Fraunhofer

# RESEARCH NEWS

09 | 2015 ||

## 1 Pulses for better posture

In an effort to find a better treatment for spinal curvature in children and young people, the EU's "StimulAIS" project is focused on electrostimulation of muscles. Fraunhofer scientists worked with partners from industry and research to develop a prototype implant that would do the job.

## 2 Gas sensors sound the smoldering fire alarm

Smoke detectors are everywhere, but still thousands of people die in fires annually. Fire gas detectors, which detect carbon monoxide and nitrogen oxide, identify fires at an early stage. Thanks to a new measurement principle developed by Fraunhofer researchers, these costly sensors will soon be inexpensive and ready for the mass market.

## 3 Wastewater to irrigate, fertilize and generate energy

To meet the requirements of Asian cities, researchers are adapting an idea they have already applied in Germany for comprehensive water management: They are developing a concept for reducing water use, treating wastewater and extracting fertilizer for a strip of coastline in the Vietnamese city of Da Nang.

## 4 Making effective use of voluntary help

In crisis situations, aid organizations have to manage the great numbers of volunteers who spontaneously appear wanting to help. In the INKA project, Fraunhofer researchers have taken a look at how to better recruit, retain and make effective use of volunteers in disaster control.

## 5 Efficient heating for electric cars

If you don't want to freeze in your electric car, you have to make a few concessions, because heating devours a substantial portion of power supply. Fraunhofer researchers will exhibit the demo model of a highly energy-efficient heating system for electric cars at the IAA: a coated film that produces a broad, radiant heat.

## 6 Recycling permanent magnets in one go

Electric motors or wind turbines are driven by powerful permanent magnets. The most powerful ones are based on the rare earth elements neodymium and dysprosium. In future, a new process route realized by Fraunhofer researchers will enable the fast and cost-effective recycling of these crucial materials.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 66 Fraunhofer Institutes and research units at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 24,000, who work with an annual research budget totaling 2 billion euros. About 70 percent of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the Americas and Asia serve to promote international cooperation.

**Editorial Notes:**

RESEARCH NEWS | Frequency: monthly | ISSN 09 48 - 83 83 | Published by Fraunhofer-Gesellschaft | Communications | Hansastraße 27 | 80686 München | Phone +49 89 1205-1333 | presse@zv.fraunhofer.de | Editorial Staff: Beate Koch, Britta Widmann, Tobias Steinhäußer, Janine van Ackeren, Tina Möbius, Chris Löwer, Tim Schröder | Reprints free of charge.We encourage you to favor the online version and newsletter via www.fraunhofer.de/fhg/EN/press. This bulletin is also available in German as FORSCHUNG KOMPAKT.

Fraunhofer



# Pulses for better posture

"Sit up straight!" It's an instruction almost every child has heard some day – but sometimes being reminded to consider your posture isn't enough: two out of every hundred children and young people between the ages of 10 and 18 suffer from a curvature of the spine. Known as adolescent scoliosis, this growth disorder causes a lasting deformation of the back. These deformations are clearly visible and sufferers often feel disfigured by them.

In nine out of ten cases, the exact causes of the spinal curvature are unknown – what doctors refer to as idiopathic. Recent research suggests that adolescent idiopathic scoliosis, or AIS for short, is caused by a disease of the central nervous system. "According to this theory, the connection between the nerves and the relevant muscles is impaired, but only on one side of the back. When muscles on the healthy side contract, the muscles on the unhealthy side fail to receive the signal to balance the contraction out. This causes the spinal column to twist and buckle," explains Dr. Andreas Heinig from the Fraunhofer Institute for Photonic Microsystems IPMS in Dresden. Building on this theory and working with research and industry partners in Spain and France, Heinig's team has developed a novel approach to treat this form of scoliosis. It makes use of functional electrostimulation, whereby targeted electrical impulses replace the nerve signals that the disease has caused to be either too weak or completely absent. The aim is for the impulses to stimulate the deep muscles along the spinal column so that they build up the necessary counter-contractions to allow symmetrical growth. Within the space of just two years, the interdisciplinary European consortium was able to develop a prototype implant.

