is proving to be an original energy concept. In Tunisia and Morocco, Fraunhofer research scientists are using solar energy to keep perishable foodstuffs such as milk, wine and fruit fresh.

3 Perfectly non-reflecting

A new nanocoating ensures a perfectly non-reflecting view on displays and through eyeglasses. The necessary surface structure is applied to the polymeric parts during manufacture, obviating the need for a separate process step. The hybrid coating has further advantages: the components are scratch-proof and easy to clean.

4 Sensor predicts glass breakage

Modern glass façades inform the architecture of major cities throughout the world. In recent years, however, there have been cases of broken glass, with collapsing façades endangering passers-by. Now, a special sensor can detect micro-fissures and warn of impending breakage beforehand.

5 Safely anchored at sea

Different layers of the seabed reflect sound waves in a specific way. Researchers are harnessing the benefits of this fact to efficiently track down suitable offshore sites for wind energy plants. They use pressurized cannons, which emit acoustic signals that are recorded by underwater microphones.

6 Posters with depth effect – 3D advertizing

Soon, manufacturers will be able to advertize with 3D posters that are remarkable for their hitherto unattained spatial effect. The casual observer need not use any special glasses. Modern lighting techniques generate the 3D images that can measure up to five meters in size..

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 59 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 17,150, who work with an annual research budget totaling 1.6 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

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Reveal-all-scanner for works of art

Many church paintings are hidden from sight because they were painted over centuries ago. In the 16th century, for instance, Reformation iconoclasts sought to obscure the religious murals, while in later times the iconoclast images often were painted over once again. Several layers of paintings from various epochs can now be found superimposed on top of each other. If mechanical methods are used to uncover these pictures there is always a risk that the original work will be damaged. What's more, the more recent layers and pictures on top of the original, which are also worthy of preservation, would be destroyed. Research scientists at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden are now working on a non-destructive method for rendering these works visible, which involves the use of terahertz (THz) radiation. In the TERAART project funded by the German federal ministry of education and research (BMBF) they are cooperating with Dresden University of Technology, the FIDA Institute for Historic Preservation in Potsdam and the Dresden Academy of Fine Arts.

»We use THz radiation because it can penetrate the plaster and lime wash even if the layer is relatively thick. Unlike UV radiation for example, THz radiation does not damage the work of art. Infrared beams cannot be considered because they do not penetrate deep enough. Microwaves offer no alternative either, because they do not achieve the necessary width and depth resolution,« explains Dr. Michael Panzner, scientist at the IWS. A mobile system that can be used anywhere was developed to conduct the examinations. It consists of a scanner with two measuring heads which travels contactlessly over the wall. One measuring head transmits the radiation, the other picks up the reflected beams. The researchers were supported by the Fraunhofer Institute for Physical Measurement Techniques IPM, which built the adapted THz component.

»To produce the THz radiation we use a femtosecond laser incorporating the design principle of a fiber laser. The THz time domain spectroscopy technique applied by us utilizes the short electromagnetic pulses with a duration of just one to two picoseconds produced by the femtosecond laser. Each layer and each pigment reflects these pulses differently so that both a picture contrast as well as depth information can be obtained,« says Panzner. »The measured results provide information for example about the thickness of the layers, what pigments were used and how the colors are arranged. A specially developed software system puts the measured results together to form a picture displaying the structure of the concealed paintings.«

