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RESEARCH NEWS

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1 High-tech spider for hazardous missions

Spiders are very agile, and some can even jump. They owe this capability to their hydraulically operated limbs. Researchers have now designed a mobile robot modeled on the same principle that moves spider legs. Created using a 3-D printing process, this lightweight can explore terrain that is beyond human reach.

2 Flexible learning in a virtual microscope lab

For every medical student, examining specimens under the microscope is part of the syllabus. However, the opening hours of the labs and the number of enlargers are limited. Thanks to a new online platform, students are now able to learn with greater flexibility and independence.

3 Simulating real-world surfaces

These days, cars are developed on computers, and to assist with this, designers want processes which generate realistic surfaces such as seat covers. Researchers have now developed high-resolution scanners which copy objects and fabric samples in a few minutes, converting them into virtual models. The light effects are startlingly realistic.

4 A fish test to make food safer

Nowadays, half of all the fish we eat comes from fish farms. The problem is that these fish are increasingly being fed vegetable matter, which could lead to a build-up of residual pesticides in them. A new test shows how high the risk of contamination really is.

5 Plasma in bags

Using plasmas, sealed plastic bags can be modified at atmospheric pressure so that human cells can adhere to and reproduce on their walls. Cell culture bags of this kind are an important aid for research and clinical purposes and may eventually replace the Petri dishes used today.

6 Custom glass bending

The possible applications for curved glass panels are many and varied – ranging from facades to designer furniture. Researchers have now developed a process which enables the panels to be shaped six times faster and considerably more cost-effectively. Even small batches can be produced economically.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 60 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 18,000, who work with an annual research budget totaling 1,66 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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High-tech spider for hazardous missions

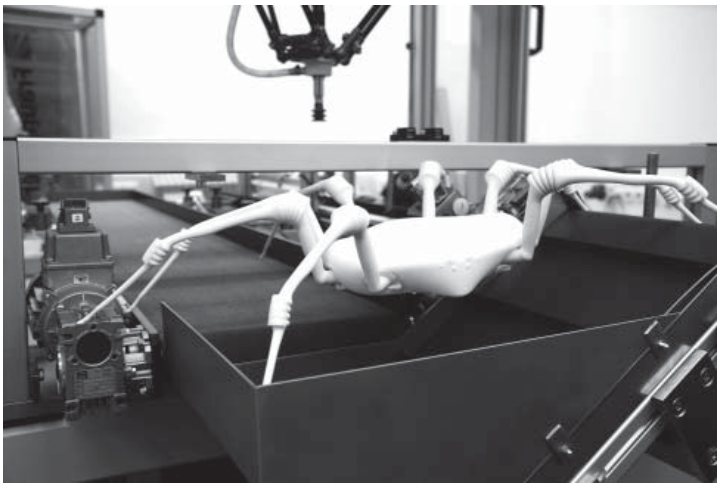
Enviably agile and purposeful, the mobile robot makes its way through grounds rendered off-limits to humans as the result of a chemical accident. Depressions, ruts and other obstacles are no match for this eight-legged high-tech journeyman. Its mission: with a camera and measurement equipment on board, it will provide emergency responders with an image of the situation on the ground, along with any data about poisonous substances. Not an easy task; after all, it must be prevented from tipping over. But this risk seems a minor one as it confidently and reliably picks its way through the area. As a real spider would, it keeps four legs on the ground at all times while the other four turn and ready themselves for the next step. Even in its appearance, this artificial articulate creature resembles an octopod. And no wonder – the natural specimen provided the model for researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA. This high-tech assistant is still a prototype, but future plans envision its use as an exploratory tool in environments that are too hazardous for humans, or too difficult to get to. After natural catastrophes and industrial or reactor accidents, or in fire department sorties, it can help responders, for instance by broadcasting live images or tracking down hazards or leaking gas.

