TECHNISCHE UNIVERSITÄT DRESDEN

cfaed

CENTER FOR **ADVANCING ELECTRONICS DRESDEN**

Contents

Welcome to cfaed!

It was certainly one of the highlights of my professional career when the Rector of Technische Universität Dresden announced that the proposal for the Center for Advancing Electronics Dresden (cfaed) had been granted by the German Research Foundation (DFG) back in June 2012. This Cluster is a unique chance to strengthen Saxony's position as largest microelectronics hub in Europe by establishing a strategically important world-class platform for fundamental research. Facing this opportunity to actively support our region made me proud and reassured my continued dedication to Dresden.

The researchers of cfaed are united by the joint vision that electronics has revolutionized and will continue to change the way we live and will enable the partaking of more and more people in wealth and prosperity. This drives us to further advance electronics to meet the changing demands of society. On the other hand, we are convinced that there is currently a unique window of opportunity to transform discoveries in materials science into innovations. Integrating discovery-driven natural sciences and innovation-driven engineering makes cfaed so unique and inspiring.

We chose a flexible 'More-Shots-on-Goal' approach to investigate alternative or complementary technologies to advance electronics. The topics were selected around the key strengths of our scientists and on the basis of having the potential to become top in the world in the next five to ten years. To support the Cluster's research we have set up a Career Development Program to foster young talents throughout their scientific career with activities such as the Grand Professor Program. I consider it a privilege to be able to work with all these bright minds sharing a common vision of advancing electronics for the world's sake and, at the same time, to support the region.

Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis
cfaed Coordinator

Key Position in Saxony

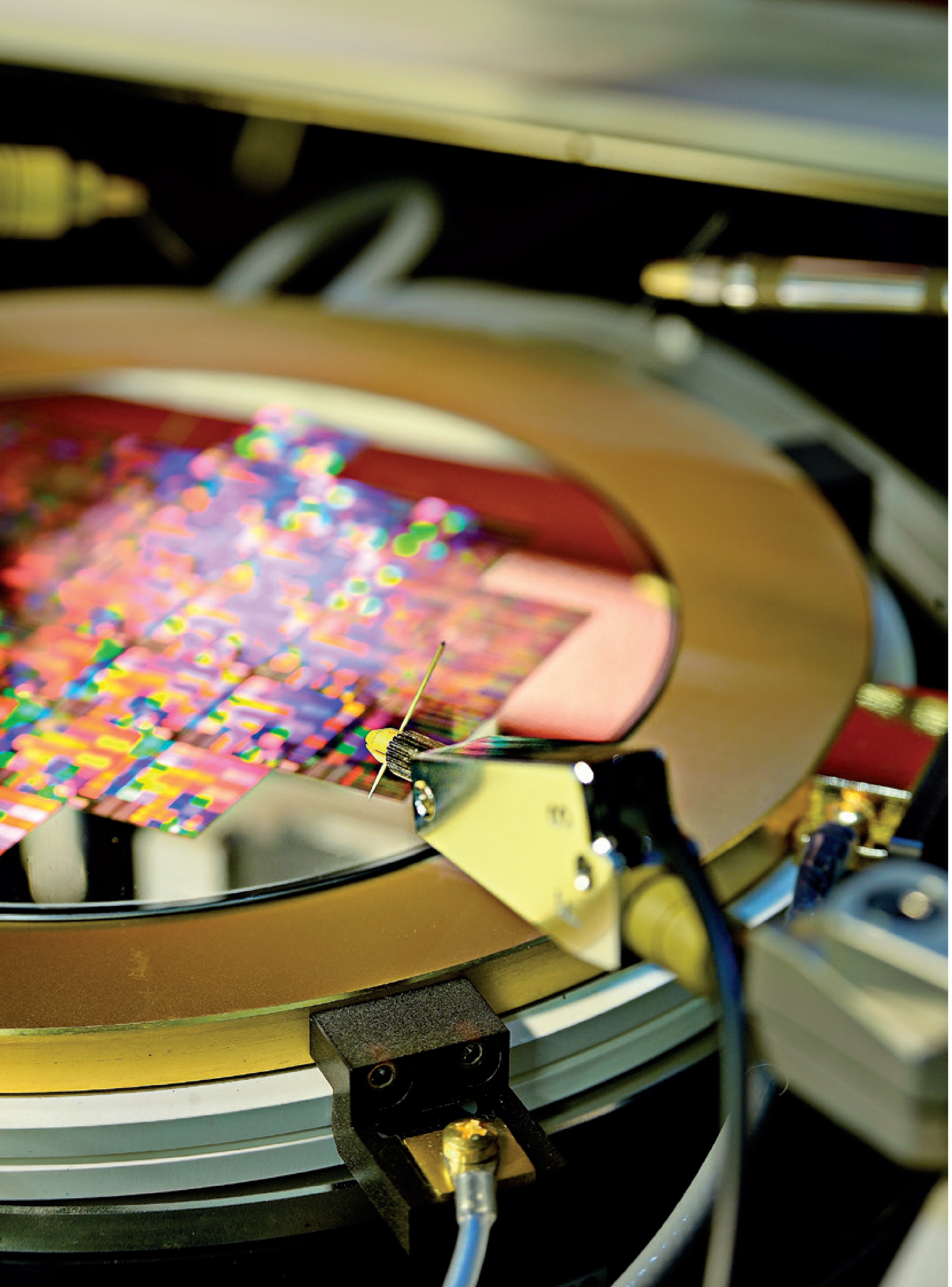
Microelectronics has changed and continues to change the world we live in. It drives advances and innovation in areas such as the automotive industry, medicine, and biotechnology which are essential for the welfare and continuous economic and scientific development of Saxony and Germany. In 2013, the European Commission recognized this decisive role of microelectronics for European economics and released the strategy ‘Chips for Europe’. Therefore, the research vision of the Cluster of Excellence ‘Center for Advancing Electronics Dresden’ (cfaed) is of strategic importance for Saxony, Germany, and Europe.

The scientists participating in cfaed are renowned for their research and represent the excellence that creates the unique spirit of the Cluster. Another key element of cfaed’s success is the comprehensive approach which is underpinned by the close cooperation with Technische Universität Chemnitz and Dresden’s non-university research institutions. As such, cfaed is a prime example of DRESDEN-concept – a network of local scientific expertise that is unique in Germany. It forms a strategic alliance to drive forward outstanding research – while at the same time fortifies university education.

The Cluster has successfully convinced the jury of the Excellence Initiative of its propositions and plans to shape the knowledge-based society of tomorrow. With the help of cfaed’s activities – its growing reputation and its international visibility – Dresden will continue to further develop its popularity as well as its attractiveness for scientists and industry. Of course, the Cluster also strengthens the Technische Universität Dresden as an elite university in Germany. Ranging from engineering to natural sciences, cfaed covers a broad variety of subject areas of Technische Universität Dresden. The impact of the Cluster’s research therefore multiplies and the achieved results may reach many areas of everyday life as well as having an effect on the development of emerging countries.

I wish the Cluster of Excellence every success for the future and I want to assure you that the Free State of Saxony will continue to support cfaed on its fruitful path to a world-leading research platform.