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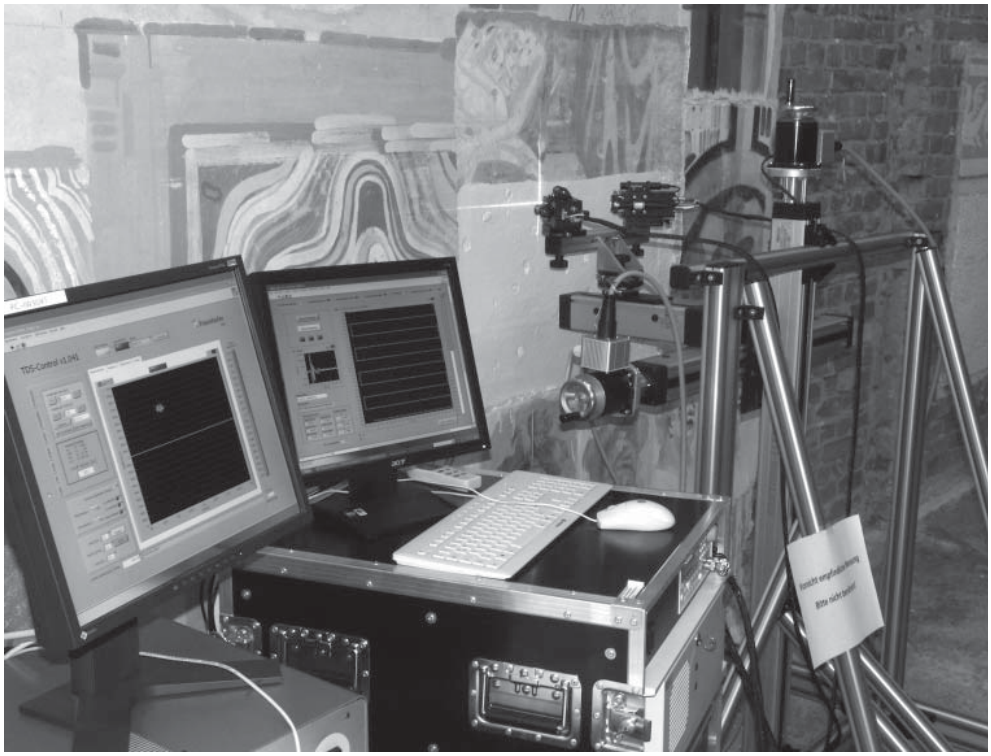
On a test wall, on which paintings in various types of paint were painted over with distemper, the scientists have already succeeded in revealing the structures of the concealed pictures. The next step will be to conduct a practical test in a church. The experts are also confident of being able to use THz radiation to detect the presence of carcinogenic biocides on and in works of art made of wood or textiles. »Preservationists will be very interested in our reveal-all-scanner for works of art, « affirms Panzner.



The mobile scanner at work on a test wall. A software system reveals the structure of the concealed paintings.(© Fraunhofer IWS)

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Sunlight with cooling factor

»Refrigerated by sunlight« – we could well see an ecostatement like this printed on food packaging in the years ahead. Solar energy is already being used to power air-conditioning systems in buildings, but now researchers also want to refrigerate fruit and other perishable foodstuffs using energy from the sun. Scientists from the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg are demonstrating that this is feasible in the Mediterranean region using the examples of a winery in Tunisia and a dairy in Morocco. In the MEDISCO project (short for MEDiterranean food and agro Industry applications of Solar COoling technologies) solar plants for refrigerating milk and wine have been installed in cooperation with universities, energy agencies and European companies. The project funded by the European Commission is run by the Polytechnic University of Milan.

»Our method is ideal for countries which have many days of sunshine and in remote areas where there are no conventional means of refrigeration owing to a lack of water and non-existent or unreliable energy sources. It is environmentally friendly and reduces the use of expensive electricity for conventional refrigerators to a minimum,« states Dr. Tomas Núñez, scientist at the ISE, listing the system's advantages. »Refrigeration is always available when the sun shines, which means that it is produced at the times when demand is at its highest.«

The scientists have installed concentrating collectors which direct the sunlight onto an absorber by means of a reflector. This makes it possible to convert the solar radiation into hot water with a temperature of 200 degrees. »This extreme water temperature is necessary in order to drive the absorption refrigeration machine for the high external temperatures that prevail there. We do not use electricity to provide the refrigeration, we use heat. The result is the same in both cases: refrigeration in the form of cold water or – in our case – a water-glycol mixture,« explains Núñez. As the absorption refrigeration machine produces temperatures of zero degrees, the experts use the mixture to prevent the water from freezing. The water-glycol solution is collected in cold accumulators and then pumped through a heat exchanger, which cools the milk. »We use a slightly different system for wine, with the refrigerant flowing through coiled pipes in the wine tanks,« says Núñez.

