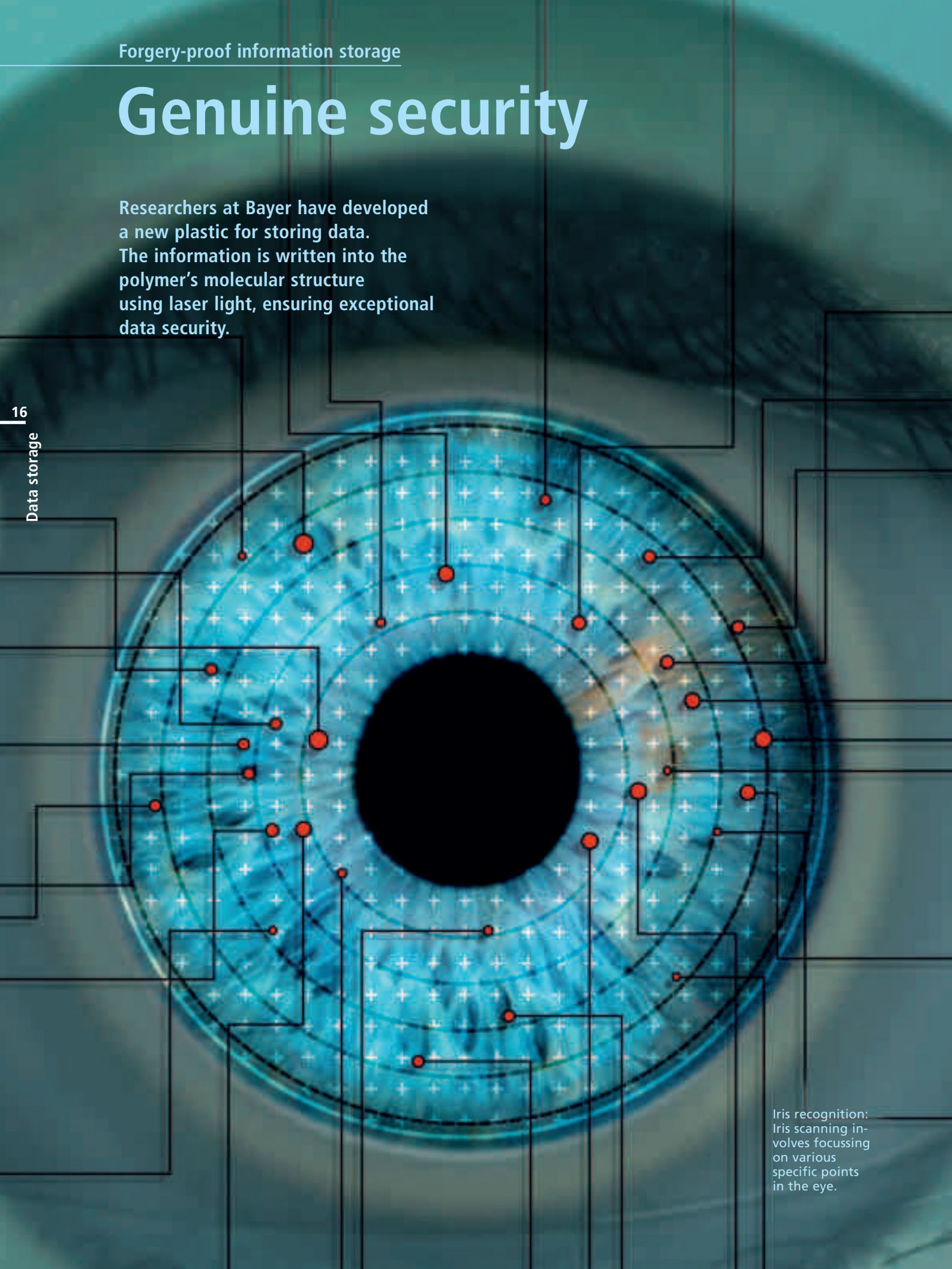
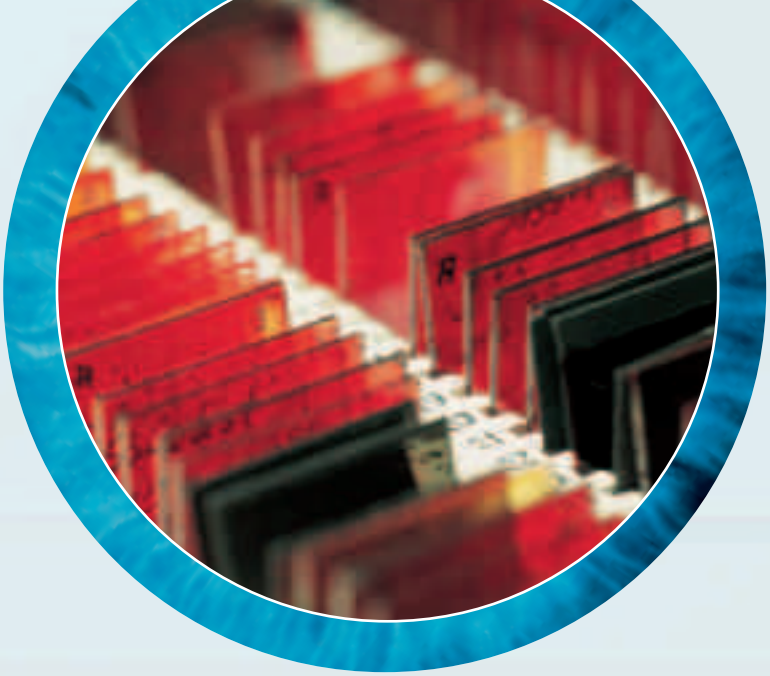
Genuine security

