Fraunhofer MIKROELEKTRONIK

Fraunhofer VμE Microelectronics News

July 2012 47

■ Title

Carved from quality wood

With its wooden housing, the "iameco" is really something to look at, but its inner values are even more persuasive. Photo: MicroPro

The range of organic products on supermarket shelves is growing. But has anyone ever thought of the need for a resource-saving computer, most of which can even be recycled? An Irish company working in cooperation with Fraunhofer IZM has developed just such a model.

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Broadband Internet for everyone. Photo: Fraunhofer FOKUS

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■ From the institutes

Flying 3D eye-bots

Whether as additional surveillance resources during major events, or as high-resolution 3D street-imaging systems, intelligent swarms of aerial drones are a universal tool for police, crisis managers, and urban planners. Special 3D sensors developed by researchers at Fraunhofer IMS ensure flawless aerobatics and prevent collisions.

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RF MEMS switches with low actuation voltage

Various frequency ranges are used to connect end devices to laptops, printers, and other devices via Bluetooth or Wi-Fi. Semiconductor switches are currently used as changeover gates. Fraunhofer ENAS is developing a MEMS technology that could replace semiconductor switches in the future.

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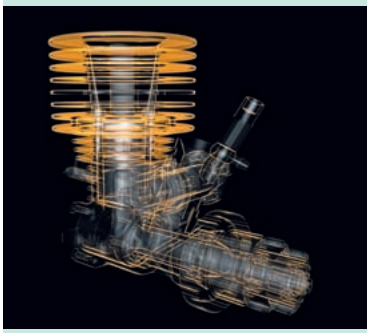

X-rays in time and space. Photo: Fraunhofer IIS

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High-pressure micropump for challenging applications

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… comes from Oliver Sawade from Fraunhofer FOKUS

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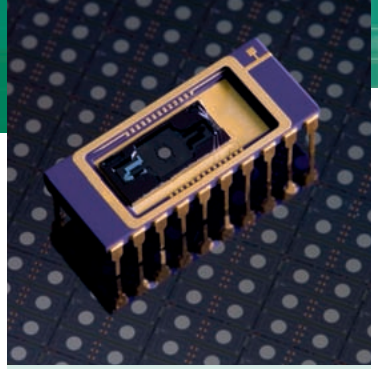
Events

Date	Event / WWW	Location	Group institutes involved
08/20 – 08/23	IEEE NanoTechnology Conference www.ieeenano2012.org	Birmingham, UK	
08/31 -09/05	IFA 2012 http://b2b.ifa-berlin.com	Berlin, Germany	FOKUS, HHI, IIS
09/05 – 09/07	SISPAD 2012 www.ece.umd.edu/sispad2012	Denver, USA	IISB
09/06 – 09/11	IBC 2012 www.ibc.org	Amsterdam, The Netherlands	HHI, IDMT, IIS
09/09 – 09/12	Electronics Goes Green 2012+ www.egg2012.de	Berlin, Germany	IZM
09/11 – 09/16	ILA 2012 www.ila-berlin.de	Berlin, Germany	ENAS
09/17 – 09/20	ESTC 2012 www.estc2012.eu	Amsterdam, The Netherlands	IZM
10/01 – 10/05	Optical Techniques and Nano-Tools for Material and Life Sciences www.izfp-d.fraunhofer.de/ont4mls.html	Dresden, Germany	IZFP-D
10/09 – 10/11	SEMICON Europa 2012 www.semiconeuropa.org	Dresden, Germany	VµE
10/15 – 10/17	International Conference on Planarization/CMP Technology 2012 http://conference.vde.com/icpt-2012/Pages/ICPT2012.aspx	Grenoble, France	ISIT
10/22 – 10/26	IST World Congress 2012 www.itsworldcongress.at	Vienna, Austria	ESK
10/26 – 10/27	AES San Francisco 2012 www.aes.org	San Francisco, USA	IIS
11/06 – 11/08	VISION 2012 www.messe-stuttgart.de	Stuttgart, Germany	HHI, IMS, IPMS
11/13 – 11/15	nano SAFE 2012 www.nanosafe.org	Grenoble, France	
11/13 – 11/16	electronica 2012 www.electronica.de	Munich, Germany	EMFT, ISIT
11/14 – 11/17	MEDICA 2012 www.medica.de	Düsseldorf, Germany	EMFT, HHI
11/27 – 11/29	SPS OPC Drives 2012 www.mesago.de/de/SPS/home.htm	Nuremberg, Germany	ESK



LinScan – quasi-static resonant MEMS scanner.
Photo: Fraunhofer IPMS

New MEMS mirror makes linear scanning possible

Fraunhofer IPMS has been working for years on scanner mirrors that can deflect light in one and two dimensions. Devices have, until now, continuously vibrated at a fixed frequency only. A new concept for a quasi-static mirror – "LinScan" – now allows the motion pattern to be adapted variably.

They are the ultimate feature for the cell phones of the future: small projectors that can be integrated into the mobile end device – they are known as pico-projectors. A projection the size of a television screen from a short distance and in high definition (HD) now seems to be technically possible.

The Fraunhofer Institute for Photonic Microsystems IPMS has been doing research into pico-project solutions for quite some time. The institute uses the principle of laser beam steering for image generation. As with an old CRT television, a laser beam whose brightness can be controlled (or, rather, three laser beams – one each in red, green, and blue for full color) is moved quickly across the projection surface using a single miniaturized scanner mirror. To the human eye, what then appears is a single cohesive image. The scanner mirrors have a typical diameter of approx. 1 mm and are manufactured in large batches cost-effectively from silicon wafers.

Fraunhofer IPMS uses an electrostatic actuator to move the scanner mirrors. Previously, only scanners with a planar structure were available; in this case, the mirror vibrates sinusoidally at a fixed frequency. Using these scanners, Fraunhofer IPMS has been able to build extremely compact projectors: They are so thin that they fit into current smartphones.

LinScan: linear scanning made easy

Scientists at Fraunhofer IPMS have now used the quasi-static scanner concept "LinScan" to develop a new device that allows the mirror to be redirected selectively. Previous disadvantages of resonant scanners, such as the fixed vibration frequency or the comparatively high scan frequencies that resulted from the mapping principle and made HD more difficult, have been overcome with LinScan. The basic technology has not been changed, but is has been sufficient to make a small modification to the mechanical design: in a later microassembly step, the actuator combs were tilted towards one another permanently.