With its long extremities, the spider has a range of ways to get around. Some models can even jump. This is possible using hydraulically operated bellows drives that serve as joints and keep limbs mobile. With no muscles to stretch their legs, these creatures build up high levels of body pressure that they then use to pump fluid into their limbs. Shooting fluid into the legs extends them. "We took this mobility principle and applied it to our bionic, computer-controlled lightweight robot. Its eight legs and body are also fitted with elastic drive bellows that operate pneumatically to bend and extend its artificial limbs," explains Dipl.-Ing. Ralf Becker, a scientist at IPA. The components required for locomotion, such as the control unit, valves and compressor pump, are located in the robot's body; the body can also carry various measuring devices and sensors, depending on the application at hand. Hinges interoperate with the bellows drives so that the legs can move forward and turn as needed. Diagonally opposed members move simultaneously, too. Bending the front pairs of legs pulls the robotic spider's body along, while stretching the rear extremities pushes it.

The special aspect of this high-tech helper: not only very light, it also combines rigid and elastic shapes in a single component; with just a few production steps, it can also be produced at low cost. To date, designs such as the mobile robot have been gene-

rated using conventional mechanical-engineering technologies – a time-consuming and costly undertaking. Researchers at IPA, on the other hand, rely on generative production technologies, and specifically on selective laser sintering (SLS) of plastics, a 3-D printing process. In this process, step by step thin layers of a fine polyamide powder are applied one at a time and melted in place with the aid of a laser beam. This way, complex geometries, inner structures and lightweight components can be produced – with structures optimized much as if produced by Nature herself. The experts at IPA have a great deal of latitude in the design of their mobile robot; the leg modules, for instance, can be designed with infinitely variable load-bearing characteristics.

"We can use SLS to produce one or even several legs in a single operation; this minimizes assembly effort, saves materials and reduces the time it takes to build a robot. With the modular approach, individual parts can be quickly swapped as well. Our robot is so cheap to produce that it can be discarded after being used just once – like a disposable rubber glove," Becker points out. A prototype of the robot can be seen at the EuroMold 2011 trade fair in Frankfurt, at the joint stand of the Fraunhofer-Gemeinschaft (Hall 11, Stand C66), from November 29 through December 2.



The robot spider's legs are 20 centimeters long. Elastic bellows drives serve as joints.
(© Fraunhofer IPA)

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Flexible learning in a virtual microscope lab

Under the microscope lies a specimen of a liver. Deep in concentration, a student is analyzing the structure of the tissue when the university official asks her to finish up – the lab is about to close. This is a situation that may be familiar to many students. After all, the examination of specimens is an important course component; to practice and consolidate the theory presented in lectures. Customarily at the beginning of the semester, students are each given a case containing 50 to 100 specimens with which they can work independently. To do so, however, they are dependent on the university infrastructure. There is another disadvantage: "Each specimen is, by nature, unique – so each student sees something different under the microscope", says PD Dr. Thomas Wittenberg from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen.

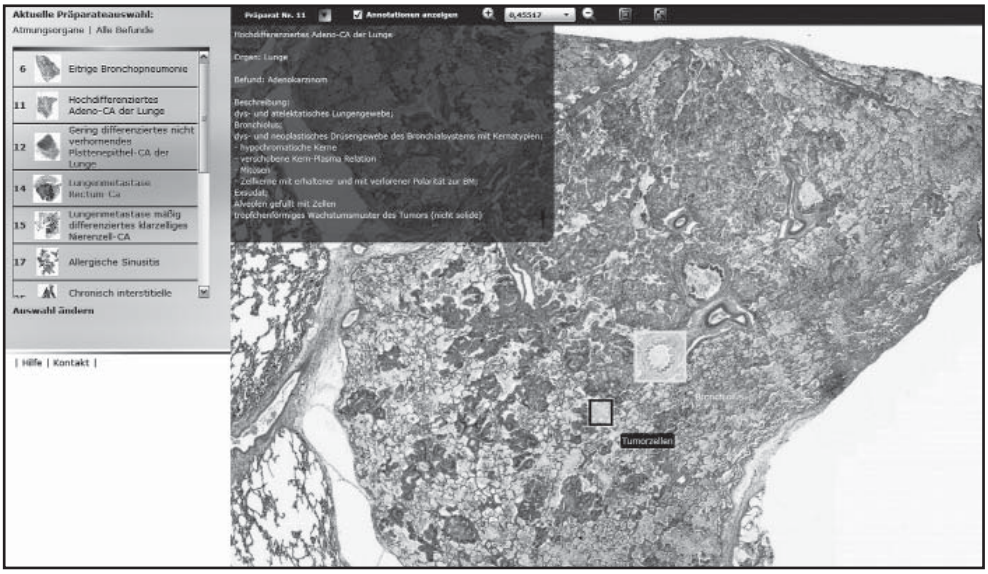
Researchers at the IIS, the Erlangen University Clinic as well as at the University of Erlangen-Nürnberg have now created an additional facility that is available to students around the clock: a platform for web-based microscopy. So far, the project partners have made digital images of 200 specimens at 40x magnification and have put them into a database. Here, students can look up and research specimens using specific keywords such as body part or diagnostic findings. At the click of a mouse, the image can be viewed with a specific degree of enlargement (5x, 10x, 20x, 40x) or with seamless zooming. Image details which present the relevant tissue changes or other characteristics are interactively labeled.