Researchers at Bayer have developed a new plastic for storing data. The information is written into the polymer's molecular structure using laser light, ensuring exceptional data security.



Iris recognition: Iris scanning involves focussing on various specific points in the eye.



Secure storage: PAP cards for experiments in holographic exposure.

How can 700 passengers be identified quickly when boarding a plane? Do all 80,000 spectators at the soccer match have genuine tickets? And is the cell phone battery you ordered over the Internet really an original part from the manufacturer? In all these cases forgers may be at work. It's therefore vital to be able to differentiate between the real thing and an imitation. No matter whether we're talking about people or replacement parts, access needs to be restricted to the "genuine article". Now more than ever, security experts from a whole range of disciplines are looking into the technology needed to develop a more forgery-proof identification system.

Eckard Foltin, Head of the Creative Center at Bayer MaterialScience, and his colleagues have identified this trend and are using the results of Bayer MaterialScience developments to carry out feasibility studies. They believe that photoaddressable polymers (PAPs) hold the key to the future. This transparent, orange plastic film is a high-tech storage material that is set to revolutionize measures used to combat ticket forgery at major events, such as soccer matches and the Olympic games, as well as the possibilities for automatically identifying passengers at airports, for instance.

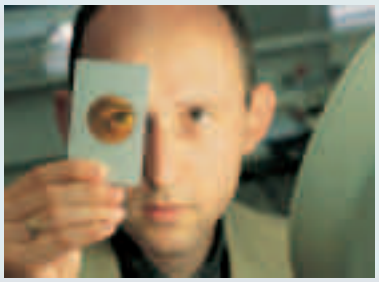
Polymers are normally long chain molecules formed through the attachment of identical components. PAPs feature two different varieties of side chain in addition. One is an azobenzene dye that absorbs light of a certain wavelength. Developers at Bayer utilize a substance with liquid crystal properties as the other side chain. This means that in the mobile state these molecules arrange themselves automatically like atoms in a crystal lattice. The long, narrow molecules have a tendency to align parallel to one another. If the dye molecules are struck by linear polarized light, i.e. by a light wave that oscillates in only one direction, they rotate so that they are positioned perpendicularly to the direction of polarization of the light. "Order is introduced at the exposed point in what was previously a tangle of unordered polymer molecules. The liquid crystal side chains reinforce the effect and retain their orientation when the light source is removed," explains Dr. Rainer Hagen, a member of Foltin's team. He was involved in developing the PAP materials and now works on identifying the market potential of products in the Creative Center.