»MEDISCO is a demonstration project. The system is not yet ready for the market, but I am certain it will be possible in future to use solar refrigeration on farms and in the chemical and cosmetics industries,« the research scientist adds.

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The solar collector at the front drives the absorption refrigeration machine. The wine in the fermenter tanks (in the background) is cooled by a cold accumulator. (© Fraunhofer ISE)

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Perfectly non-reflecting

Moths are the prototype. As they search for food at dusk they have to hide from predators. Their presence must not be betrayed by reflections on their facet eyes. On other insects these eyes shimmer, but the moth's eyes are perfectly non-reflecting. Tiny protuberances smaller than the wavelength of light form a periodic structure on the surface. This nanostructure creates a gentle transition between the refractive indices of the air and the cornea. As a result, the reflection of light is reduced and the moth remains undetected.

Research scientists at the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg have adopted this artifice and adapted it to a range of different applications. On eyeglasses, cell phone displays, fitting or panel covers, transparent surfaces are generally only useful if they allow viewing without light reflecting back. Whereas conventional methods apply the anti-reflective coating in a separate step after production, the Fraunhofer scientists have found a way of reducing light reflection during actual manufacture of the part or component: »We have modified conventional injection molding in such a way that the desired nanostructure is imparted to the surface during the process,« explains Dr. Frank Burmeister, project manager at the IWM.

For this the researchers have developed a hard material coating which reproduces the optically effective surface structure. »We use this to coat the molding tools,« says Burmeister. »When the viscous polymer melt is injected into the mold, the nanostructures are transferred directly to the component.« Because no second process step is required, manufacturers achieve an enormous cost saving and also increase efficiency. »Normally the component would have to undergo an additional separate process to apply the anti-reflex coating,« Burmeister adds.

Normal plexiglass and some anti-reflex coatings are particularly sensitive, but the scientists are producing wipe-resistant and scratch-proof surfaces. For this purpose the injection mold is additionally flooded with an ultra-thin organic substance made of polyurethane. Burmeister: »The substance runs into every crevice and hardens, like a two-component adhesive.« The result is an extremely thin nanocoating of polyurethane on which the optically effective surface structures, which are just one ten-thousandth of a millimeter thick, are also reproduced. Working in cooperation with industrial partners, the research scientists now aim to develop components for the auto industry, for example, which are not only attractive to look at but also hard-wearing and easy to clean.

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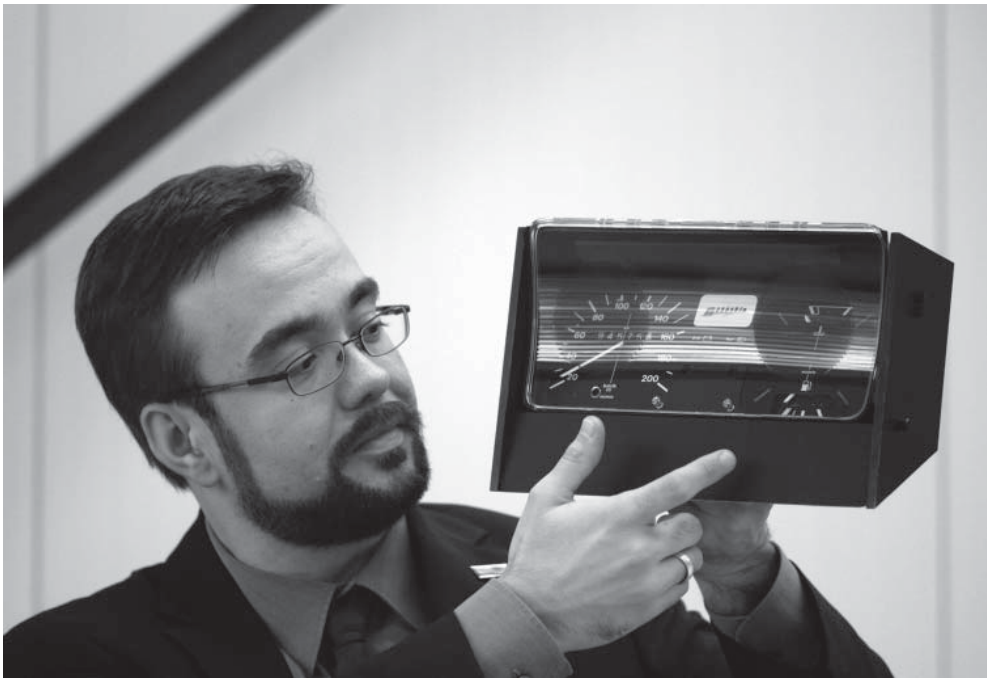