The implant's principal function is to deliver a pattern of electrical pulses made up of active phases and rest periods, with doctors adjusting the pattern on an ongoing basis to match patients' individual needs. The device's core is implanted in the groin region. It contains circuit boards from which eight one-millimeter electrical cables lead to selected spots along the spinal cord. There, electrodes both stimulate the slack muscles on the side of the body neglected by the brain and monitor their activity. Several additional electrodes lead to the healthy side of the body to record muscle activity there – providing a set of reference values. An internal control mechanism compares these differing datasets with a view to constantly adjusting the muscle stimulation in line with the progress of the treatment.

It takes 50 pulses per second to stimulate the rotator muscles – and these pulses must be delivered over a long period of time. A typical training program involves six to eight hours of treatment every day, preferably during the night or at other quiet times, with several waves of muscle stimulation, each lasting a maximum of ten seconds, separated by at least ten minutes of rest.

**Tailoring stimulation and resting times to the muscles**

The battery the implant uses to carry out the standard program lasts around nine days before it needs to be recharged. Recharging takes roughly 90 minutes and is realized wirelessly via an inductive coupling. The data, too, are sent wirelessly from the implant to an external reader device – and vice versa. This makes it possible both to track the muscle activity measured in the body and to tailor each AIS patient's stimulation and resting times on an ongoing basis depending on the state of their muscles. "Our partners in Valencia were responsible for designing the relevant system. Should the implant be given to children with AIS one day, it will be their attending physician who operates the reader device," says Heinig.

Initial testing showed that the technology works in principle, with researchers sending data in both directions without a hitch. The muscle activation worked as planned, too. To position the fine electrodes in exactly the right place in the deep muscles along the spinal column, French company Synimed (another member of the consortium) developed special precision surgical instruments.

Compared to today's therapies, which oblige children to wear a corset or which involve operations to fuse the spine with metal plates and pins, the concept of functional electrostimulation is superior: this minimally invasive implant-based treatment not only promises to prevent the worst, but also opens the way to achieving a lasting correction of deformations. Whether the concept proves itself in practice is something only time will tell, Heinig stresses: "We have clearly shown that this form of therapy is technically feasible. Now it's up to future clinical studies to demonstrate that the therapy is medically effective and can cure or at least alleviate scoliosis."


**The implant uses electrical pulses to stimulate muscles. In the future, the unit will be implanted in the patient's groin area. The picture shows the prototype of the implant. (© Fraunhofer IPMS) | Picture in color and printing quality: www.fraunhofer.de/press**

**Fraunhofer Institute for Photonic Microsystems IPMS** | Maria-Reiche-Straße 2 | 01109 Dresden | www.ipms.fraunhofer.de
**Press:** Romy Zschiedrich | Phone +49 351 8823-233 | romy.zschiedrich@ipms.fraunhofer.de

Fraunhofer

# Gas sensors sound the smoldering fire alarm



As the stars twinkle in the sky high above the house, people lie sleeping in their beds. It's just an ordinary night – and yet, on this night, the slumberers' lives are at stake: A cable is smoldering away and poisonous carbon monoxide spreads unnoticed through the room. The smoke detector doesn't sound the alarm because it responds only to smoke, which is not always produced in a smoldering fire. In short, the room's occupants are in great danger.

## Reliably detects carbon monoxide

Gas sensors could wake people in time and save their lives. Researchers at the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg have developed just such a sensor. It recognizes a fire not by its smoke but by the carbon monoxide it emits. Nitrogen dioxide, which is produced a little later in the course of the fire, also triggers the alarm. Even the tiniest amounts of these gases suffice. "The sensors are extremely sensitive, so they respond very early in the fire's development. After all, every second counts," explains Dr. Carolin Pannek, a researcher at the IPM.

Life-saving carbon-monoxide sensors of this kind are already available today, but they are too expensive for the mass market. Furthermore, they require maintenance and use a lot of electricity. Commercially available semiconductor gas sensors are cheaper, but can't distinguish between different gases. That's not the case with the new sensor type created by the IPM researchers. "Ours responds only to carbon monoxide and nitrogen dioxide – it ignores other gases. By using roll-to-roll processing, we can produce the sensors very inexpensively, making it affordable for consumers," confirms Pannek.