Storing ten megabytes of data on one square centimeter of film

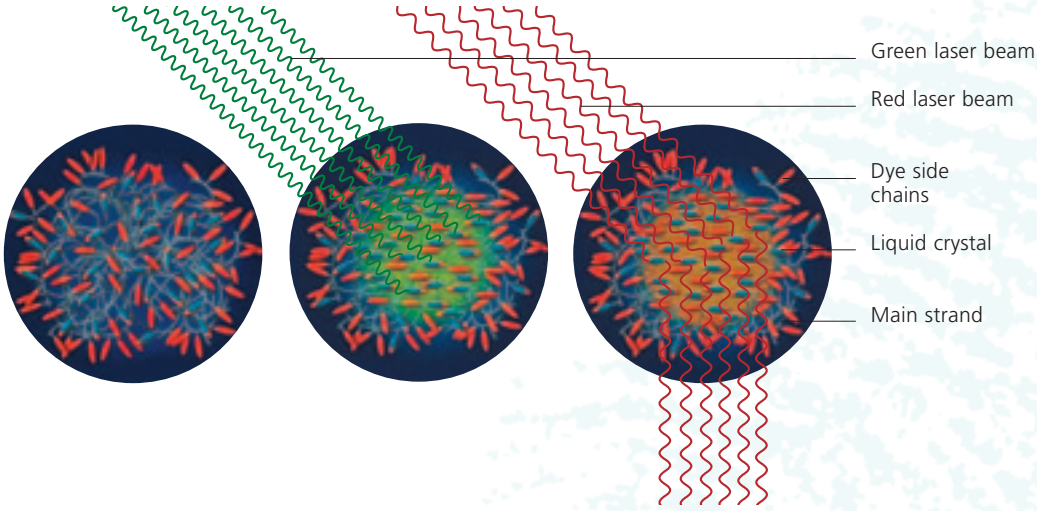
PAPs are suitable for storing data because they change their optical characteristics when exposed to light. "The material becomes doubly refractive," explains Hagen. A light beam that strikes an exposed point is split into two beams which pass through the material at different speeds. The exposed surfaces can be made visible with two polarization filters rotated at 90 degrees to each other, with one fit-

High-tech holograms

If you take a five Euro bill and move it back and forth under the light, the figure five and the Euro symbol in the silver strip light up one after another in all the colors of the rainbow. Similar holograms protect against forgery on ID cards, rail cards and, until recently, on European debit cards. For example, the silver strip on banknotes means they cannot be forged using a color copier. This type of hologram with the characteristic silver background is known as an embossed hologram. They are relatively simple to manufacture and can be produced in large quantities. Hologram technology uses either a white light hologram or a master hologram generated directly by computer. The basic principle is that an image appears even when illuminated with normal light, though only at certain angles.



Quality assurance: Dr. Rainer Hagen examines a holographic data storage system.



Creating order out of chaos
Photoaddressable polymers (PAPs) resemble a string of lights – additional components are attached to the side of the long main strand. Light-sensitive dyes (red) and the liquid crystal components (blue) alternate with each other. If green polarized light strikes the plastic, the short side chains position themselves perpendicular to the direction of polarization. The long side chains follow suit and retain the order that has been created, thus storing the information. Red laser light is required to read the information. It changes its direction of polarization in the PAP and the information is now encoded in the laser beam.

ted in front of the film and one behind. While the light is blocked out by the filters over the unexposed surfaces, the exposed surfaces remain transparent. "The direction of polarization is changed at the exposed points through the double refraction. Part of the light can therefore also pass through the second polarization filter," explains Hagen.

A laser is required to store images or binary data on a PAP film. "A laser of the same wavelength as is absorbed by the dye molecules is used for writing," says Hagen. He and his fellow researchers chose an orange dye as it predominantly absorbs green and blue light. A green laser can write data spots with a diameter of one micron on the PAP film. "That is about the same level as CDs," explains Gerhard Langstein, who heads the New Technologies department and examines new material developments for feasible uses in Bayer products. Theoretically, around ten megabytes of data can be stored on one square centimeter of the film. PAPs can also be rewritten on as often as required. The data can easily withstand temperatures of up to 120 degrees Celsius and the information lasts for many years if stored at room temperature. "But you can't leave a PAP card in direct sunlight," says Gerhard Langstein, "because the information would disappear after a few days."