Prof. Dr. Dr. Sabine von Schorlemer
Saxon State Minister for Higher Education, Research and the Arts



Mission Statement

"Semiconductors are the crude oil of the information age." (J.F. Akers, former IBM Chairman)

Advancing electronics beyond conventional technologies is the major aim of the Cluster of Excellence Center for Advancing Electronics Dresden (cfaed). Electronic information processing is currently dominated by the complementary metal oxide semiconductor (CMOS) technology that has provided exponential improvements, governed by Moore's Law (doubling of the number of transistors per chip every 18 months), for decades. However, as this technology is approaching physical, atomic boundaries, the CMOS roadmap will saturate, and Moore's Law is projected to end. Inspired by the huge impact of semiconductor technology, researchers of cfaed have thus joined forces to explore new technologies for electronic information processing with the potential to overcome the limits of CMOS.

It is accepted that breakthrough innovation in electronics cannot be based solely on higher planar integration densities. New ways must be found to address the challenges of electronic information processing systems: physical size, speed, energy efficiency, new functionality, self-assembly/-organization, adaptivity, resilience, cost.

Specifically, it is the vision of cfaed that future CMOS technology will be complemented with new technologies (augmented CMOS), resulting in heterogeneous architectures to form highly efficient information processing systems. cfaed drives forward several different technology candidates, which have been enabled by promising new materials, to a state where information processing becomes possible, and prepares for their integration in heterogeneous large-scale systems. While materials research needs to continue, some discoveries have now reached a point that warrants exploring device fabrication, circuits, and information processing systems for potential applications. The Cluster believes that university-based research faces currently a unique window of opportunity to transform discoveries on new materials into technological innovations with the potential for advancing electronic information processing beyond 2020.

High impact findings based on new materials can only be achieved if complete systems are considered. cfaed therefore follows a unique approach by comprehensively addressing all three abstraction layers (materials & functions, devices & circuits, and information processing) with its nine research areas which are referred to as Research Paths to highlight the exploratory dynamic character in search of breakthroughs. These Paths are selected based on the internationally renowned strengths of the researchers at TU Dresden and the Cluster's partner institutions. Following this 'More-Shots-on-Goal' approach, cfaed wants to maximize the chances for high impact technological breakthroughs and benefits from the cross-fertilization between the Paths.

International leading scientists shape the Cluster's research and avail of an stimulating environment: a strong microelectronics industry – represented by its networks Silicon Saxony and Organic Electronics Saxony – and a research landscape which is unique in Germany and represented through its elite university TU Dresden and the synergetic alliance DRESDEN-concept.

Supporting Young Talents
Career Development Program

Attracting and developing young international researchers is of utmost importance to cfaed. Not only does the comprehensive research program require a high number of well-qualified and highly-motivated young researchers but also the excellence of the scientists will provide the foundation to sustain cfaed far beyond the initial funding period. In addition to the Cluster's scientific output, creating a strong output of superbly trained experts is one of the cores of cfaed. To achieve this, cfaed relies on three key characteristics: (i) attractiveness through highly challenging research topics, (ii) an inspiring scientific environment, and (iii) a systematic career development allowing young researchers to progress quickly. cfaed's career development approach comprehensively addresses undergraduate and master students, doctoral students, research group leaders, and young professors. It includes specific initiatives from talent attraction and recruitment to systematic development on all career levels. The key elements are:

cfaed GRADUATE SCHOOL
The program of the cfaed Graduate School comprises general scientific training in the involved cfaed disciplines as well as specialized training per Path. In addition, modules on academic skills (e.g., awareness of innovation, engineering vs. discovery, sciences cultures, grant acquisition, didactics), technology transfer (e.g., intellectual property rights, innovation strategies, entrepreneurship) and soft skills (e.g., project management, presentation, negotiation, leadership skills, gender awareness) are offered. One main component of the cfaed Graduate School is the Thesis Advisory Committee (TAC) which consists of two to three professors, reflecting the interdisciplinarity of cfaed, who jointly guide a PhD student throughout the thesis. This process includes the definition of a set of defined achievements (e.g., doctoral seminars, conference/journal papers) which is jointly reviewed and used to give feedback and agree on development measures if necessary.

RESEARCH INSPIRATION SEMINARS (RIS)
To foster a lively scientific exchange with cooperating universities, these seminars will provide an opportunity to a group of PhD students, Postdocs, and Research Group Leaders to join an intense exchange of research visions. RIS aims at inspiring new ways of thinking, new research approaches, and creating open-minded students with an international scientific view and interest by spending a period at scientifically exciting international universities and leading industry labs.

GRAND PROFESSORS
cfaed invites international experts to join cfaed to act as personal mentors, engage in teaching postgraduate courses, and act as collaboration partners in research projects. All members of cfaed benefit from the interaction with our Grand Professors and especially young scientists can win long-term mentors to support their careers. In addition, the Grand Professors foster their integration into the scientific community.

Prof. em. Dr. Heinrich Meyr
RWTH Aachen, Germany

Prof. Dr. James R. Cordy
Queens University, Canada

Dr. habil. Hélène Kirchner
Institut national de recherche en informatique et en automatique (INRIA), France

Prof. Dr. Jan M. Rabaey
University of California, Berkeley, USA

Prof. Dr. Itamar Willner
Hebrew University of Jerusalem, Israel

Linking Science and Industry
Industry Liaison Program

Not without pride can Dresden be declared as Europe's leading location for microelectronics and information technology. Silicon Saxony counts for more than 2,100 enterprises with more than 51,000 employees and a total revenue of about € 8 billion. The technology sector ranges from small specialist local companies to international leading enterprises covering all aspects of the wafer production line. The strong local semiconductor industry is complemented by world-famous expertise in the fields of microelectronics and microsystems, mobile communications, software, photovoltaics, and future-oriented organic semiconductor technology (OLEDs). In fact, Saxony is also Europe's largest cluster for organic semiconductor research, development and manufacturing, covering the full value chain starting at universal fundamental research up to high end technological products.

Beside this excellent industrial preposition in Saxony, the Dresden region is also distinguished through its exceptional research landscape: three Leibniz Institutes, eleven Fraunhofer Institutes, three Max Planck Institutes and one Helmholtz Center. Within DRESDEN-concept, the cooperation between the university and research institutes in Dresden has been formalized to create synergies. The German Research Societies represented in DRESDEN-concept participate in cfaed, making it the first joint activity between all four societies and yielding great potential to benefit from their strength and experience as well as from their diverse cultures and approaches.

Despite the positive development of the region so far, more initiatives from research, industry and administration need to secure Europe's and Saxony's position in order to keep pace with the international competitors. Innovations in micro- and nanoelectronics drive the economic development of enterprises, regions, states, and societies.

In order to not only benefit from but also support the region and its unique close bonds between academia and industry, cfaed has initiated an 'Industry Liaison Program' (ILP). ILP facilitates a platform for companies to sustain close contact to on-going research activities carried out at cfaed. Designed to support and strengthen the collaboration with industry, ILP offers access to the latest research results of cfaed; enhanced visibility in context of the Cluster of Excellence, and contacts to world-class experts in electrical engineering, computer science, material and natural sciences. By providing a common ground for industry and academia, ILP is committed to fostering strong, productive collaborations that enable technology transfer in manifold ways and generate value for industry partners and for the researchers working in cfaed.

cfaed at a glance

cfaed unites about **60 Investigators** and their teams from **11 institutions** to act jointly towards reaching the Cluster's ambitious aims.

cfaed's research is organized within **9 Research Paths**, clustered as follows: Materials-inspired Paths, System-oriented Paths and one 'Discovery Path'.