This is primarily thanks to the dyes at the core of the sensor. Just as a lock opens only with a specific key, each dye responds only to a specific gas. Thus the sensor contains one dye for carbon monoxide and another for nitrogen dioxide. It works by having a small LED shine blue light into a waveguide coated with a polymer into which the dyes have been mixed. The light travels in a zigzag path to the other end of the waveguide, where it meets up with a detector. If the air in the room is normal, the coating glows purple – which means it absorbs only a small amount of blue light and lets most of the blue light reach the detector. If however there is carbon monoxide in the air, the dye glows yellow. The yellow dye absorbs more blue light – so the overall amount of light reaching the detector is lower. Below a given threshold value this trips the alarm. To detect nitrogen oxide, the researchers include a second waveguide coated with another dye.

## Costs slightly more than a smoke detector

The researchers were careful to ensure that the sensor could be manufactured cost-effectively in bulk – after all, no one wants to dig much deeper in their pocket than

they would for a conventional smoke detector, even though gas sensors offer significantly more protection. "When mass produced, the sensors will cost about the same as smoke detectors – and significantly less than the fire gas detectors currently available," Panneck believes.

To make their fire gas sensors, the researchers use the same components found in smoke detectors and supplement them with the optical waveguides. The electronics determine the threshold at which the sensor should sound the alarm. To manufacture these components, the researchers have worked together with an industry partner to develop a roll-to-roll process similar to newspaper printing that is capable of printing 15,000 measurement systems on a continuous roll. The process is both suitable for mass production and cost effective. But it will certainly take a few years for the gas sensors to become as ubiquitous in living and bedrooms as smoke detectors are now.

**In Fraunhofer IPM's sensor, dyes react to gases – and trigger an alarm, even in the case of smoldering fires. (© K.-U. Wudtke/Fraunhofer IPM) | Picture in color and printing quality: www.fraunhofer.de/press**

**Fraunhofer Institute for Physical Measurement Techniques IPM** | Heidenhofstraße 8 | 79110 Freiburg | www.ipm.fraunhofer.de
**Press:** Holger Kock | Phone +49 761 8857-129 | holger.kock@ipm.fraunhofer.de

Fraunhofer



# Wastewater to irrigate, fertilize and generate energy

Urbanization is in full swing. Particularly in Asia, solutions are needed for feeding the growing population, supplying water and energy, and cleverly recycling waste wherever possible. In Vietnam, researchers from the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart have adapted a wastewater treatment concept they developed in the DEUS 21 project to support the supply of water, energy and fertilizer.

Under the auspices of the German Society for International Cooperation GmbH (GIZ), the "Integrated Resource Management in Asian Cities: The Urban Nexus" project will now implement the innovative infrastructure along a strip of coastal land with some 200,000 residents in the Vietnamese city of Da Nang. Starting in the fall, 110 plots – home to around 500 people – are to be connected to a novel sewage network made up of vacuum pipes, which have a significantly smaller diameter than standard pipes. Wastewater is extracted with pumps, similar to the process used in trains and aircraft.

Until now, Da Nang's wastewater often flowed untreated into leaky ditches. Not only does this risk contaminating beaches, it also leaves untapped a valuable resource that the Fraunhofer researchers are now making accessible. Now for the first time, wastewater will be processed together with hotel kitchen waste; the resulting biogas will be used for cooking in hotel kitchens. Treated water will be used for urban agriculture – meaning farmers will require less groundwater, reserves of which are at risk of becoming ever more saline as seawater is drawn in to replace the excessive volumes of freshwater being extracted during periods of drought. A further advantage is that nutrients found in the processed wastewater work as a natural fertilizer. So the novel system connects the pressing issues of supplying water, energy and food with little effort – and the researchers achieve good results in each area. For example, with biogas: "At 45 liters per resident per day, our solution produces twice as much biogas as with traditional water treatment plants in Germany," says group manager Dr. Marius Mohr from the IGB.

## Even the wastewater energy is used

This concept sees wastewater purified biologically. "At the heart of the system are anaerobic bioreactors in which the organic component of wastewater ferments into biogas," Mohr explains. Bioreactors can also be combined with membrane filtration so that all larger particles, including the bacteria, remain inside the bioreactors. For cost reasons, this is not part of the initial plan for Da Nang.

The DEUS 21 concept was developed to maximize the recycling of wastewater and of the resources it contains. Not only can the biogas created in the anaerobic bioreactor be used for cooking, it can also be used to supply electricity and heat or to power

vehicles. And because the wastewater remains relatively warm after processing, it is possible to draw additional thermal energy from it and supply this to households in cooler regions via a district heating network. "As another product of wastewater treatment nitrogen-phosphorous fertilizer can be won through a process of precipitation and ion exchange," Mohr explains.