This makes it possible to use a combination of resonant drive in the fast horizontal axis and LinScan in the slow vertical axis in a two-dimensional scanner – the core of pico-projectors. The laser beam can be directed to jump from row to row at a frequency that can be adjusted from outside. Pico-projectors with resolutions of SVGA (800 x 600) and above will be simple to put into practice. LinScan is also suitable for all other applications where static positioning of a laser beam or scanning at variable frequency is required. This is ideal for making "LinScan" the pocket presentation tool of the future for meetings, at school, for e-learning sessions, and for entertainment.

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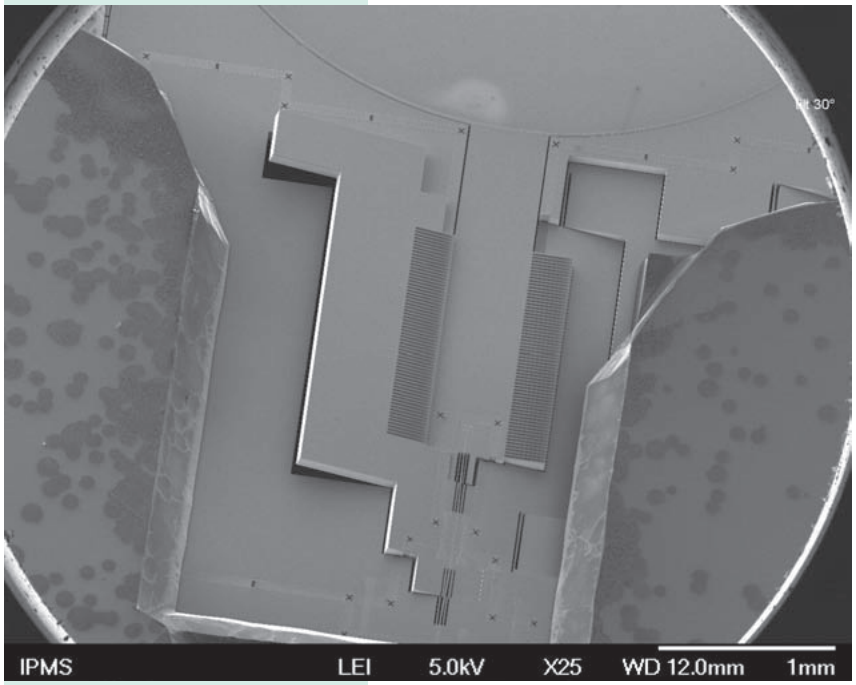


Centered vertical comb (CAVC).
Photo: Fraunhofer IPMS

Pure sustainability: the housing of the "iameco" is made of wood. Photo: pixelio.de / Bettina Stolze

Carved from quality wood

The range of organic products on supermarket shelves is growing. Our nights are illuminated by energy-saving light bulbs. And the cars of the future will put considerably fewer emissions into the air. Environmental protection and sustainability have moved into focus in more and more areas of our lives. But has anyone ever thought of the need for a resource-saving computer, most of which can even be recycled? With the "iameco" an Irish company working in cooperation with Fraunhofer IZM has developed just such a model.

Today's computers do not have a long life expectancy. Yesterday's newest and most powerful model will be obsolete tomorrow. This is because the innovation cycles in the information and communication technology sector are getting shorter and shorter. But where do retired PCs end up? Until now, their last resting place has been the hazardous waste site. With elements such as PVC or heavy metals, only a very small part of a PC can be recycled. But other factors also impair the ecological impact of a conventional PC – primarily its appetite for electricity. An average PC workstation uses 201 kWh of electricity per year, according to the BITKOM study "Resource-efficient workstation computer solutions 2020."

Old casing, new core

The Irish company MicroPro Multimedia, together with the Fraunhofer Institute for Reliability and Microintegration IZM, has now developed an all-in-one computer that has less environmental impact. With a wooden housing and largely halogen-free standard components – including processors and memory – the iameco is made up of up to 98% recyclable materials. 20% of them can even be used again immediately. Thanks to a modular upgrade concept, the eco-computer will also have an extended life time compared to standard PCs. While today's standard PCs usually have to be replaced after three to four years, technologically obsolete components of the iameco can simply be exchanged by MicroPro for new ones. Its renewable "inner life" in the old housing should allow the computer to continue running for seven to eight years. Thanks to passive cooling and a solid-state drive (SSD), its yearly energy consumption is a mere 94 kWh. That is 45% less than the current energy-saving star of this computer class, a model with a category-A limit of 148 kWh.

70% fewer CO_2 emissions

The researchers at Fraunhofer IZM were responsible for the development of an ecological product design. This offers a means of mapping the environmental effects of a product in detail during the development phase and being able to incorporate the findings into the product design. Using data from the predecessor of the iameco, the scientists analyzed the entire life cycle of the PC – from production and usage to recycling. The focus was largely on energy consumption. The scientists also took a close look at the PC's carbon footprint. These are the CO_2 emissions produced over the entire life of a product. At below 360 kg, the carbon footprint of the iameco is relatively low– a typical desktop PC with monitor would have 70% higher CO_2 emissions. The iameco was the first computer in its class to be awarded the EU Ecolabel

Photo: MicroPro

Alexander Schlösser.
Photo: Fraunhofer IZM

"The iameco is low-maintenance and very easy to recycle"

It certainly catches the eye – you don't see a wooden PC every day. Alexander Schlösser runs his nimble fingers across the touchscreen of the "iameco," a computer whose environmentally friendly and elegant product design, energy efficiency, and sustainability make it unique. Fraunhofer VµE spoke to Schlösser about the environmental balance sheet of the "iameco."

About Alexander Schlösser:
Alexander Schlösser studied history of science and technology and environmental technology at the Technische Universität Berlin. In 2011, he won the 2nd place in the Elektronik Ecodesign-Preis for his master's thesis on "Environmental policy for electronics/green IT – a consideration of environmental laws in the PR China and Germany based on selected examples." He currently works as researcher at Fraunhofer IZM in the Environmental and Reliability Engineering department and is concerned with the development of sustainability strategies and evaluation methods in the context of electronics and ICT. Mr. Schlösser deals with the optimization potential of IT technologies for energy-efficient data centers.

What contribution did Fraunhofer IZM make to the development of this eco-PC?