About **300 scientists** from more than **20 countries** are engaged in these Paths, spanning the scientific areas Electrical Engineering, Computer Science, Materials Science, Chemistry, Physics, Biology, and Mathematics.

cfaed is funded by the **German Research Foundation** (DFG) within the Excellence Initiative of the Federal Government.

The **funding volume** comprises **€ 34 million** and covers a **funding period** from November 2012 to October 2017.

The initial proposal for cfaed as a **Cluster of Excellence** was submitted to the DFG in August 2011; the funding decision was announced in June 2012: cfaed became 'Cluster of Excellence' and supported the application of Technische Universität Dresden to become an 'University of Excellence'.

The Cluster's **research program** started in November 2012 and the official opening celebration was held on 27 February 2013 with an 'Opening Festival'.

The **Cluster Coordinator** is **Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis** (Vodafone Chair Mobile Communications Systems at Technische Universität Dresden).

PARTNER INSTITUTIONS

- Technische Universität Dresden – Host University
- Technische Universität Chemnitz
- Helmholtz-Zentrum Dresden-Rossendorf (HZDR)
- Leibniz Institute of Polymer Research Dresden e.V. (IPF)
- Leibniz Institute for Solid State and Materials Research Dresden (IFW)
- Max Planck Institute of Molecular Cell Biology and Genetics (MPI-CBG)
- Max Planck Institute for the Physics of Complex Systems (MPI-PKS)
- Fraunhofer Institute for Ceramic Technologies and Systems Dresden (IKTS), Branch Materials Diagnostics
- Fraunhofer Institute for Electronic Nano Systems (Fraunhofer ENAS)
- Nanoelectronic Materials Laboratory gGmbH (NaMLab)
- Kurt-Schwabe-Institute for Measuring and Sensor Technology Meinsberg e.V. (KSI)

Path Overview — the Research Program

MATERIALS-INSPIRED PATHS

A — *Silicon Nanowire Path*
Investigating special properties of silicon nanowire based circuits and creating a technology platform for biosensoring.

B — *Carbon Path*
Enabling high-performance radio frequency communication systems based on a carbon nanotube technology platform.

C — *Organic/Polymer Path*
Creating new organic information processing systems by overcoming the major limitations of organic electronics.

D — *Biomolecular-Assembled Circuits Path*
Investigating how DNA-origami might enable a new circuit manufacturing paradigm, using the self-assemby properties of DNA.

E — *Chemical Information Processing Path*
Developing a new 'Lab-on-Chip' concept based on components which actively process chemical information (composition, physical state, concentration, etc.).

SYSTEM-ORIENTED PATHS

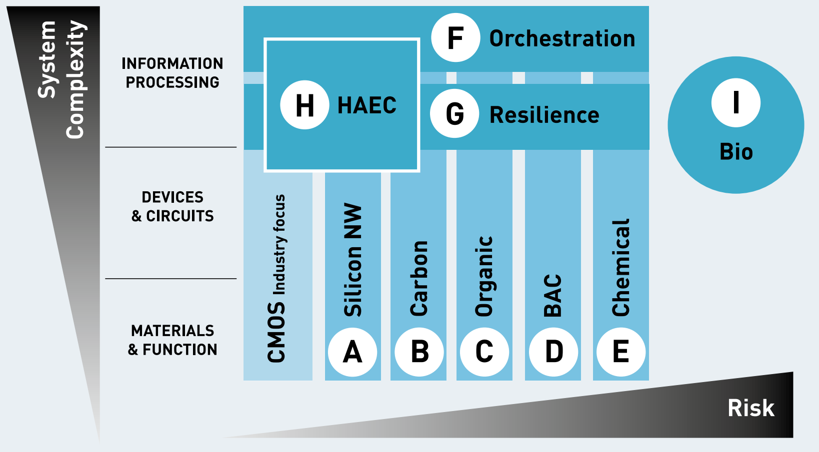
F — *Orchestration Path*
Orchestrating heterogeneous electronic systems by automatic adaption of applications and software systems.

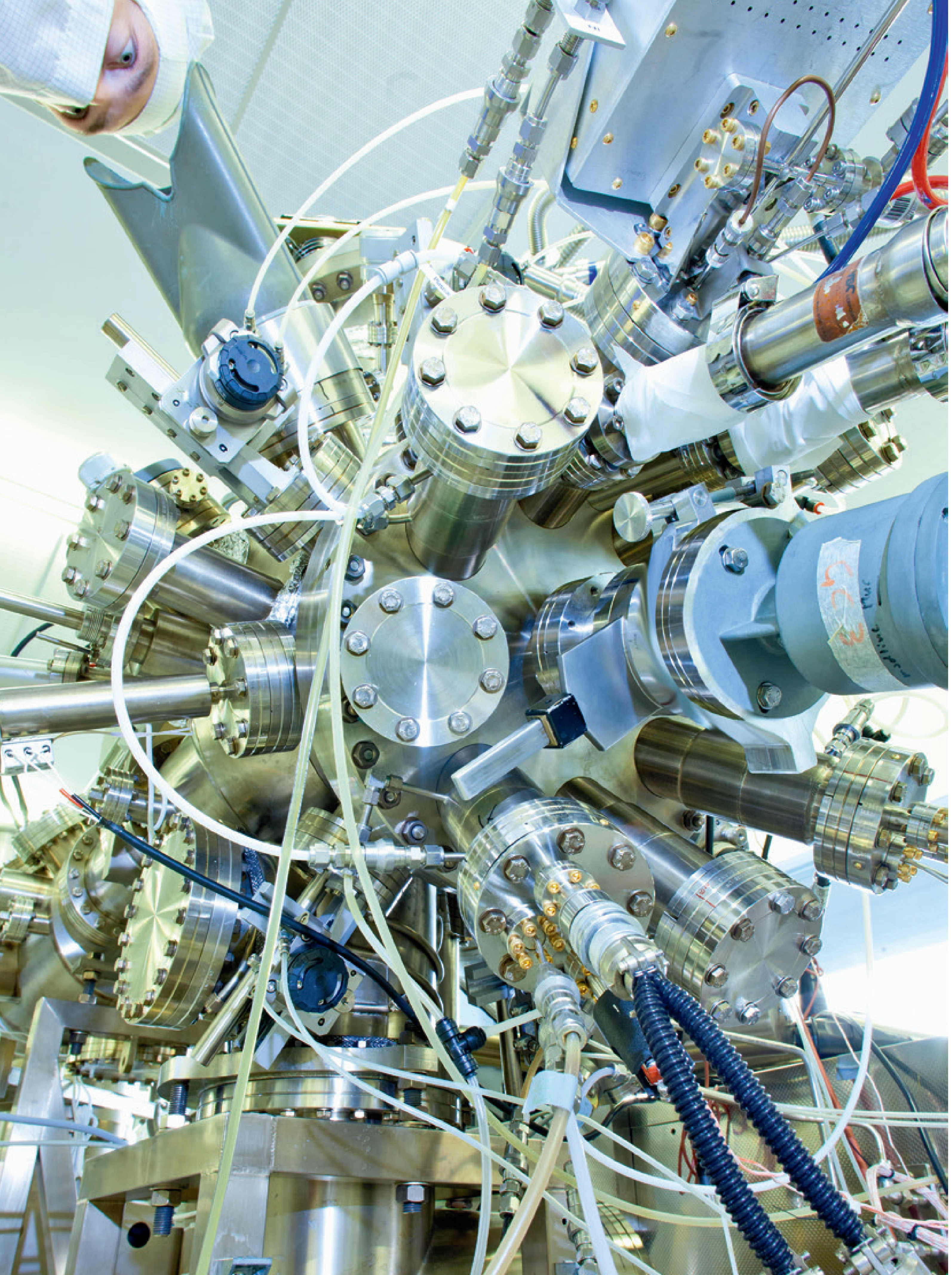
G — *Resilience Path*
Mastering resilience of heterogeneous electronic systems by focusing on flexible, application-specific, adaptive resiliency mechanisms.