The system could be implemented in many different regions, in particular where there is no sewer system or sewage treatment. "It's also suitable for export to areas with little water because it can be adapted to fit the needs of arid and semi-arid regions," Mohr adds.

**Agricultural areas in the Vietnamese city of Da Nang: in the future, residents can use purified wastewater to water their crops. (© Fraunhofer IGB) | Picture in color and printing quality: www.fraunhofer.de/press**

**Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB** | Nobelstraße 12| 70569 Stuttgart | www.igb.fraunhofer.de
**Press:** Dr. Claudia Vorbeck | Phone +49 711 970-4031 | claudia.vorbeck@igb.fraunhofer.de

Fraunhofer

# Making effective use of voluntary help



The flooding of the river Elbe in early summer 2013 was another reminder of just how important volunteer help is in a crisis situation. Thousands of people came out to help, filling sandbags or handing out food. The willingness of members of the general public to provide assistance in an emergency is as great as ever. But in recent years, we have seen a shift in the nature of that engagement. Germany still has many volunteer firefighters, members of the German federal agency for technical relief, or people who volunteer with other rescue organizations. Many of them, however, now feel unable to take part regularly – for instance due to work pressures or lack of family time. At the same time, many people want to help out in a crisis but don't want to commit to be permanent members of an aid organization.

That's why researchers from the Fraunhofer Institute for Industrial Engineering IAO in Stuttgart joined the project entitled "Professional integration of voluntary helpers in crisis management and disaster prevention." This project, known as INKA, featured the German Red Cross as consortium head and also involved the Berlin fire department, the universities of Stuttgart and Greifswald, and the German national network for civil society. Its aim was to investigate how to recruit volunteers in the future, considering not just volunteers who are prepared to become a permanent member of an aid organization but also the more spontaneous helpers who want to chip in when there's a real crisis.

Numerous workshops provided the researchers with the chance to analyze the situation in organizations and public authorities charged with security responsibilities. They also surveyed leaders and volunteers on the ground. "Lots of volunteers want to feel that more is being done to take their needs into account. It's often the case that operations, training and exercises take up more time than they have to spare," says Dr. Wolf Engelbach, head of department at the IAO. The study demonstrates that there are several ways to improve conditions for volunteers. For instance, volunteers in primarily administrative roles don't have to be trained on every piece of technical equipment. It would also be good to make better use of volunteers' skills – for instance technical expertise, foreign languages or teacher training.

It is important for aid organizations to provide specialists with leadership training as well as technical training. An alternative would be to spread tasks such as personnel development among more people. They could cater to spontaneous volunteers by offering them targeted training courses without obliging them to become members straightaway. "It also makes sense to develop databases of interested volunteers so that you can contact them directly in emergency situations," says Engelbach.

**Guidelines for aid organizations**

INKA also yielded a final book containing scientific analyses and practical contributions in addition to guidelines for work within aid organizations. These include tips for how to engage spontaneous volunteers and how to recruit and retain permanent volunteers. The guidelines also explain how organizations can utilize social media to coordinate volunteers in crisis situations. For instance, they can use Facebook or WhatsApp to notify whole groups of people with a single message, and to selectively assign volunteers to specific tasks. These channels can also be exploited to broadcast pictures or video of the damage. Researchers will be presenting the findings from the INKA project, which was sponsored by the German Federal Ministry of Education and Research (BMBF), at the environment forum in Berlin on September 23.

Now there are two follow-up projects underway, KOKOS and DRIVER. KOKOS is again sponsored by the BMBF, and is looking at how to involve clubs, choirs and church groups in crisis situations. The partners in the EU-sponsored DRIVER project, meanwhile, are conducting experiments to analyze how to efficiently coordinate the work of spontaneous volunteers and organizations in crisis management.