Schlösser: We were commissioned by the MicroPro company to carry out an environmental assessment of the PC. In concrete terms, we investigated the design and technologies used and suggested improvements.

How exactly did the environmental assessment of the iameco proceed?

Schlösser: We evaluated the primary energy consumption of the all-in-one PC across its entire life cycle, i.e. from production and use to recycling. We also analyzed its carbon footprint and looked at the level of CO_2 emissions the iameco would produce throughout its life cycle. In addition to using the renewable resource of wood as the material for the housing, the carbon footprint is mainly determined by the PC's energy consumption in the use phase. We then drew up design optimizations for reduced energy consumption and increased recyclability; these optimizations were adopted immediately at the product development stage.

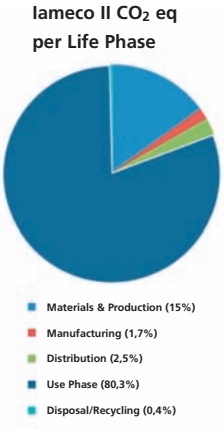
And what kind of footprint does the iameco have?

Schlösser: The result was impressive. Its carbon footprint is very small. It produces less than 360 kg of CO_2 emissions, which is only 30% of that of a typical desktop PC with monitor. 80% of these emissions are generated by the operation of the computer. The largest energy consumption is therefore in the use phase, rather than during production. The wooden housing also improves the carbon footprint, but in comparison to the use phase and the manufacture of the mainboard and the monitor, its contribution is less important.

How did you manage to reduce the energy consumption of the iameco?

Schlösser: Only notebook components were used in the PC. We recommended, for example, that a fan-less cooling concept be integrated and an SSD hard drive installed. This type of hard drive is very low-noise and uses less electricity. We also suggested equipping the iameco with an LED monitor, as these use 30 – 40% less energy than conventional monitors.

How recycling-friendly is the iameco?



Schlösser: The iameco is low-maintenance and very easy to recycle. That means that its standard components can be replaced easily. We are working on allowing the entire "inner life" of the PC to be designed in a modular manner using standardized interfaces, so that, ideally, users will be able to remove old components and simply replace them with new ones. In principle, that will make a completely new PC, although the housing and screen will remain.

Looking into the future: will there soon be eco-TVs and eco-laptops?

Schlösser: Definitely! We are currently working with MicroPro on developing an environmentally friendly notebook with a wooden frame as part of the EU project "LCAtoGo."

Mr. Schlösser, thank you very much for talking to us.

Alexander Schlösser was talking to Juliane Otto.

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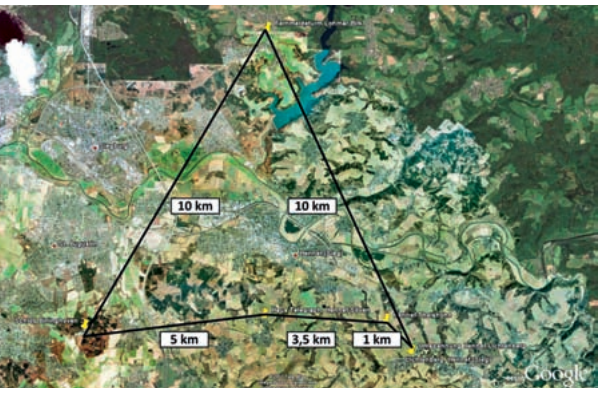
Broadband Internet for everyone

In the developing world, 96% of all households have no Internet access. Even in Germany, many regions are still without broadband connectivity. For this reason, Fraunhofer FOKUS has developed a cost-effective wireless technology called „WiBACK" that supplies rural areas with broadband Internet and mobile communications.

John lives in a rural area in Zambia and has no Internet access. When he wants to get his teammates and the opposing team together for a soccer game, he must organize the entire game using his cell phone – which is time-consuming. But that's about to change, for John's village is set to acquire an eKiosk with a number of PCs, and its inhabitants will then have access to services such as email, chat, web browsing and Internet telephony. This new Internet connectivity is being made possible by WiBACK Wireless Backhaul Technology, which has been developed by the Fraunhofer Institute for Open Communication Systems FOKUS. WiBACK is a wireless network that uses existing technologies to build a far-reaching network of radio links using inexpensive WiBACK routers. Naturally, the system is designed to support all existing wireless technologies



Fast Internet for everyone: Fraunhofer researchers are fitting a farm in Hennef with mobile communications and broadband Internet as part of a pilot project. Fig.: Fraunhofer FOKUS

WiBACK network: cost-effective and robust

The demands that will be made on the WiBACK network in the developing world are huge. "Our technology has to be reasonably priced, low maintenance, auto-configuring and robust. It also has to bridge massive distances of several hundred kilometers. Should a router fail, data must divert automatically. And should an operating error occur, the system must be able to restore itself to normal operation. WiBACK fulfills all these requirements," says Prof. Karl Jonas, project leader at FOKUS. Routers are installed on water towers, purpose-built masts or other similar high-lying points. Since the equipment has GSM and UMTS interfaces, the network is also suitable for mobile communications. And this extremely energy-efficient technology is powered by solar cells. WiBACK wireless networks are due to be rolled out to several countries in sub-Saharan Africa in summer 2012. Even schools and hospitals in sparsely populated areas will then be able to access the Internet.

Internet in the Westerwald

In the meantime, FOKUS researchers have already embarked upon their next project, to ensure that infrastructure-poor regions within Germany will also benefit from these inexpensive developments for wireless broadband Internet. The first pilot network is currently being built on the fringes of the Westerwald and will be used to test just how reliable the network will be when it is in continuous operation. For example, what will happen when a network hub fails, perhaps because of a power cut? As Jonas points out, "We won't be installing solar cells in Germany, since the electricity network covers almost the entire country." Initially, he and his team are providing a remote farm in Hennef-Theishohn with mobile communications and broadband Internet. To do this, they have set up a 21-kilometer radio link between the Fraunhofer-Gesellschaft's existing fiber optic connection in Birlinghoven and the farm, using a local substation operated by energy supplier RWE as a relay point.

WiBACK technology can also be employed during major events such as soccer games to increase the overall capacity of the mobile communications network for a set period of time. In this connection, the researchers are keen to draw attention to the system's energy consumption: WiBACK will automatically register if a soccer stadium is full to bursting and increase the number of available network hubs accordingly or else reduce the wireless output to save energy.