H — *HAEC — Highly Adaptive Energy-Efficient Computing*
Developing a new architecture and a demonstrator for large-scale multichip computing platforms enabling a new quality of energy-efficient computing.

DISCOVERY PATH

I — *Biological Systems Path*
Unraveling engineering principles of biological systems to inspire novel electronics.





A — Silicon Nanowire Path

Path Leader // **Prof. Dr.-Ing. Thomas Mikolajick**, TU Dresden, Chair for Nanoelectronic Materials and Director of NaMLab gGmbH
Path Co-Leader // **Prof. Dr. Gianaurelio Cuniberti**, TU Dresden, Chair for Materials Science and Nanotechnology

The Silicon Nanowire Path follows the most conventional approach by virtue of using silicon. Nevertheless, the potential electronic properties of these nanowires go far beyond current silicon technologies. In addition to very beneficial electronic properties, silicon nanowires can be configured to change transistor behavior dynamically. Potentially, complex functionality can thus be implemented with a much smaller number of devices. In this context, the design of novel and fault tolerant computing algorithms that make use of the transistors' multi-functionality is targeted. Furthermore, silicon nanowires are explored as a selective sensor platform for biomolecules, opening a completely new application domain.
The Silicon Nanowire Path focuses on approaches, which exhibit functional reconfiguration by exploiting the unique combination of nanoelectronics with state-of-the-art silicon technology. Two different approaches are followed to achieve reconfigurability at the devices & circuits level. First, reprogrammable silicon nanowire field effect transistors and fine-grain reconfigurable logic circuits and systems fabricated thereof are studied. Second, reconfiguration of nanowire field effect transistor by the attachment of biofunctional units is investigated. The latter enables building a novel multiplexer platform for complex bioelectrical transducer systems as required for the interaction between computing systems and biological components in strong interaction with the Biological Systems Path. Both approaches are based on the same basic nanowire technology, are complementary, and can be combined with each other.
At the system level, fault tolerant algorithms are developed that make use of device reconfigurability during circuit operation. The results aim at providing sophisticated electronics with higher computational power and enhanced user interfacing capabilities by suggesting highly sensitive and highly specific bionano sensors.

Prof. Thomas Mikolajick

Left: The molecular beam epitaxy tool in the NaMLab cleanroom is used for growing complex semiconductor heterostructures.

Inside the Path

For a ‘Green’ Microchip

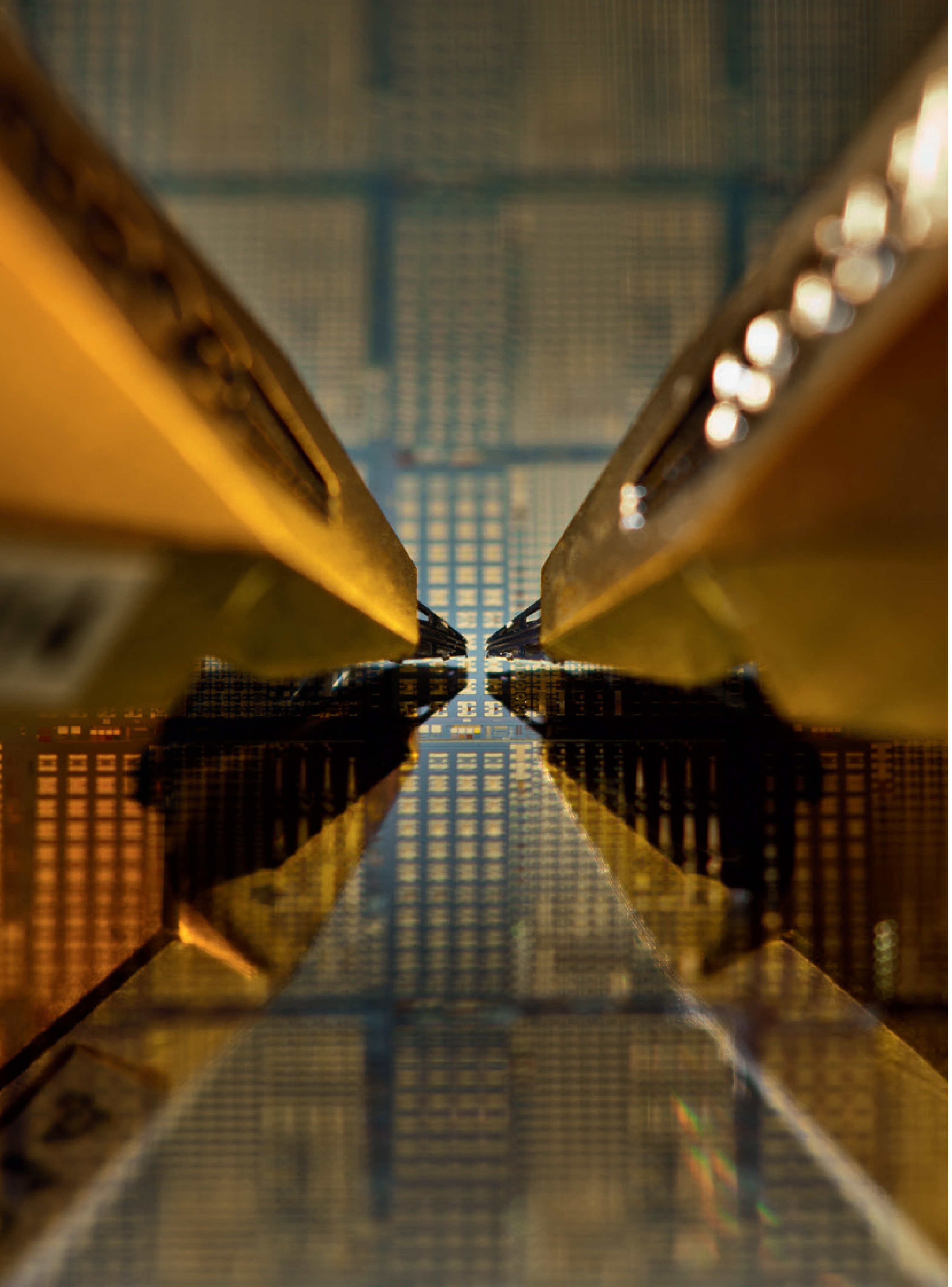
Sibylle Gemming does not own a smartphone. “This is my personal way to limit the information flood”, the 45-year-old scientist says. At the Helmholtz-Zentrum Dresden-Rossendorf, she works on reducing the energy consumption of microchips to make them ecologically more efficient. Within the Silicon Nanowire Path, her research focuses on the properties of electronic elements in the nanometer range, such as molecules, clusters, wires, tubes, films and complex composites. Her aim is a scale-adapted and multi-scale description of material properties under the influence of external factors and their validation in experiments.