The data are also read by a laser, albeit one with a different wavelength which the dye is not sensitive to – after all, the information must not be overwritten. Double refraction transforms the linear polarized laser light into unpolarized light, similar to the tests with the two polarization filters. This change can be converted into electronic data by a photodiode.

Rapid passenger handling: Long lines at airport check-in desks could soon be a thing of the past thanks to PAP cards.

Checking biometric data in seconds

What makes PAPs so attractive as forgery-proof data storage systems is the fact that information can be stored in the form of holograms. The film therefore only contains a muddled, illegible interference pattern which cannot be recognized with the naked eye. To make the original image visible again, you have to know the conditions that applied during the exposure. Future demands for reliable identification using biometric data, i.e. unique physical features such as fingerprints or the iris, could thus be met with a PAP card. Bayer Innovation GmbH is currently developing high-security access control systems based on ID cards featuring PAP memories. The biometric data can be stored on a single card rather than in an unwieldy and sluggish database.

Sensitive information can even be additionally encoded using a mask that is held in front of the object during the exposure stage. The same mask would then be required to read the information. Unlike information on chips which is encoded using software, hardware-encoded holograms are theoretically impossible to crack. A hologram is also difficult to forge as you have to reproduce both the exposed object, e.g. a fingerprint or face, and the exact exposure setup. Hagen believes that storing information from several banks, for example, on a single card does not present any problems. "Banks will never even know that the cardholder is also a customer at another bank."

Foltin and Hagen have plenty more ideas for applications involving this high-tech film. For instance, PAP films could prove to be invaluable when it comes to preventing product piracy.

Think-tank: (from left) Dr. Georg Wiessmeier, Dr. Constantin Schwecke, Eckard Foltin, Dr. Rainer Hagen and Dieter Boesveld.

Secretly attached PAP labels could even be used to confirm the authenticity of automotive parts that are shipped from the Far East to Europe by container.
Rainer Hagen believes that now is just the right time for the materials to be launched on the market. "The combination of large storage capacity and high security is an almost unbeatable advantage."

www.bayermaterialscience.com
Further information on plastics innovations at Bayer is available here.

Lateral thinkers

"We develop visions based on future requirements," says Eckard Foltin, Head of the Creative Center at Bayer MaterialScience, commenting on the strategy followed by his five-member team. The team develops its ideas in a completely normal, open-plan office far away from the labs and plastic manufacturing plants, with most of the work going on inside their heads. The team tries to identify market demands and requirements for which there are no obvious solutions so far. These lateral thinkers generally venture far into the future with their projects, asking questions such as: Will cars be replaced by conveyor belts in city centers? Will shirts ever tell the washing machine what program they require? "Drawing up images of the future like this is relatively theoretical work," says Foltin. Like futurologists, the team puts together a "road map" charting the future course of each new technology.
"The results show the requirements that our plastics need to satisfy. For example a bumper will need to be transparent to infrared light if automatic parking assistance is to be incorporated into vehicles," reports Foltin. They then pass on their discoveries to researchers at Bayer MaterialScience. Some of the ideas that emerge from the brainstorming sessions in the Creative Center can even be realized straightaway. In fact, two products have already been made – a loudspeaker that can be integrated into walls and the first business handbag illuminated using electroluminescence. The light in the handbag is generated by a thin, flexible luminescent film powered by a conventional battery. This film also has many other uses - it has unique advantages over incandescent lamps or LEDs when used in swimming pools, cars and refrigerators, for example.
Designers and developers have already contacted Foltin to learn more about the possibilities of the technology. "This provides us with feedback on requirement profiles and we can then further develop them accordingly." In Foltin's experience, a technology developed without taking account of the market often will not sell. "The art is in finding the right time to introduce a new technology."

Shaping ideas: Eckard Foltin with a polyurethane molding.