A researcher adjusts the antennas of the WiBACK system. Photo: Fraunhofer FOKUS

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Flying robots can keep an eye on large-scale events such as soccer games. Photo: Chmouel Boudjnah / www.wikipedia.de

Flying 3D eye-bots

Whether as additional surveillance resources during major events, or as high-resolution 3D street-imaging systems, intelligent swarms of aerial drones are a universal tool for police, crisis managers, and urban planners. Special 3D sensors developed by researchers at Fraunhofer IMS ensure flawless aerobatics and prevent collisions.

A formation team of flying robots rises slowly into the air with a loud buzzing. A good two dozen in number, they fly above the seething hordes of soccer fans. Rowdy hooligans have stormed the field and set off flares. Fights are breaking out, smoke is hindering visibility, and chaos is the order of the day. Only the swarm of flying drones can maintain an overview.

Precise overview from above

The flying robots are like a mini-helicopter, with a wingspan of around two meters. They have a propeller on each of their two variable-geometry side wings, which lends them rapid and precise maneuverability. Above the playing field, their cameras and sensors capture urgently needed images and data and transmit them to the control center. Where are the most seriously injured people? What's the best way to separate the rival gangs?

A CMOS sensor developed by researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg is the heart of the anti-collision technology. "The sensor can measure 3D distances very efficiently," says Werner Brockherde, head of development. Just as in a black-and-white camera, every pixel on the sensor is given a gray value. "But," he explains, "each pixel is also assigned a distance value." This enables the drones to determine their position in relation to other objects.

Sensor has a higher resolution than radar

The distance sensor developed by Fraunhofer IMS offers significant advantages over radar, which measures distances using reflected echoes. "The sensor has a much higher local resolution," says Brockherde. "Radar images would be far too coarse in near-field conditions." The flying robots can detect even small objects 20 by 15 cm² at up to 7.5 m. This distance information is then transmitted at 12 images per second.

Even when there is interfering light such as direct sunlight, the sensor will deliver accurate images. It uses the time-of-flight (TOF) method, whereby light sources emit short pulses that are reflected by objects and bounced back to the sensor. In order to prevent ambient light from masking the signal, the electronic shutter only opens for a few nanoseconds. The sensor also takes differential measurements, where the first image is captured using ambient light only, a second is taken using the light pulse as well, and the difference between the two determines the required output signal.

The 3D distance sensors are built into cameras manufactured by TriDiCam, a spin-off company of Fraunhofer IMS. The work falls under the AVIGLE project, one of the winners of the 'Hightech.NRW' cutting-edge technology competition which receives funding from both North Rhine-Westphalia and the EU.

Aerial surveillance of major events is not the only intended use for flying robots. They could also be of benefit to disaster relief workers and urban planners. Whether used to create virtual maps of remote areas, to monitor construction sites, or to measure contamination at nuclear plants, they could replace expensive aerial photography or satellite imaging.

The 3D camera in the flying robot can detect small objects of 20 x 15 cm² from up to 7.5 m. Photo: Fraunhofer IMS

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More precious than gold: the wonder material gallium nitride

Gallium nitride is considered the semiconductor material of the future. But its manufacture is still very expensive. Scientists at Fraunhofer THM in Freiberg want to use a new method to make the commercial use of gallium nitride in electric cars and mobile communication a reality.

They are small, robust, and energy-efficient: light-emitting diodes have long been part of our daily lives. They are found in flashlights, traffic lights, and ceiling lamps. Semiconductor crystals such as gallium nitride (GaN) turn darkness into light. The chemical compound, made up of gallium and nitrogen, can make blue and even white light.

Wonder material of the future

But the crystal material contains even more potential. In the future, it could replace the current number one semiconductor material – silicon – in optical and electrical applications in power electronics and the high-frequency range. "Gallium nitride is a semiconductor with outstanding physical properties, and these are reflected in low loss rates, a good return, and high energy efficiency. That is why gallium nitride is very interesting for a range of applications," explains Dr. Jochen Friedrich, spokesperson for the Fraunhofer Technology Center for Semiconductor Materials THM and director of crystal growth at Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen. Power electronics for highly efficient, low-loss devices in photovoltaics, mobile communications, and electric and hybrid cars relies more and more on the new material.

The challenge of crystalline structures

The problem is that these devices require large GaN single crystals with near-perfect crystalline structures. But these cannot be produced with classic crystal growth techniques from the melt. GaN must be grown from the vapor phase or from a solution containing gallium and nitrogen. These methods are very costly and the GaN yield is limited: the crystals produced weigh only a few hundred grams. The wonder material is thus still extremely expensive. A GaN substrate with a diameter of 5 cm is worth almost ten times its weight in gold. That is not a problem for most illumination purposes, as the LEDs do not have to be as powerful and the crystals can contain imperfections. But for extremely bright LEDs or special devices in power electronics, a thousand defects per square centimeter in the active layer are enough to impair the power of the devices.

Success thanks to HVPE method

That is why Fraunhofer scientists from THM and IISB are working with experts from Freiberger Compound Materials GmbH on a new technology. The researchers want to use the hydride vapor phase epitaxy (HVPE) technique to improve existing production methods for GaN crystals. This method is based on gaseous hydrogen chloride, which bonds with liquid gallium to form gaseous gallium chloride. Within a reaction zone, the gallium chloride is transported in the vicinity of a gallium nitride seed crystal at temperatures between 1000 °C and 1100 °C.

GaN crystals grown from the gas phase. Photo: Fraunhofer IISB

Test system at Fraunhofer IISB for accompanying research into increasing the material efficiency of HVPE GaN. Photo: Fraunhofer IISB

At the same time, ammonia is added, and this bonds with the gallium chloride to form crystalline gallium nitride. The crystal grows and, under optimum conditions, reaches a diameter of 5 cm and a thickness of a few millimeters. The procedure is still expensive, but the Fraunhofer scientists are confident that they will be able to change the HVPE method to allow GaN crystals to be produced significantly more cheaply.
The crystal growth experts from Freiberg have just under three years to increase material efficiency of HVPE GaN growth – and to make GaN cheaper than gold in the long term.