Sibylle‘s material analysis results in Rossendorf furnish a base for application-oriented developments such as the NaMLab works on. Here, the team of Path Leader, Thomas Mikolajick, succeeded in constructing the worldwide first universal transistor. His team demonstrated an energy-efficient circuit with one single transistor type instead of the two different types used in conventional electronics. This new technology could change the current major CMOS technology significantly, enabling a single technology with enhanced functionality.

“I appreciate the unique cfaed network of outstanding research institutions”, the material scientist says. Sibylle is also head of a research team in the virtual Helmholtz institute called ‘Memriox’ which unites scientists of the universities in Dresden, Freiberg, Jena, Chemnitz, the Helmholtz centers in Dresden-Rossendorf and in Jülich as well as the University of California in San Diego, USA and the ETH Zurich in Switzerland. Here, she develops new materials for ion-tailored oxide-based memristive elements.

In January 2013, she was appointed to a professorship of Technische Universität Chemnitz with the focus on nanoscale material characteristics. Furthermore, Sibylle was granted € 1 million by a program for excellent female scientists of the Helmholtz Association. After a PhD in chemistry at the TU Munich she habilitated in physics at Technische Universität Chemnitz. Her husband, a scientist at the Leibniz Institute for Solid State and Materials Research Dresden, is also affiliated to cfaed. “Of course, working in the same place is optimal for us as a family”, Sibylle says. Thus, the Bavarian cannot imagine a better research location than ‘Silicon Saxony’.

“I appreciate the unique cfaed network of outstanding research institutions.”



B — Carbon Path

Path Leader // **Prof. Dr. sc. techn. habil. Dipl. oec. Frank Ellinger**, TU Dresden, Chair for Circuit Design and Network Theory
Path Co-Leader // **Prof. Dr.-Ing. habil. Michael Schröter**, TU Dresden, Chair for Electron Devices and Integrated Circuits

Carbon is clearly an outstanding candidate for advancing electronics beyond today's boundaries. This Path seeks to establish a sustainable research platform for carbon-based electronics with initial focus on a Carbon Nanotube Field-Effect Transistor (CNTFET) technology for wireless communication systems. This platform aims at the design and fabrication of CNTFET based circuits with competitive performance and distinctive electrical device characteristics (such as high linearity) compared to incumbent technologies. Excellent device linearity leads to very low signal distortion in receiver circuits, which is of utmost importance for high-performance wireless data transmission. To evaluate the linearity properties expected for CNTFETs, the path demonstrator will be a CNTFET-based receiver circuit working in the 2 GHz band. Depending on the progress in technology development and the device performance achieved, higher frequencies will be considered, too. To achieve the Path goals, the extensive and complementary multi-disciplinary CNTFET competences in Dresden and Chemnitz are combined, which cover materials science, wafer-scale fabrication, multi-scale device modeling, RF circuit design, and wireless communications. The knowledge gained and methods employed may then be transferred to other high-potential material classes.

Prof. Frank Ellinger

Left: On-wafer high-frequency characterization of CNT-based transistors.

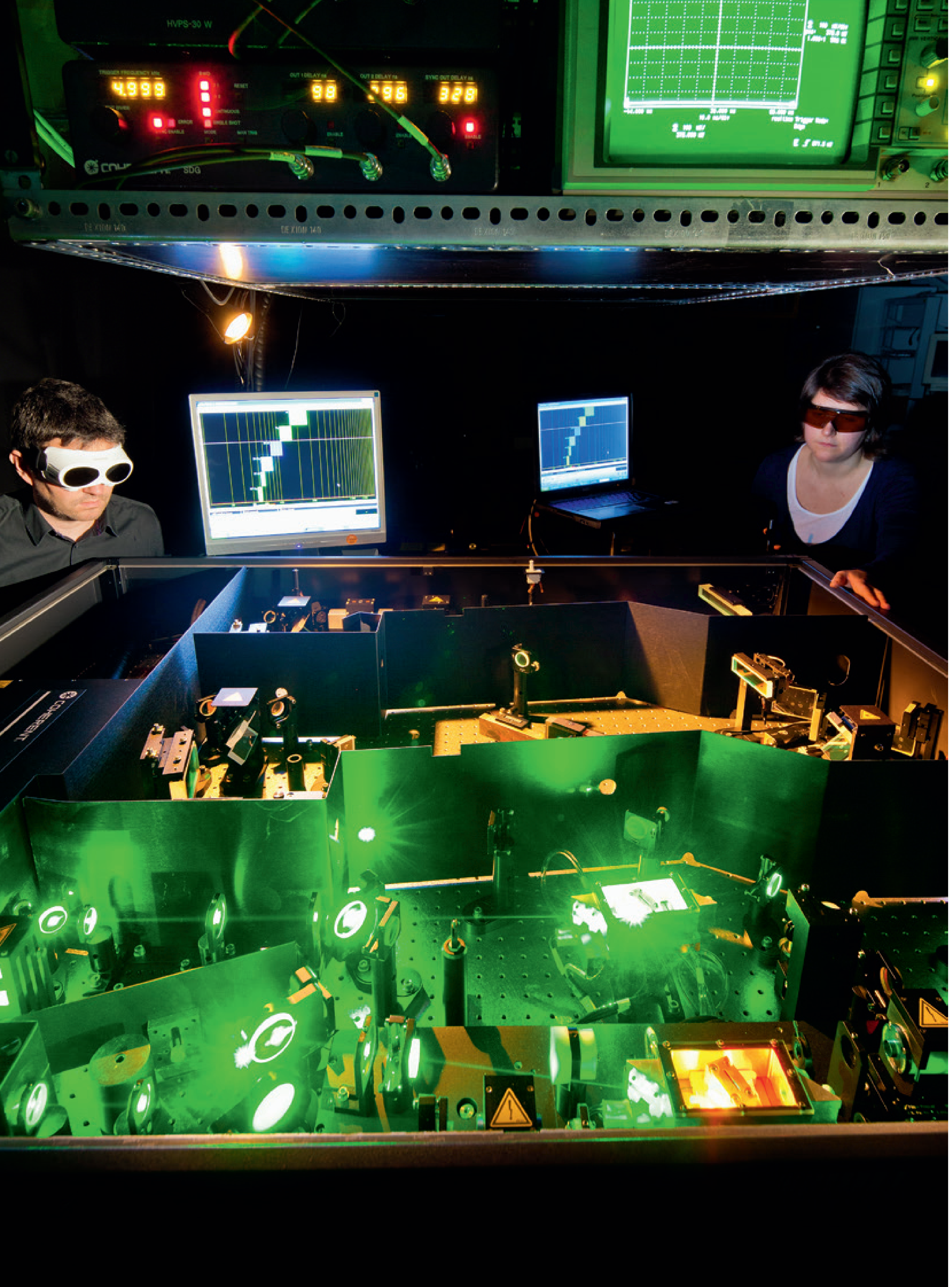
Inside the Path

Entering the Brazilian Scene

“A carbon nanotube which is the base of our electronic devices looks just like this”, Martin Claus points at a big tube of paperboard on his desk. The Module Leader of the Carbon Path explains: “The electronic properties of the CNT help to avoid distortions in data communication. Therefore, CNT-enhanced communication systems have the potential of transferring more data than those realized with conventional silicon- and III-V based electronics while reducing the power consumption.