This car speedometer cover with two anti-reflective circular surface areas was manufactured in just one step. (© Fraunhofer IWM)

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Sensor predicts glass breakage

The Pompidou Center, the pyramid entrance to the Louvre, the Munich Uptown tower and Berlin's Spreedreieck office triangle: When constructing modern buildings, architects readily choose constructions designed of glass and steel. Nowadays, entire glass façades are no longer a rarity. Meanwhile the constantly recurring reports of collapsing façade elements have prompted the federal ministry for transportation, construction and urban development to mandate regular inspections of potential risk. The problem: The monitoring instruments in use until now merely register the sound of breaking glass. Thus, they can only ascertain breakage once it has occurred, and are unable to warn of looming peril in a timely manner.

Researchers at the Fraunhofer Institute for Silicate Research ISC in Wurzburg in collaboration with industry partners have developed a sensor that even detects micro-fissures of five millimeters in length, and thus point out the need for repairs early on – long before the glass actually breaks. »We attached several piezoelectric sensor actuator modules in a window pane. Four sensors are situated on a one square meter surface, on the edge of the pane at a distance of one meter from each other. One sensor actuator module produces an ultrasound wave that is registered by the others. If the acoustic signal remains constant, then the pane is not defective. If it changes, then this indicates a fissure caused during transport or due to an installation error. This fissure most often emanates from the edge of the pane and is initially invisible. It is only as time goes by that it gets larger due to various factors, like fluctuations in temperature,« explains Dr. Bernhard Brunner, working group manager at ISC.

The sensors are linked to the building control systems by cable. The data received there is analyzed automatically. If a fissure occurs, an alarm goes off. »We have succeeded in integrating our sensors, which measure 15 by 15 by 0.5 millimeters, into laminated glass. They can be integrated between both glass sheets as early as the manufacturing process. Therefore, the sensors can test the glass for transport defects even before installation,« adds Brunner.

Glass manufacturers and glass refiners also have the opportunity to conduct tests when goods are received or shipped. Yet the new safety system not only warns of glass breakage; it also offers comfort functions: The sensor-actuator modules are coupled with temperature and light sensors that – depending on incident light – target individual louvers for opening or closing, and thereby control room temperature.