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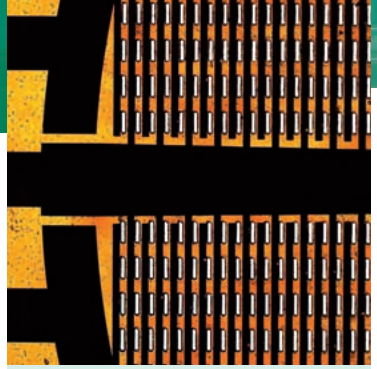


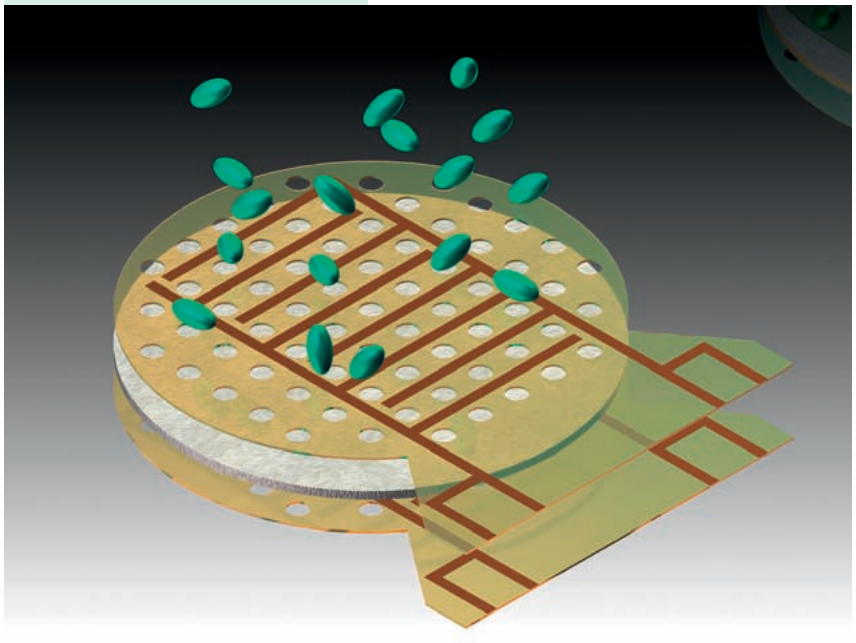
Electrode film with laser-cut openings (approx. 120 x 25 µm²). Photo: Fraunhofer EMFT

Intelligent microfilter that can monitor its own load level

Scientists at Fraunhofer EMFT have developed a sensor-based microfilter that constantly monitors its own load level. This allows early warning to be given before the filter becomes blocked. Monitoring the fill level and condition of the microfilter also provides useful information about the process.

Microfilters are used in many technical systems. They catch tiny particles during the production process and ensure that these do not escape into the environment or into systems downstream. After a certain operating time, however, they become blocked and must be replaced or cleaned. With conventional filters, measuring the current load and blockage level of each filter membrane is no simple task. Often a blockage only becomes apparent when the system loses pressure.

Schematic diagram of the sensor filter stack. Fig.: Fraunhofer EMFT



Keeping an eye on the current status

Scientists at the Fraunhofer Research Institution for Modular Solid State Technologies EMFT have developed a new type of microfilter stack. In the future, this "smart filter" will make it possible to constantly monitor the fill level of a filter and to prevent a blockage before it sets in. The filter independently detects its own load level, allowing automated monitoring of the filter, sample, and process for the first time.

Wide range of applications in process control

Researchers have combined sensors and filter technology in a film-layer system. The microfilter comprises two sensor films with capacitive electrode structures (inter-digital condensers) with a filter membrane placed between them and adapted for the application. During operation, cells or particles held back by the filter change the electrical properties of the flowing medium on the face side of the filter. These parameters allow the load level to be measured capacitively. Measuring the change in the filter load level over time also provides information about the density of particles or cells in the medium. The substances that collect in the module can, where needed, be later analyzed further.

This analysis offers valuable information about the processes and opens up a wide range of possible applications in process control and production monitoring. These could include cell cultures in the field of life sciences, fermentation in food technology, and the cultivation of algae for medical purposes or biomass production. The filter could also be used to filter gases, either for safety applications or in process technology.

Roll-to-roll process for cost-effective production

The sensor filter can be integrated into various technical machinery and microfluidic systems for online measurement. Using polymer films as carrier material and for the electrodes and manufacturing the filter in a roll-to-roll process enables cost-effective production.

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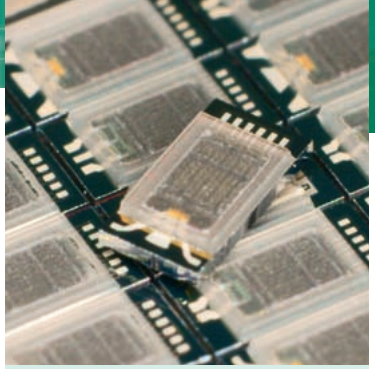
RF MEMS switches with low actuation voltage



RF MEMS switches after dicing. Photo: Fraunhofer ENAS

Mobile communication is particularly on trend right now. Internet, voice calls, and many other functions are available on smartphones. Various frequency ranges are used to connect end devices to laptops, printers, and other devices via Bluetooth or Wi-Fi. Semiconductor switches are currently used as antenna switches. Fraunhofer ENAS, together with the Chemnitz University of Technology, is developing a MEMS technology that could replace semiconductor switches in the future.

In many mobile communication devices, frequency-specific front-end modules (FEMs) with corresponding transmitter and receiver amplifiers as well as filter and matching circuits allow use of different frequency bands. Changeover gates connect multi-band antennas to the currently active FEMs; Semiconductor switches used for this purpose typically have an insertion loss of between 0.4 dB and 0.6 dB and an IP3 (intermodulation intercept point, which refers to the switches' non-linearity) of between 30 dBm and 40 dBm. A few microwatts of control power is consumed, and these contribute to the device's total power consumption and reduce the battery operation time.

The central issue is reliability

Switches based on micro-electro-mechanical systems (MEMS) could become alternative devices. They boast lower insertion loss as well as considerably better non-linearity, and only require one thousandth the control power of semiconductor switches. Some companies already offer MEMS switches with insertion loss of 0.2 dB and an IP3 of 65 dBm, with control power of less than 1 nW. The switches are electrostatically driven, but the actuation voltage – above 40 V – is often incompatible with CMOS electronics (≤ 3 V).