Our ultimate goal is to improve the performance of mobile communications while simultaneously ensuring that for instance a cell phone must be charged only once per week.” Three interdisciplinary modules within the Carbon Path explore the properties of CNT-based devices for communication applications. Engineers in the group of the Path Leader, Prof. Frank Ellinger, design the circuits, the group of the Path's other Module Leader, Sascha Hermann, at Technische Universität Chemnitz fabricates the electronic elements, and the group of Martin is responsible for the experimental device characterization and the development of the theoretical background.

He already presented his work at the universities in Brasília and Rio de Janeiro. “Brazil is very interested in building up its own microelectronics industry and invests a lot of money to reach this target”, the scientist remarks. “The country is looking for new ways, e.g., in the area of organic and nanotube-based electronics.” Martin studied at Technische Universität Dresden and wrote his PhD thesis about the modeling and simulation of CNT-based field effect transistors, under the guidance of Prof. Michael Schröter, the Co-Leader of the Carbon Path. “The excellent support by cfaed for young group leaders to build up their own group and to develop their scientific career was a strong argument to join the Cluster”, the engineer explains. Now, the 34-year-old expert uses his knowledge in joint projects with Brazil.



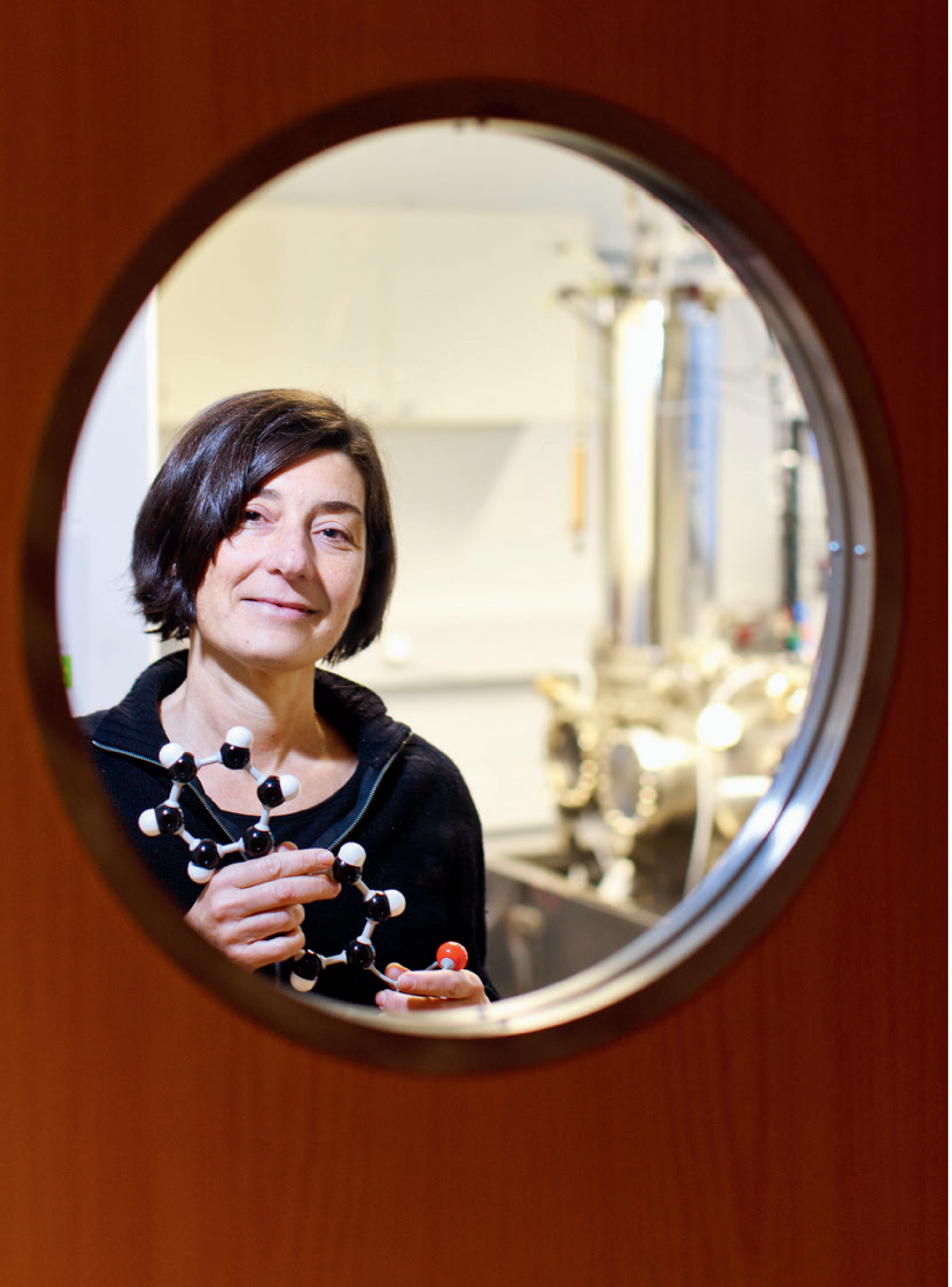
C — Organic / Polymer Path

Path Leader // **Prof. Dr. Karl Leo**, TU Dresden, Chair for Optoelectronics
Path Co-Leader // **Dr. habil. Francesca Moresco**, TU Dresden, Group Leader, Chair for Materials Science and Nanotechnology, Max Bergmann Center for Biomaterials

Organic semiconductors allow novel applications beyond those possible with classical crystalline semiconductors. Organic materials can be deposited on flexible substrates, are lightweight, and suitable for low-temperature processing. Most importantly, organic polymers are fully compatible with many printing processes, from low-cost roll-to-roll technology to high-speed nano-imprinting and ink-jet patterning. A complete organic technology can also offer multi-functionality hosting electronics, photonics, actuators, sensors, and more. It is the vision of the Path to transform the promising potential of organic electronics for information processing systems into real product maturity. The Path's approach towards this goal is twofold. First, a significant improvement of performance is needed, using novel materials and device principles. Second, such device principles and architectures are investigated where organic and polymer materials offer unique features, beyond those offered by competitive technologies. The Path's work is organized around a number of specific topics, with the intention of focusing efforts and exploiting specific local expertise: novel display technologies based on organic materials; novel, ultra-low-cost, roll-to-roll printed audio technology; next generation nano-imprint and ink-jet Organic Field-Effect Transistor (OFET) technology; development of device modeling tools and a compact model for circuit design and device optimization; circuit and system design for printed speaker pre-amplification and wireless data transmission; nanoscale materials characterization. A major step of the Path in 2013 was the development and realization of the first organic inversion transistor. This breakthrough was recognized by publication in "Nature Communications", one of the internationally most renowned science journals.

Prof. Karl Leo

Left: TU Dresden's Institute of Applied Photophysics: A new colorant is measured by a UV-Laser before being implemented in an OLED.