The crux of this development work is that in order to make even the slightest details easily discernible, the images have to be made available at a very high resolution. This means image files quickly reach sizes of up to 5 GB; with a standard broadband connection, downloading would take forever. So the researchers employ a creative trick: "So that students can work with these huge data effectively, we divide the images into individual image tiles. Depending on which image section the user is looking at, at any given time, only the corresponding tile in the required resolution has to be transmitted. It's similar to how Google Earth works," explains Wittenberg's colleague Sven Friedl. Depending on the image section, the resolution is reduced in pyramid fashion, step by step: the larger the image section, the lower the resolution and vice versa.

The platform is not meant to replace "real" microscopy, but rather to supplement it, as Friedl is keen to point out. "We want to give students the opportunity to be able

to study more flexibly than before. Plus, our databank makes a much more extensive collection of specimens available to them", says the scientist.

Proof that demand for such a resource exists came with the initial test run: Since the summer term of 2011, students at the University of Erlangen have been able to use the platform as a supplement to pathology lectures. They receive password-protected access to the database at the time of registering online for the lectures, and thereafter there is ongoing evaluation of student satisfaction and learning success. "The feedback has been entirely positive", reports Friedl happily. In the future, the collaboration is to be expanded to include other institutes and universities. From November 16 – 19 at the MEDICA trade fair in Düsseldorf, the project partners will present the online platform as well as further solutions for the automatic analysis of microscopic image data, at the joint Fraunhofer booth in Hall 10, Booth F05.



The portal for web-based microscopy offers students an extensive collection of specimens.
(© Fraunhofer IIS)

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Simulating real-world surfaces

When buying a car, customers are not just interested in its fuel consumption. They rather turn their attention to the car's appearance. The interior fittings should have a quality look, the pattern on the seat covers should be subtle and understated and the leather-look dashboard should add a sense of luxury. That is why designers want to know at an early stage how a piece of fabric or imitation leather will look in the new car cockpit. Models used to be manufactured by hand, but that was time-consuming. And although computer simulation is faster, it takes time as well: real-world objects must first be scanned at high resolution and then translated to the virtual world. Researchers at the Fraunhofer Institute for Computer Graphics Research IGD in Darmstadt are now hoping to accelerate this process. They have developed two scanners which capture images of real objects with micrometer precision and use the data to generate deceptively lifelike virtual images. The first device, the HDR-ABTF scanner, is specifically designed to capture images of materials such as textiles and leather, lit from different directions, precisely and especially quickly. Computers can then be used to simulate how an object – for instance a car seat – covered in that material will look in changing light conditions. The second device, the meso scanner, captures high-resolution images of three-dimensional objects. Unlike conventional systems, it even records finest surface details with yet unmatched precision.