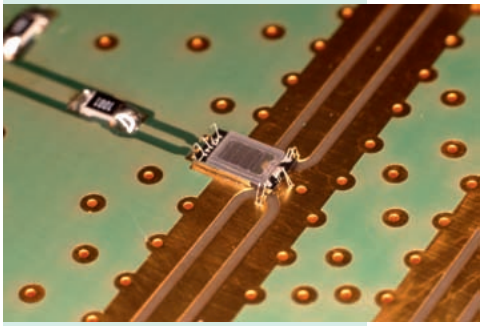
Particular risks to reliable functioning of RF MEMS switches are addressed. On the one hand, it is the possibility of becoming locked in one status due to sticky contacts or by the electric charging effects of insulating materials on the drive electrodes. On the other hand, contamination and wear and tear of metal contacts over time lead to an increase in insertion loss.

Success thanks to MEMS technology

For this reason, the Fraunhofer Institute for Electronic Nanosystems ENAS, together with the Center for Microtechnologies at the Chemnitz University of Technology, has developed an MEMS technology that reduces the risks mentioned. Electrostatic comb drives are produced using special etching technology and a method to reduce the electrode gaps after etching. Even at low drive voltages of between 3 V and 5 V, they – together with suitable return springs – produce strong contact and separation forces. This significantly reduces the risk of locking contacts.

The relatively strong drive force results in a switch time of < 10 µs. The electrodes do not require insulating material, with the result that lifetime tests showed one billion switch cycles with no sign of electric charging effects. The scientists coat the contact surfaces with metal in one of the final steps of the process. This minimizes contamination, a phenomenon otherwise frequently seen as a result of subsequent processes such as photolithography or the addition and removal of sacrificial layers on the contact surfaces. Packaging takes place at wafer level by bonding a glass wafer with a special gas filling; this means that, after separation, the devices can be used as a flip-chip device without further packaging.

Other fields of application, particularly for MEMS switches with ohmic (metal-metal) contacts, are opening up in mobile communication base stations, in radar systems (for beam shaping and for rotating the orientation direction of the antenna), as well as in the switching matrices of automatic test equipment.



RF MEMS switch on a test board. Photo: Fraunhofer ENAS

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Photo: pixelio.de / D. König

Analyzing energy potential

Sensors, radio transmitters and GPS modules all feature low power consumption. All it takes is a few milliwatts to run them. Energy from the environment – from sources such as light or vibrations – may be enough to meet these requirements. Whether the energy potential is high enough, determines a new measurement device. A new type of measuring device developed by researchers from Fraunhofer IIS will determine whether the energy potential is sufficient.

The freight train races through the landscape at high speed, the train cars clattering along the tracks. The cars are rudely shaken, back and forth. The rougher the tracks, the more severe the shaking. But, although this shaking would spoil the journey for passengers, it has a positive side-effect when transporting freight: This vibration delivers enough energy to charge small electronic equipment. This is how the sensors that monitor temperatures in refrigerator cars, or GPS receivers that keep tabs on the location of the freight, can receive the current they need to run.

Vibration replaces batteries

Experts refer to this underlying technology as "energy harvesting," where energy is derived from everyday sources such as temperature or pressure differences, air currents, mechanical movements or vibrations. But is this really enough to supply electronic microsystems? The answer is provided by a data logger that is also installed on board, a product from the Fraunhofer Institute for Integrated Circuits IIS. This compact system analyzes and characterizes the potential of usable energy – in this case, the oscillations created during the ride. It measures key parameters of the source of the vibrations, such as the amplitude and the frequency spectrum of acceleration. "We can use the data collected to design vibration converters, such as piezoelectric generators, to feed the sensors, radio transmission receivers, tracking systems and other low-power-consuming devices with enough energy to power them," explains the IIS group manager and engineer, Dr. Peter Spies. The tracking systems in use to date run on just a battery. These batteries need constant replacement, but that involves a lot of effort and expense. Logistics processes are not the only candidates, however. The energy "harvested" can be used for a great many other applications as well – to charge heart-rate monitors, sensors in washing machines and production plants, or measurement systems in cars to measure the air pressure in tires.

Optimally trimmed to match the application

The elements of the data logger include an acceleration sensor, a GPS module, a microcontroller, an SD card and a Wi-Fi interface. The sensor measures the freight train's acceleration along three axes. At the same time, the GPS module determines the vehicle's position and stores the data along with the acceleration values on the SD card. These parameters can be used to pinpoint the train's speed and the amount of energy available to it. "That way, we can fine-tune the energy converter and tailor it to the application involved," the researcher adds. The data logger is already in use in freight cars, trucks and machinery. Spies and his team are currently working to develop a complete tracking system that includes not only a GSM module and a GPS receiver but also a vibration converter that turns mechanical energy into electrical energy.

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Researchers attach the data logger to a container. Photo: Fraunhofer IIS

Satellites to control asphalt machines

The majority of paved roads have an asphalt surface. But asphalting is a complex process: temperature, layer thickness, density, and evenness play a decisive role in ensuring quality later. The smallest faults in construction can soon lead to cracks, unevenness, and potholes. This means that road surfaces need to be repaired or replaced sooner than planned. As part of the "ASPHALT" (Advanced galileo navigation System for asPHALt fleeT machines) project, partners from research and industry have developed solutions to improve road surfaces and optimize processes. That should reduce road maintenance costs drastically in the future.

An important part of the project is the Galileo/GPS/EGNOS receiver developed by Fraunhofer IIS. This localization technology allows asphalt machines to be localized and controlled with high precision. The multi-frequency receiver from the Erlangen-based institute has many benefits:

the use of two frequencies reduces disturbances from the ionosphere. This allows the position of the asphalt machines to be determined more precisely. Combining GPS and Galileo also increases the availability of satellite signals. Exact control of the machines guarantees a consistent layer thickness and thus a more even road surface. The project partners also took a closer look at the processes and supply chains for asphalting, and were able to optimize them: all machines used are linked to one another and can exchange important parameters such as temperature, layer thickness, and density. End-to-end data capture allows thorough checking and logging of processes.

Photo: MOBA Mobile Automation AG

The "ASPHALT" project
The "ASPHALT" project partners are: MOBA Mobile Automation AG, Fraunhofer IIS, DKE Aerospace, Dynapac, TeleConsult Austria and in-Position. The project was completed at the beginning of May.