Inside the Path

High-Tech Electronics on Plastic Materials

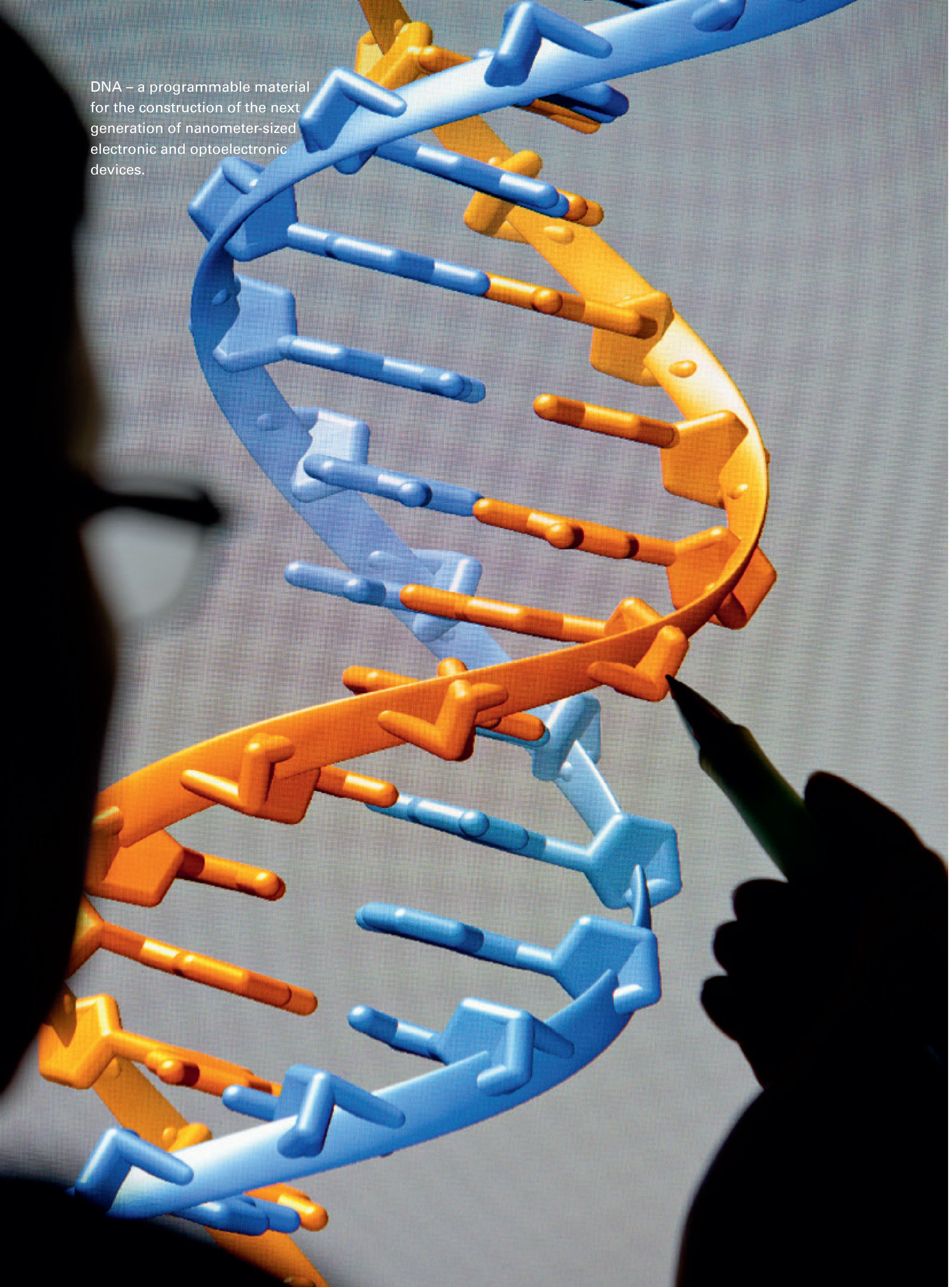
In the basement laboratory of Max Bergmann Center for Biomaterials, organic molecules are observed at minus 268 degrees Celsius. With a special low temperature scanning tunnel microscope, Francesca Moresco analyzes the behavior of organic molecules on metallic and semiconductor surfaces. Her fundamental research helps to develop new models for systems of nanosensors and organic solar cells. The 48-year-old Italian physicist is the Co-Leader of the Organic/Polymer Path. This Path researches a relatively new area using not silicon, but organic substances as raw material. "It is the vision of this Path to develop materials and technologies which allow entering industrial production and becoming commercially attractive", Francesca says.

Dresden is already a center of the organic electronic industry with more than a thousand people working in this area. The Dresden-based OLED company Novaled which was co-founded by Path Leader Prof. Karl Leo has been taken over by the world market giant Samsung. The other successful enterprise of Prof. Leo's group, Heliatek, focuses on photovoltaics.

Francesca originates from Genoa. "In Italy, there are a lot of women studying mathematics or physics", the scientist explains. But when she first came to Hannover to write her PhD thesis, she was the only woman. "In Germany, there are no female role models for natural scientists", the physicist says.

She continued her scientific career at the Freie Universität Berlin up to her habilitation. In 2004, her first son was born. She moved to her husband in Dresden and worked for the chip company Qimonda. After the company's insolvency in 2009, Francesca started a new research position at TU Dresden's Chair for Materials Science and Nanotechnology where she is now leader of the molecular electronics group. Because of her own experience, she appreciates the balancing act her PhD students have to juggle when combining scientific career and family life. "I really enjoy my work in cfaed. It enables the close cooperation of several groups in Dresden working all in the field of advancing electronics – this is extremely important to me", Francesca says. "The Cluster of Excellence brings together research fields that have normally little interaction. In cfaed, we have the unique chance to combine basic research and applications, experiments and theory, bridging the gap from single atoms to complex devices."

"cfaed enables the close cooperation of several groups in Dresden working all in the field of advancing electronics – this is extremely important to me."



DNA – a programmable material for the construction of the next generation of nanometer-sized electronic and optoelectronic devices.

D — Biomolecular-Assembled Circuits Path

Path Leader // **Prof. Dr. Dr.-Ing. habil. Michael Mertig**, TU Dresden, Chair for Physical Chemistry, and Director of the Kurt-Schwabe-Institute for Measuring and Sensor Technology Meinsberg
Path Co-Leader // **Prof. Dr. Stefan Diez**, TU Dresden, ZIK B CUBE, Chair for BioNanoTools

Following a more unconventional approach, this Path uses complex biomolecular structures as templates for metallization and functionalization in the process of bottom-up fabricating electronic and photonic building blocks. The development of novel strategies for the controlled fabrication of artificial nanostructures with tailored electronic and optical properties increasingly involves synthesis routes that use the unique recognition and self-assembly capabilities of biomolecules. In particular, learning how nature organizes inorganic material at the nanometer scale by so-called biomolecular templating has already led to the controlled formation of complex, artificial, low-dimensional, hybrid structures with precision and stability which cannot be achieved by current lithographic methods. The main advantages of biomimetic materials chemistry are the local control of nucleation and growth processes under physiological conditions as well as the capability of massively parallel fabrication. cfaed researchers have already played a major role in developing methods for using deoxyribonucleic acids (DNA) as a selective metallization template for the fabrication of nanowires as well as for the assembly of those into microelectronic contact arrays. The Path here harnesses biologically-inspired self-assembly of DNA and proteins for the fabrication of basic nano and microscopic optoelectronic components – to synthesize basic building blocks with defined electronic and optical functionality. So the Path focuses on the development of a novel, assembly-based technology platform for future fabrication of analog and digital circuits.

Prof. Michael Mertig

"Dresden as a special hub of microelectronics is an excellent research environment."