Both scanners have been developed from established processes which are more expensive or which take longer. "For industrial applications, though, we need fast and affordable devices with high resolution," explains Martin Ritz, a developer at Fraunhofer IGD. This is what the HDR-ABTF scanner delivers. A single-lens reflex camera installed in the device looks down on the object from above. The material is lit successively by several LEDs arranged in a quadrant arc, so that the surface is lit from various different angles and photographed in varying light conditions. The end result is a series of exposures for each light direction, which can then be integrated on a PC to produce high-resolution HDR images. A vehicle designer can then combine the image data with the computer model of a car seat and observe the material's behavior when lit from any angle. There are already similar processes that use multiple cameras and considerably more light sources, but working with the equipment developed by Fraunhofer IGD is both simpler and faster. Within the period of just ten minutes, a new material can be scanned and translated to a virtual model.

The meso scanner captures images of small three-dimensional objects. Conventional 3-D scanners project a relatively coarse pattern of stripes onto an object and the

software infers the three-dimensional shape from the distortion of the stripes. This innovative new scanner instead projects a much more detailed pattern of black and white stripes onto the object, each of which is just about a third of a millimeter or so across. Using a special lens in front of the projector, this pattern is moved across the object with sub-pixel accuracy, which is to say it is shifted in individual steps of 1/25 of a pixel or less. This means that the object is scanned in much greater detail than before, achieving high resolution. Any hollows or wrinkles can be recorded with a depth measurement which has an accuracy of around 30 micrometers – which is two to three times more accurate than without the lens-shifting system.

As Ritz points out, "The meso scanner isn't just interesting for car development. There's also scope for museums to use it to scan rare exhibits such as jewelry or coins with high precision." Another possible application for the device would be in the computer gaming industry. Researchers will be showcasing the initial prototypes of the new scanners at the booth of the Fraunhofer Additive Manufacturing Alliance at the Euromold trade fair (Hall 11, Booth C66a) from November 29 to December 2, 2011 in Frankfurt am Main.

The HDR-ABTF scanner captures physically realistic images of materials such as textiles, lit from various different angles (left). The meso scanner records detailed 3-D structures of surfaces with great precision (right). (© Fraunhofer IGD)

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A fish test to make food safer

People are eating more and more fish. To meet rising demand, fish are increasingly being cultivated in fish farms. Aquaculture is the fastest-developing branch of the global food industry, with annual growth of nine per cent. This rapid rise is also pushing up demand for fish feed, producers of which are facing a formidable challenge, because the supply of fishmeal and fish oil – important ingredients in feed – is dwindling. They are set to be replaced by crops such as soya, maize and rape, but the trouble with these is that feed pellets made from them might contain pesticides. To protect consumers, there has to be a way to test fish bred in captivity for pesticide residues, but this has not been possible up to now. While techniques known as metabolism studies are already used to test how the active ingredients in pesticides accumulate and break down in ruminants, poultry and pigs, these techniques are not suitable for use with fish. Germany's Federal Office of Consumer Protection and Food Safety has let it be known that urgent action is required. Now scientists at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Schmallenberg have developed a system to test whether chemical substances accumulate in fish that are fed contaminated feed.

"First, we test whether ingestion of the feed leads to a build-up of pesticide residues in fish tissue, and we look to see which degradation products or metabolites result from the fish's metabolic processes. Essentially, the more fat-soluble a substance is, the higher the probability of it accumulating in fish," explains Dr. Christian Schlechtriem, a scientist at the IME. "Our tests form the basis for later studies on feeding. The results determine whether these subsequent studies, which ascertain maximum pesticide residue levels, are required."

For their metabolism studies the researchers use water tanks that are two cubic meters in size. Into these tanks they place carp and rainbow trout each weighing 300 to 500 grams; both these freshwater fish are frequently bred in farms. To detect and identify pesticide residues and their metabolites, Schlechtriem and his team add a radiolabeled test substance to the pellet feed – a challenge for the researchers, as radiolabeled material is difficult to handle under aquatic conditions. A powerful filtering system prevents the dissolved test substance from accumulating in the water. The researchers then test the flesh of these fish for pesticide residues using highly sensitive analytical methods which permit even the smallest quantities of a substance to be detected with certainty. Dr. Dieter Hennecke, head of the IME's ecological chemistry department, says: "Our new test leaves no stone unturned in the search for pesticides

and their degradation products in fish – from breeding through to tissue analysis in the laboratory."