For more information on INKA, please visit www.inka-sicherheitsforschung.de

**During the flooding crisis in eastern Germany in June 2013, volunteers and professional aid workers toiled side by side. (© Deutsches Rotes Kreuz, LV Brandenburg) | Picture in color and printing quality: www.fraunhofer.de/press**

**Fraunhofer Institute for Industrial Engineering IAO** | Nobelstraße 12 | 70569 Stuttgart | www.iao.fraunhofer.de
**Press:** Juliane Segedi | Phone +49 711 970-2124 | juliane.segedi@iao.fraunhofer.de

Fraunhofer

# Efficient heating for electric cars



Electric car drivers now have one more reason to love the summer, because in the winter, the vehicle's range declines markedly due to the additional energy demanded by the heating system. Electric cars generate next to no heat as opposed to conventional passenger vehicles, which produce more than enough engine heat to heat the interior. An additional electric heater is required. This is supplied with power by the same battery that provides the engine with energy. "In the most unfavorable case, you can only drive half the usual distance with the car", says Serhat Sahakalkan, project manager at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart.

Researchers at the IPA have developed a film-based panel heater, which quickly provides a comfortable warmth in electric cars, which is – particularly on short journeys – more effective than former electric heaters. The heating concept is based on a film that is coated with conductive carbon nanotubes (CNTs). For this, the researchers spray on a very thin layer of CNT dispersion. "The film is glued to the inner door trim and generates a comfortable warmth there in the area of the armrest within a very short time", Sahakalkan explains. The heater functions in accordance with the Joule principle: When electricity flows through the film, it comes across a natural resistance between the individual nanoparticles. These "collisions" generate heat.

**Extremely thin film saves energy and costs**

Conventional electric resistance heaters of the type used in electric cars, also make use of this principle. Usually, the conductive material used is copper wire, which is embedded in silicone mats, for example. The solution of the researchers from Stuttgart, however, offers several advantages: While the copper wire heaters available at present are relatively "bulky" and take up quite some installation space, the film heater consists of a layer of conductive material with a thickness of only a few micrometers. It can be flexibly applied to the most various surfaces and contributes to saving energy and costs due to its low weight. The CNTs themselves have a low heat storage capacity, as a result of which the generated heat is directly released into the environment. As opposed to the wire-based variant, the heat is evenly distributed here over the entire surface of the film, which considerably increases efficiency. When the driver switches the heating off, the material cools down just as quickly. "These fast response times are ideal for short distances such as urban trips", Sahakalkan explains. The desired heating output can be infinitely adjusted by the user. Even isolated defects do not impair functionality. In wire-based heating systems, for example, even minor breaks in the metal can lead to failure.

In order to evenly apply the film to the arched door trim, the researchers divide it into small modules and then glue them to the door trim in sections: "Slight creases arise at

the curvatures, which change the spacing of the electrodes. Even heat distribution would then no longer be ensured", the scientist states. In the longer term, the experts from Stuttgart intend to further simplify the procedure and spray the CNT dispersion directly onto the corresponding vehicle components. "This would make the production process considerably more economical – particularly in comparison to wire-based solutions", Sahakalkan says. A first demonstration model of the film heater will be presented by the scientists in September at the IAA in Frankfurt. The trade fair will take place from September 17th to 27th, the press day September 15th and 16th.


**In order to analyze the heating effect of the films for cars, the researchers connected them to a power source and monitored them using a thermo camera. (© Fraunhofer IPA) | Picture in color and printing quality: www.fraunhofer.de/press**

**Fraunhofer Institute for Manufacturing Engineering and Automation IPA** | Nobelstraße 12| 70569 Stuttgart | www.ipa.fraunhofer.de
**Press:** Joerg-Dieter Walz | Phone +49 711 970-1667 | joerg-dieter.walz@ipa.fraunhofer.de

Fraunhofer

# Recycling permanent magnets in one go



The rotors whir in the wind and provide the networks with electricity. In order to ensure that the plants run as fault-free as possible and achieve a high energy yield, the latest generation is increasingly being equipped with strong, multi-ton permanent magnets instead of a gearbox. These magnets do a good job in cars, too: They enable the numerous electric actuators, which drive the windscreen wipers, for instance, to be of a smaller and lighter design. Electric actuators or servomotors are located in many positions inside a car, wherever things need to be specifically moved and positioned, whether for the side windows or for the seat adjustment. The most powerful magnets are based on neodymium, iron and boron. Dysprosium is also frequently contained. The problem: While iron and boron are readily available, the supply of neodymium and dysprosium is critical. Because these rare earth elements are only gained under difficult conditions and with a great deal of energy input. They are therefore quite expensive in comparison and their procurement leaves an ecological footprint behind. Furthermore, more than 90 percent of these elements come from China. Almost half of the worldwide reserves are situated there.