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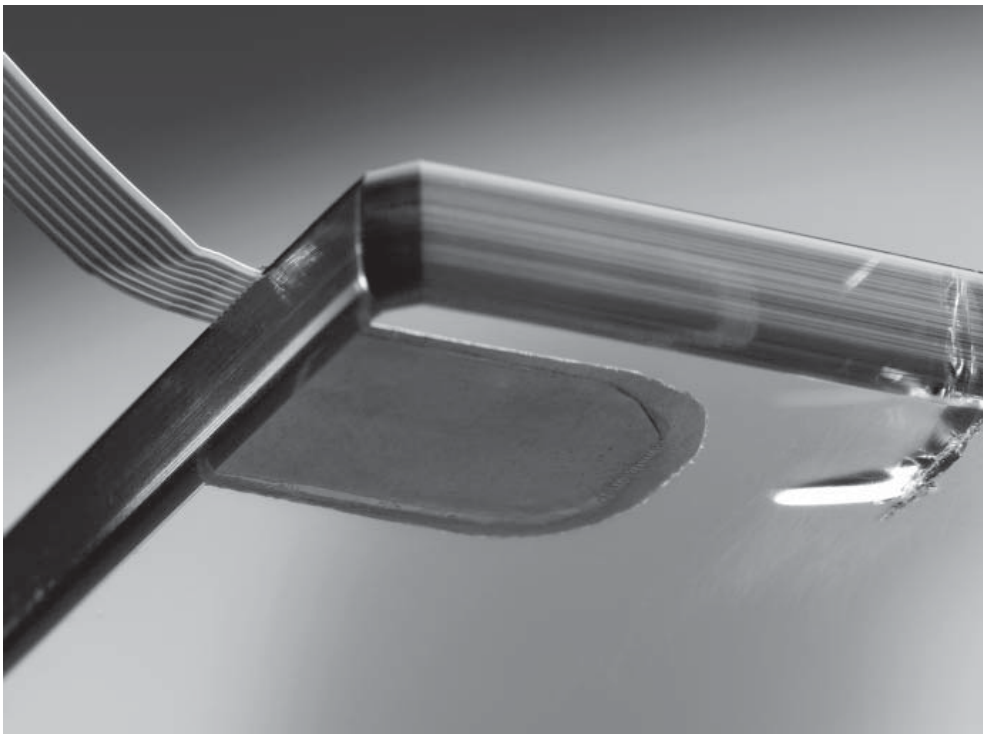
Currently, the project partners are looking for façade builders who want to use the sensors on a test basis. The experts are displaying a prototype at the Sensor+Test trade show in Nuremberg from May 18 to 20 (Hall 12, Stand 202).



The sensor is located on the rim of the sheet of glass. It is linked to the building control systems by cable. (© Fraunhofer ISC)

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Safely anchored at sea

Visible from miles around, the wind turbines thrust out of the North Sea. Standing beside each other in neat lines, they brave the rough seas and defy the ravages of any storm. To determine the best locations for wind energy plants, extensive studies of the ocean floor are needed. Ultimately, the foundations must not loosen in the sediment, not even years later. In order to evaluate offshore sites, researchers at the Fraunhofer Institute for Wind Energy and Energy System Technology IWES in Bremerhaven are utilizing the fact that different layers of the seabed reflect acoustic waves in a specific pattern. Using acoustic or pressurized cannons, the scientists generate signals that are recorded by underwater microphones. The test readings on the ground conditions are essential for the planning of the foundations.

»To generate acoustic signals, we exclusively use pressurized cannons for our seismic measurements. Based on the acoustic speed and time period that the signal needs to reach the microphone, on the one hand we can deduce the depth position of various reflectors or sedimentary layers. On the other hand, acoustic waves reverberate off the surface of the ocean floor and the layers of sediment below it at differing strengths. Where the physical traits of the individual seabed layers markedly differ from each other, the reflections are particularly strong,« explains Florian Meier, Geologist at IWES. By virtue of its stability, sand has proven to be a suitable material for offshore foundations. More precise investigations are often necessary at locations with clay layers; by contrast, soils with boulders or massive peat beds are unsuitable as foundation soil.

Hydrophones mounted inside streamers are towed through the water behind a survey vessel, and record the reflections. A streamer refers to a waterproof tube, up to several kilometers in length, filled with oil. The hydrophones at fixed at one-meter intervals. Software analyzes the recorded signals. The computer is conveniently located right on the ship. »We are the first to use shallow water multi-channel seismology in the North Sea at depths of 20 to 100 meters to explore foundation soil. While we use 50 or more hydrophones, other researchers often work with just a single channel. Among other things, this multi-channel method provides for better signal quality. Furthermore, most surveys don't use pressurized cannons. But by using these, we can penetrate into deeper sediment layers, up to the foundation of the wind energy system,« says Meier. In 2009, IWES conducted a seismic foundation soils exploration for RWE.