In autumn 2011, the European Commission will publish new data requirements for fish as part of the approval process for pesticides. These will oblige every producer and importer who intends to bring a new pesticide onto the European market not only to register it but also to provide information proving it cannot accumulate in the edible parts of fish. The fish test developed at the IME will supply the information required.

Researchers inspect the two-cubic-meter water tanks equipped with a powerful filter system. (© Fraunhofer IME)

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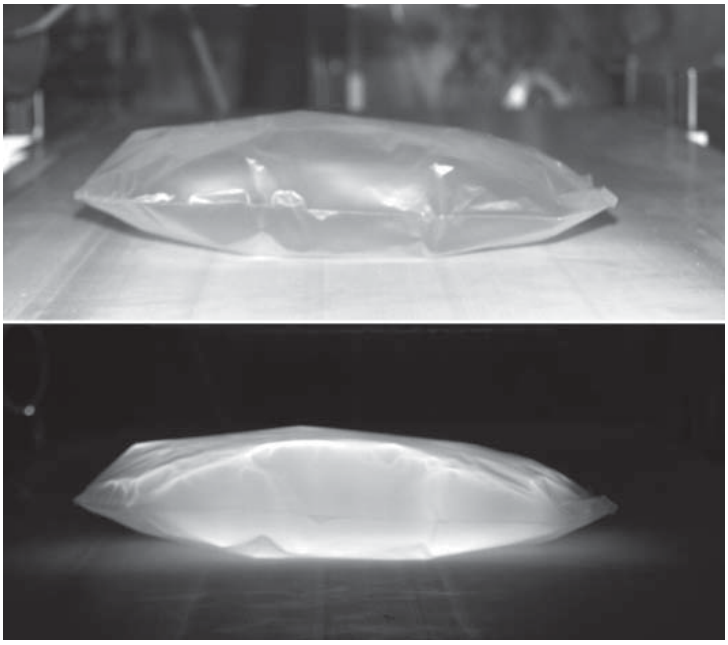
Plasma in bags

Physicians are increasingly using live cells in their treatments: in blood transfusions and bone marrow transplants, as well as in stem cell therapies and following severe burns. Cells taken from the patients themselves are ideal for replacing burned skin, eliminating immune deficiencies, repairing degenerated cartilage or to treat injured bones as they are not rejected by the immune system. These cells have to be kept, cultivated, reproduced or even modified in a patient-specific manner. The problem, however, lies in the storability of the cell solutions used. As they can easily become infected by germs, they can only be stored for a few days in the containers conventionally used today. The joint project InnoSurf aims to remedy this problem: scientists from five research institutions, along with partners in the industry have developed innovative plastic surfaces and measuring methods for efficiently producing human cells for diagnostic and therapeutic applications. The work was coordinated by the Helmholz Centre for Infection Research (HZI) in Braunschweig, Germany.

The idea is to cultivate the cells in sealed, sterile plastic bags. The inner surface of the bags has to be modified so that they provide cells with good conditions for survival. A team led by Dr. Michael Thomas at the Fraunhofer Institute for Surface Engineering and Thin Films IST in Braunschweig, Germany, has now developed a plasma technology process for use at atmospheric pressure. "We fill the bags with a specific gas mixture and apply an electrical voltage" explains scientific assistant Dr. Kristina Lachmann. "Inside them, for a brief period, plasma is created, i.e. a luminescent, ionized gas, which chemically alters the plastic surface". During this process the bag remains sterile as plasmas also have a disinfecting action. "The advantage of the process is that it operates at atmospheric pressure and is therefore cost-effective, fast and flexible" emphasizes group leader Dr. Michael Thomas who specializes in the use of such atmospheric pressure plasmas to modify surfaces.