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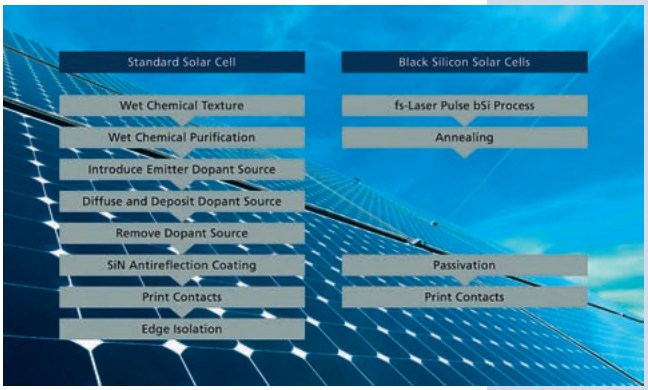
Record result for black silicon solar cells

Obtaining energy from sunlight is about to get more efficient. Researchers at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut HHI, have succeeded in doubling the efficiency of black silicon solar cells. A femtosecond laser pulse method has now made it possible to capture the previously unused infra-red element of sunlight and extract its energy. The highest level of efficiency previously obtained – 2.2%– was the work of a team of scientists at Harvard University.

One of the decisive contributing factors for this process, developed at Fraunhofer HHI in Goslar, is a change made to the silicon base material. The surfaces of silicon wafers are treated with ultra-short laser flashes – femtosecond laser pulses – which makes them turn black. The material is known as "black silicon." Thanks to this change, the surface of the solar cells can also absorb the infra-red element in sunlight. The infra-red element, which accounts for about a third of the spectrum, is not captured by conventional solar cells.

There has also been another step forward in improving the efficiency of silicon solar cells: the front texture of the cell and the emitter together form one step in the femtosecond laser pulse process, which reduces the number of steps required to produce a solar cell by approximately one half.



Comparison of the process used for a standard silicon solar cell with that used for the black silicon solar cell developed at Fraunhofer HHI. Fig.: Fraunhofer HHI

The solar cells thus produced are characterized by current densities in the range of 38 mA/cm² < J_{SC} < 42 mA/cm². Professor Dr. Wolfgang Schade, director of the project group in Goslar, had this to say: "We can see great potential for development in this technology, and initial consultations with the German photovoltaic industry have been extremely positive."

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Joint simulations save a lot of time and money. Fig.: Daimler AG

Breakthrough for virtual vehicle development

The automobile sector has long used simulations to design reliable components for vehicles. There are now, however, countless simulation programs especially developed for individual components. This becomes a problem even when designing an automatic trunk lid. Various parts suppliers usually work with different and often not mutually compatible simulators. For that reason, a special solution must be used to simulate all trunk-lid functions, or the components cannot be tested together on a single model before construction.

Researchers from the Dresden branch of the Fraunhofer Institute for Integrated Circuits IIS, together with other partners, have developed special interfaces to solve the problem within the joint project MODELISAR. The Functional Mock-up Interface (FMI) has been created as an open standard, allowing models to be swapped between different simulators. These device models can then be merged and the interaction of vehicle parts can be reproduced virtually – much faster and more precisely than was previously possible. Fraunhofer IIS/EAS has also helped to develop methods and algorithms for interfaces that can be used to connect simulators to one another.

All of that allows developers from different domains to work together on designing, simulating, and optimizing. Simultaneous design of systems and software, in particular, is a great aid to the industry, and something that was previously impossible due to different standards. Around 30 European manufacturers of simulators have already announced that they will support FMI in the future. The same goes for Daimler, Volkswagen, and Volvo, who have tested the FMI standard in practical application along with other project partners.

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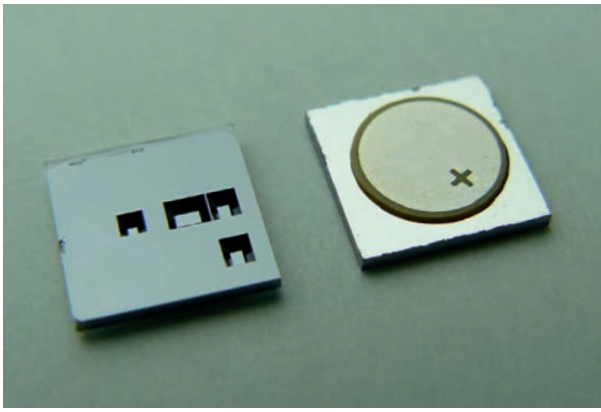
High-pressure micropump for demanding applications

Micropumps that can transport the tiniest volumes of liquids or gases are used in a wide range of applications. One area of use for these little helpers is in administering very precise dosages of medication, essential for example for treating tumors. In an industrial context, they regulate coolant circulation or ensure that machines are topped up precisely with lubricant. The delicate systems, however, are usually very sensitive to varying back pressures, particles, free flow, and air bubbles, all of which can affect the accuracy of the dosage result or result in the failure of the micropump.

Scientists at the Fraunhofer Research Institution for Modular Solid State Technologies EMFT have now developed an extremely small and powerful micropump made of silicon that is not affected by these factors. At only 7 x 7 x 1 mm³, the pump is no bigger than a sugar cube, yet can create pressures of up to 6 bar (liquids) or 1 bar (air and other compressible gases). An important "side effect" of this high compression ratio is that gas bubbles in fluids no longer present a problem to the mini-pump. With a cubic capacity of a mere 80 nl – about one five-hundredth of a drop of water –



High-pressure micropump chip made of silicon: front with piezo (right) and rear (left). Photo: Fraunhofer EMFT

the pump allows extremely fine dosage of medication or lubricant. Thanks to its strong resistance to counterpressure, the cubic capacity is reduced by less than 1.5% at a counterpressure of 0.1 bar – making the pump almost independent of pressure in this low-pressure range. A special seal fitted directly at the pump chip functions as a safety valve. This valve can close even at high excess pressures and thus prevent free flow. A special filter has been integrated into the pump housing to catch occasional particles. Last but not least, the new high-power pump uses very little energy thanks to specially developed electronics.

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X-rays in time and space

What happens inside a running engine? The Fraunhofer Institute for Integrated Circuits IIS visualizes the previously invisible interaction of the components: the Fraunhofer researchers have added the fourth dimension – time – to three-dimensional x-ray computed tomography (3D CT) systems, creating 4D CT and giving us insight into the moving world of dynamic processes.