## Turning old into new

Therefore, scientists are trying to recycle magnets. Up until now, this means: You extract the rare earth elements from the magnets again. This is, however, extremely laborious and expensive. The scientists of the Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS in Alzenau and Hanau of the Fraunhofer Institute for Silicate Research ISC are now pursuing a different approach. "Instead of trying to regain each individual type of rare earth, we focus on recycling the entire material, meaning the complete magnet – and this in only a few steps", Oliver Diehl, scientist in the Project Group IWKS explains. "This process is much easier and more efficient, because the composition of the material is already almost as it should be."

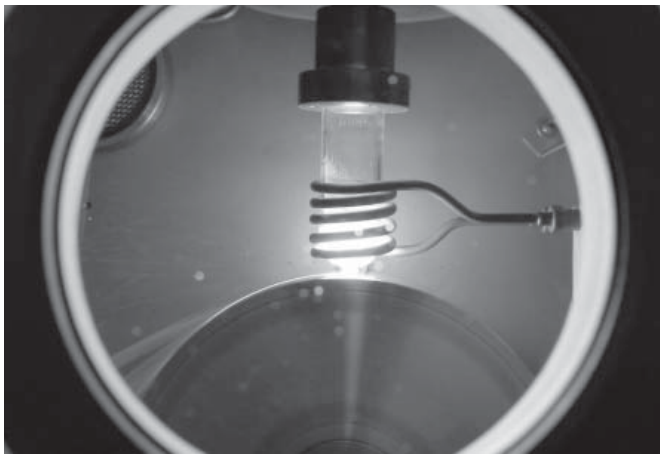
For recycling, the scientists rely on the melt spinning process – a method already tried and tested for other alloys, also known as "rapid solidification". The name reveals the method: The researchers liquefy the magnet in a melting pot. The liquefied material, heated to more than 1000 degrees Celsius, is directed via a nozzle onto a water-cooled copper wheel that rotates at a speed of 10 to 35 meters per second. As soon as the melted droplet comes into contact with the copper, it transfers its heat to the metal within fractions of a second and solidifies. The scientists call the emerging material formations "flakes". The special feature is the structure formed inside the flakes. If the melted material were allowed to solidify in the normal way, the atoms would "line up in rows" in a crystal lattice. In the melt spinning procedure however, crystallization is avoided: Either an amorphous structure is formed, in which the atoms are completely irregularly arranged, or a nanocrystalline structure, in which the atoms arrange themselves in nanometer-sized grains to form a crystalline structure. The advantage: The

grain sizes – meaning the areas with the same crystalline structure – can be specifically varied. They can be used to change the properties of the permanent magnet. In a further step, the researchers mill the flakes into a powder, which can then be further processed. "We press it into its final shape", Diehl says.

**First magnet successfully recycled**

The scientists have already set up a demonstration plant and have managed to recycle magnets there. "The demo system can process up to half a kilogram of molten material and is somewhere between a lab and a large-scale plant", Diehl goes on to specify. The researchers are now optimizing the properties of the recycled magnets by varying the melt spinning process – such as the speed of the copper wheel, for example, or the temperature of the melted material during the rapid solidification process. Both influence the cooling rate and consequentially also the crystalline structure of the solidified material.

In many cases, the magnets are extremely difficult to remove from the engines. The scientists are therefore developing potential ways of creating a collection cycle for used engines, and also of a design more suitable for disassembly: How could the engines be alternatively designed to make it easier to remove the magnets at a later date? What costs will be incurred is a question that is currently difficult to answer: "The anticipated financial advantage in recycling the magnets depends not only on the recycling process, but also on the price development for rare earth elements", Diehl says. "The higher the raw material prices for rare earths, the more it will pay off to recycle already existing materials."



**The researchers rely on the melt spinning process for the recycling of permanent magnets. For this, the material is melted in a crucible using an induction coil and subsequently poured onto a copper wheel. (© Fraunhofer Project Group IWKS) | Picture in color and printing quality: www.fraunhofer.de/press**

**Fraunhofer Institute for Silicate Research ISC, Fraunhofer-Project Group Materials Recycling and Resource Strategies IWKS** |
Brentanostraße 2 I 63755 Alzenau I www.iwks.fraunhofer.de
**Press:** Dr. Eva Bertrand | Phone +49 6023-32039-866 | eva.bertrand@isc.fraunhofer.de