The new bags facilitate the sterile handling of cell cultures. Previously, researchers and clinicians had to use open Petri dishes, bottles or bioreactors. As these systems need to be opened, at least for filling, contamination can easily occur. By contrast, when using the new technology with its sealed bag system, the cells migrate directly into the bag via an injection needle or connected tube systems without coming into contact with their surroundings. The sterile interior of the bags contains nutrient medium and germ-free air or a suitable gas, which been added beforehand. Even during the cultivation period the containers do not have to be opened, and at the end the cells can be removed again by injection needle.

The researchers also maybe intend to use the disposable systems for growing artificial organs. If the bags are provided with a three-dimensional structure, cells could attach themselves to it and create artificial skin, nerves, cartilage or bone which could be used prosthetically in the patient. So far their cultivation has mainly failed because the stem cells have been reluctant to attach themselves to spatial structures. The plasma process developed at the IST could solve this problem. In collaboration with the University of Tübingen, Braunschweig City Hospital plans to isolate certain stem cells from tissue samples and investigate on which of the new plastic surfaces they could develop into bone or cartilage, for example. For this development by the group led by Dr. Michael Thomas, the IST was awarded "Selected Location 2011" as part of the "Land of Ideas" initiative. The prize will be awarded at the IST in Braunschweig on December 8, 2011.



The cell culture bag before (top) and during coating (bottom). (© Fraunhofer IME)

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Custom glass bending

At times a shimmering gray, at times more of a greenish color, the glass facades of high-rise buildings are mostly fairly similar in appearance. They become unique when individual glass elements are shaped differently, however. The problem is that manufacturing a large number of short runs of glass elements is complex and expensive. The glass bender must first produce an appropriate mold, before laying the glass on top of the mold in a walk-in furnace. At this stage, the glass is only in contact with the top edge of the mold. The furnace is closed and heated over a period of several hours until the material becomes viscous, sinks downward and takes on the shape of the bending mold. The process has its pitfalls, though: if the glass is not heated for long enough, it will not adopt the predefined shape. But if the process lasts too long, pressure marks form at the support points.

All that is set to change now, as researchers at the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg have developed a new glass-bending process as part of a sponsored joint project. "Our process is roughly six times faster than the conventional process, as well as being considerably more energy-efficient and cost-effective," explains Tobias Rist, a scientist at the IWM. "It's no longer necessary to produce a special steel mold." Instead, the researchers have developed a mold which changes according to requirements – it is vaguely reminiscent of the pin art gadgets that you can press your hand into to make an image. The mold starts out flat, with all the support points at the same height. Since the mold and the glass panel placed on it are moved into the furnace by machine, there is no longer any need to reheat the furnace for each batch of glass because the researchers can load it while it is in operation. The process saves a lot of energy and a few hours' time which the furnace would otherwise need to heat up and cool down.

For one thing, the temperature of the furnace is a few degrees below the temperature at which the glass becomes viscous. Another feature is that additional heat is applied to the glass using a stream of hot air or a laser only at those points which are to be shaped, so that only these parts of the glass become viscous. The mold then adopts the desired geometry at the touch of a button. A device positions the support points so the glass is able to sink downward as dictated by its temperature and the shape of the mold. The major advantages of this approach are that the material changes shape only at the desired points and that flat surfaces stay flat. They do not warp unchecked as before and do not bend back into shape again. This considerably improves the quality of the product's appearance, with fewer distortions for example.

The material assumes the shape better and fewer indentations are formed in the glass.

But how long does the glass need to be heated for? And what is the ideal temperature? "While the conventional process relies a great deal on trial and error, we simulate the process and the material behavior on a computer. We then compare the outcome with the results from physical tests so we can identify and implement the most favorable process conditions," says Rist. The researchers are also able to regulate and monitor the temperature during the process. So far they have processed sheet glass measuring up to approximately one square meter. The next steps will see the sizes increase and the shapes become even more complex; for example the scientists are aiming not only to produce hemispherical structures but also to go one step further and create aspherical forms. There is also scope for the specialists to improve bending processes or develop processes for producing sheet glass with functional coatings.

Researchers are examining a curved glass panel in front of the test furnace. (© Fraunhofer IWM)

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