For many years, 3D CT systems have been used for industrial product testing. 3D CT allows complex objects to be observed without touching or destroying them. The data record generated is a static 3D map of a real measured object. The Fraunhofer researchers are now adding information about time and motion to this 3D CT data record. This is achieved by the use of several consecutive volume data records. This volume sequence allows dynamic processes to be visualized and analyzed. To this end, Fraunhofer IIS is developing different recording and reconstruction procedures for processes that change over time. The reconstruction data obtained allows a 4D analysis of the temporal-spatial behavior and interaction of components under extreme external conditions, e.g. during endurance tests.

Areas of application for this new "4D view" include investigation of the temporal effect of tensile and pressure tests or temperature gradations on products as well as process and quality analyses. For the first time, the motions of a combustion engine piston and the rolling bodies in a ball bearing can be mapped and analyzed in full. These processes, which were previously hidden, as well as their effects on individual product components, provide important information for improving production processes.

Moving two-stroke engine including views of the CT recording. Photo: Fraunhofer IIS

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INC8: 8th International Nanotechnology Conference in Japan

On the occasion of the 8th International Nanotechnology Conference on Communication and Cooperation (INC8), around 20 of the world's leading movers and shakers of the nanoelectronic and nanotechnology scene from Europe, Japan, and the USA met at the beginning of May in Tsukuba, Japan. Over four days, scientists presented current developments in nanotechnology and held joint discussions with international politicians and leaders in the industry about the continuance of international funding programs, future developments, and possible cooperations within nanotechnology.

The conference was started in 2005 and has the aim of sharing information about regional nanotechnology programs – with a focus on nanoelectronic topics – on a global stage using up-to-date overview presentations. The intention is to use this basis to promote communication and cooperation between different initiatives in nanoelectronics and related fields (chemistry, optoelectronics/photonics, biology, etc.). The poster session also gives young scientists the opportunity to present current research results.

The host of this year's INC was the Japanese Institute for Advanced Industrial Science and Technology (AIST). Next year, the INC will take place in Europe for the third time. Prof. Hubert Lakner, Chairman of the Fraunhofer Group for Microelectronics, announced in Tsukuba that the Fraunhofer Forum in Berlin would be the location for the INC9. The VµE business office and its manager Dr. Joachim Pelka will be responsible for organizing the event locally.

Dr. Mihail Roco (NFS, USA), Dr. Michel Brillouet (CEA-Leti, FRA), Dr. Paolo Gargini (Intel, USA), Dr. Roger De Keersmaecker (IMEC, BEL), Prof. Sumio Iijima (AIST, JAP, keynote speaker at INC8), Dr. Joachim Pelka (FhG, GER), Prof. Hubert Lakner (FhG, GER). Photo: Toyohiro Chikyo (NIMS)

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Photo: pixelio.de / hldg

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The Fraunhofer Group for Microelectronics (German abbreviation: VµE), founded in 1996, combines the expertise of 16 Fraunhofer institutes, with a total of more than 2,700 employees. Its main focus is the preparation and coordination of interdisciplinary research projects, conducting studies and to assist in the process of identifying strategies.

The business office of Fraunhofer VµE is located directly at the River Spree in the heart of Berlin. Photo: Fraunhofer VµE / Kracheel

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… today goes to Oliver Sawade

Photo: Fraunhofer FOKUS

About Oliver Sawade:
Oliver Sawade was born in Berlin in 1980. He studied computer science at the TU Berlin, focusing on open communication systems. He wrote his degree dissertation about recommender algorithms in the area of IPTV while working at Fraunhofer FOKUS. After the Automotive Services and Communication Technologies department was founded, he moved there and since then has been working on Car-2-X communication, particularly in the context of active and autonomous driver assistance. As part of the simTD and DRIVE C2X projects, he also manages the development of tools for planning and executing field tests. Since 2009, he has taught a seminar on autonomous vehicles at the TU Berlin.

Mr. Sawade, what are you currently working on?

We are working on vehicle-to-vehicle communication, i.e. the digital wireless communication that will soon be making its entrance into production vehicles. Taking this technology as a basis, many new kinds of applications can be designed, that will soon make driving more comfortable, safer, and more efficient. My personal interest lies in researching how this technology can be used to create or improve autonomous driver assistance systems – systems that intervene actively in driving and, say, save lives by mitigating or event preventing accidents. My interest includes automated and even fully autonomous driving.

How did you come to work at Fraunhofer?

Towards the end of my degree I attended several classes hosted by Fraunhofer employees. At one of them I took the opportunity to apply as a student, and I have been here ever since: first as a student assistant, and then as research fellow. I now teach a seminar myself at the university, so it's gone full circle.

What excites you about applied research?

To me the most exciting research topics in the area of automobile research are to be found in applied research: I find the basics too vague and series production too constrained by regulations and standards. In our area, however, you can try out new ideas and build prototypes fairly quickly – I think that's fascinating.

What has been your nicest experience as a researcher?

It is always great in a project, when you see the part you built yourself in action. So far, the best experience was during the final presentation of PRE-DRIVE C2X. This project laid the basis for a large-scale European field operational test to show that vehicle-to-vehicle communication is ready to go to market. We decided at relatively short notice that Fraunhofer should also take part with its own test vehicle. After many all-nighters, our vehicle was ready in time and took its place among the submissions of all major European car manufacturers at the final demonstration. The follow-up DRIVE C2X field test is now almost ready to begin and Fraunhofer has once again entered a vehicle.

What invention would you not like to do without in daily life?

It would be pretty difficult to get by without the Internet …

What do you wish you could learn overnight?

To really master a musical instrument.

What else would you like to do or achieve?

Well, finishing my doctorate is certainly one thing; I would also like to be involved in building a completely autonomous vehicle. In one of our "pet projects," we are testing autonomous driving and cooperative maneuvers with 1:18-scale model cars – we have been able to gather a lot of basic information and test new applications. Moving over to a real vehicle, however, is still a big step.

What song belongs to the "soundtrack" of your life?

At the moment definitely "So viel zu tun" ("so much to do") by Berlin-based band Budzillus.

And, last but not least. Can you tell us what motto you live by?

"The brave shall inherit the earth." In my case, I take that to refer to being brave enough to make decisions.

Oliver Sawade demonstrates the FOKUS exhibit "Intelligently networked electromobility" at CeBIT 2012. Photo: Fraunhofer FOKUS

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