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Employees put the streamer with the underwater microphones from the survey vessel into the sea. (© Fraunhofer IWES)

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Posters with depth effect – 3D advertizing

The advertisement glows in three dimensions. If the observer gets closer to it, the image appearance changes with each step and adjusts to the visual angle. The visual impression when sauntering past a 3D depiction of columns is as if you were walking past a row of them for real. The 3D displays will be produced on an industrial scale in future. These posters are the brainchild of researchers from the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg, working jointly with their colleagues at the RealEyes company (www.lenscape.eu) and the University of Kiel.

»The displays function similar to the lenticular images that we've all seen on postcards,« says Dr. Dominik Giel, group manager at IPM. »Instead of the grooved sheet with the image attached, we use a lens array. It consists of 250,000 individual lenses with a diameter of two millimeters each.« Whereas the lenticular images can really only be viewed well at arm's length, these new kinds of displays can be seen clearly even from the other side of the street. That's because of the greater precision: With a lenticular image, the finished picture is glued to the grooved sheet. In the process of attaching it, the sheet cannot always be put in an exact position. »It's just like filling out a pre-printed form: If you use a typewriter to complete it, the print often shifts slightly downward or upward. By contrast, if you enter the information into a computer and then print out the form, the print sits exactly where you want it,« explains Giel. »The same applies to how we make these displays: We glue the lenticular sheet to the photo paper, and only apply the image in the next step.«

A specialized software modifies the digital image data so that the lenses do not distort the resulting image. Based on the three dimensional model of the overall motif, the program calculates a complete image for each of the 250,000 individual lenses. Each lens subsequently renders a perspective of the overall motif that shifts toward or away from its neighbor to a negligible degree. For each of the 30,000 different viewing angles, the display delivers an independent view of the scene – therefore, the viewer sees one image that continuously changes with the viewing angle. Altogether, in a one-square meter display a data volume is illuminated that corresponds to more than a full-length feature film.

One prototype already exists in DIN-A0 size. Over the course of the next year, the first advertising posters may soon appear. They are expected to be larger and cover a space of approximately three to five meters – something you cannot simply pass by.

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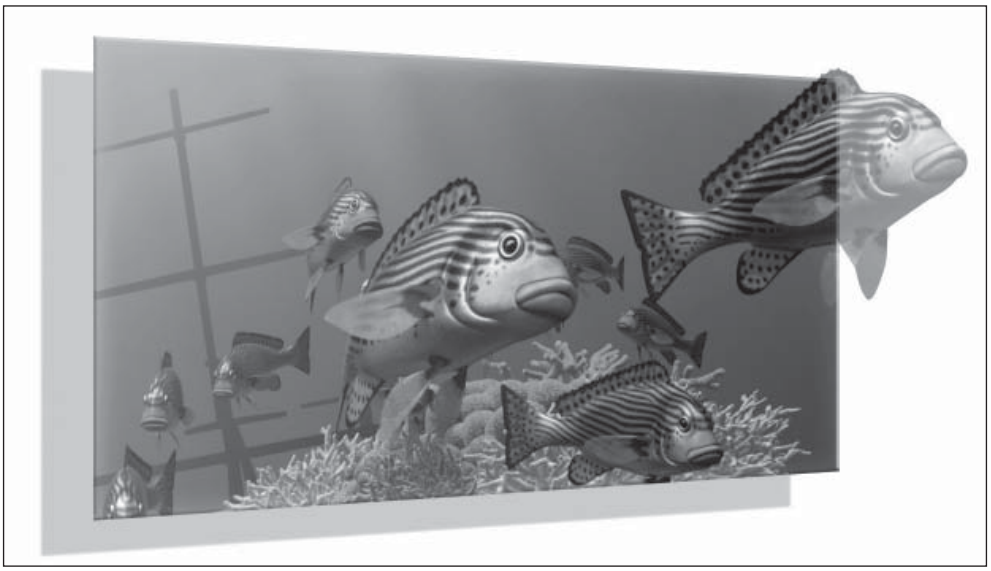

This poster is impressive for its spatial effect. A unique visual perspective appears at each viewing position – just like in the real world. (© RealEyes)

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