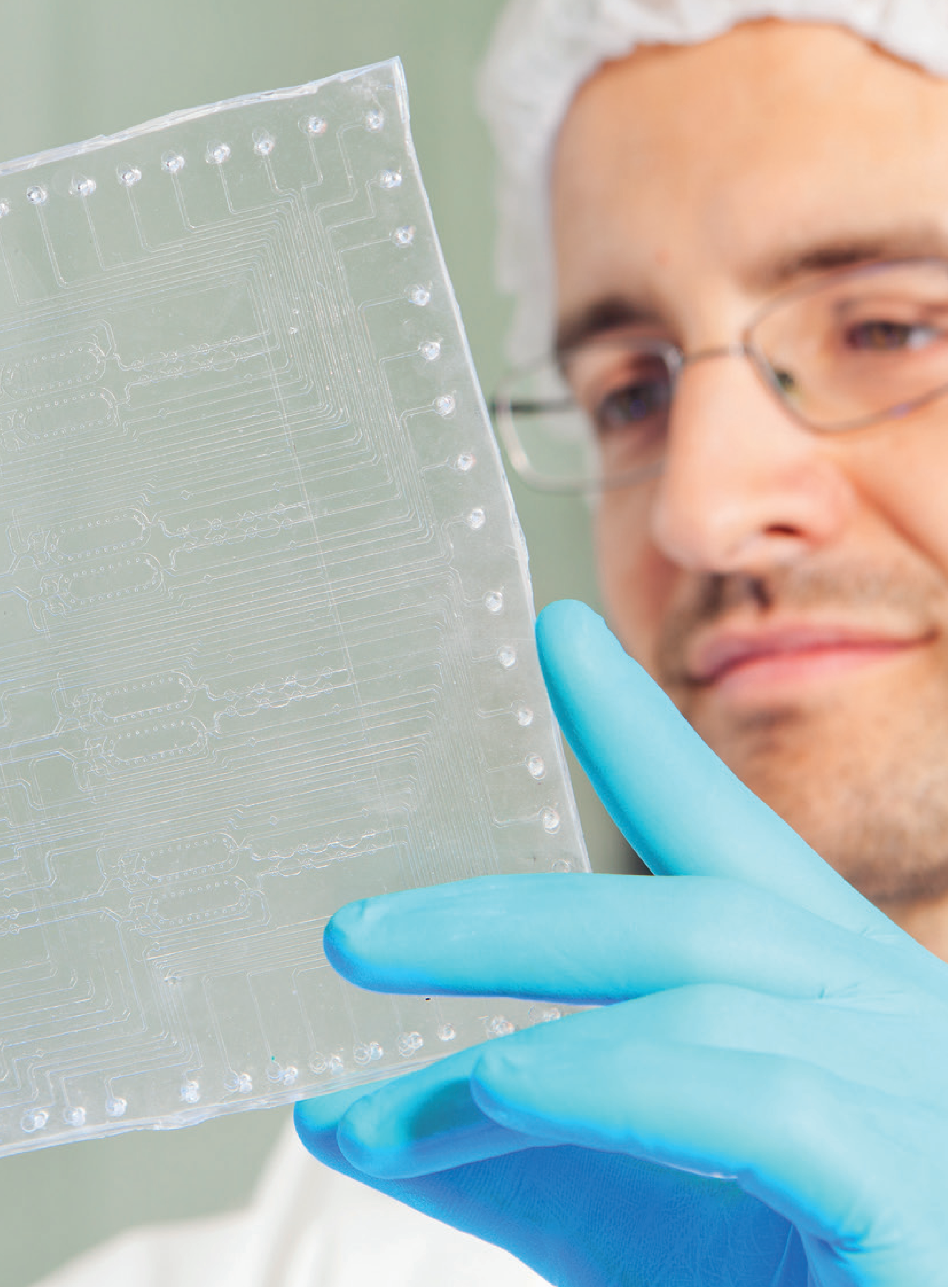
Inside the Path

The Smallest Wedding Rings of the World

For his wedding, Thorsten-Lars Schmidt created two intertwined rings of deoxyribonucleic acids (DNA) and gave them to his bride. The rings were not bigger than 20 nanometers and therefore probably the smallest wedding rings of the world. "My wife is also a scientist, so she honestly appreciated this gift", the 34-year-old chemist remembers.

Thorsten has already a reputation as a world-leading expert in his specific research area – the construction of nanostructured DNA objects. Before joining cfaed, he worked for three years at the Wyss Institute for Biologically Inspired Engineering at Harvard / Boston (USA). Since summer 2013, he is a Research Group Leader in the Biomolecular-Assembled Circuits Path of cfaed. His research goal is utilizing DNA structures for the bottom-up fabrication of basic nano- and microscopic opto-electronic components.

Thorsten really appreciates his new hometown: "Dresden as a special hub of microelectronics is an excellent research environment." The scientist was born in Romania, then his family moved to Bonn where he later studied chemistry. When he was working on his PhD thesis in Frankfurt, he met his wife Diana, a Portuguese chemist whose mother originated from Angola. "We together went to Harvard and took the chance to start off our scientific careers at this reputational institution." After the birth of their son, the researcher couple decided to return to Europe. Thorsten declined another job offer from a university in Denmark, because his spouse was offered a job in Dresden as well. But first of all, cfaed provides a unique interdisciplinary platform for his research with access to many experts in his scientific area. Furthermore, the Cluster also gives the perspective to apply for a full professorship after successful evaluation of his work. This process which is similar to the US-American Tenure Track is a highly attractive incentive to continuously strive for best results in a young researcher's career.



E — Chemical Information Processing Path

Path Leader // **Prof. Dr.-Ing. Andreas Richter**, TU Dresden, Chair of Polymeric Microsystems
Path Co-Leader // **Prof. Dr. habil. Brigitte Voit**, Scientific Director, Leibniz Institute of Polymer Research Dresden, and TU Dresden, Chair for Organic Chemistry of Polymers

Besides electrons in electronic IT-systems, another carrier of information dominates our life – chemical information. It forms the base for e.g., science, manufacturing industry, medical diagnostics – and of the information processing of all living organisms. The latter is much more powerful, resilient, energy-efficient, and multi-functional than of any electronic computer. Therefore, it is a source of inspiration that enables us to improve and reevaluate existing electronic information processing systems. This is exactly the idea behind the Chemical Information Processing Path: creating a concept of integrated circuits (IC) that actively process chemical information. Using computational power of highly integrated information systems, this kind of IC is intended to solve complex chemical problems chemically, e.g., the computer-aided design of molecules, catalysts and nano-materials, or the intelligent molecular diagnostics of diseases. The concept is based on special organic materials, which provide unique properties to actively interact with chemicals as information, especially phase transition materials and (bio)molecular motor proteins. The target is to lay the complete foundation of chemical large-scale ICs comprising strategies to their computer-assisted design and fabrication, the basics of the system and chip architecture as well as the theory of chemical information processing. Already, the first results indicate that the concept of chemical ICs has the potential to drastically influence the Lab-on-a-Chip technology. It provides a solution for one of the most challenging problems: the scalability. In microelectronics, this is the key factor, therefore it can be expected that scalable Lab-on-a-Chip technology will experience a similar story of success.

Prof. Andreas Richter

Left: Chemical Information Processing – a new chance for quick and complex medical diagnoses.

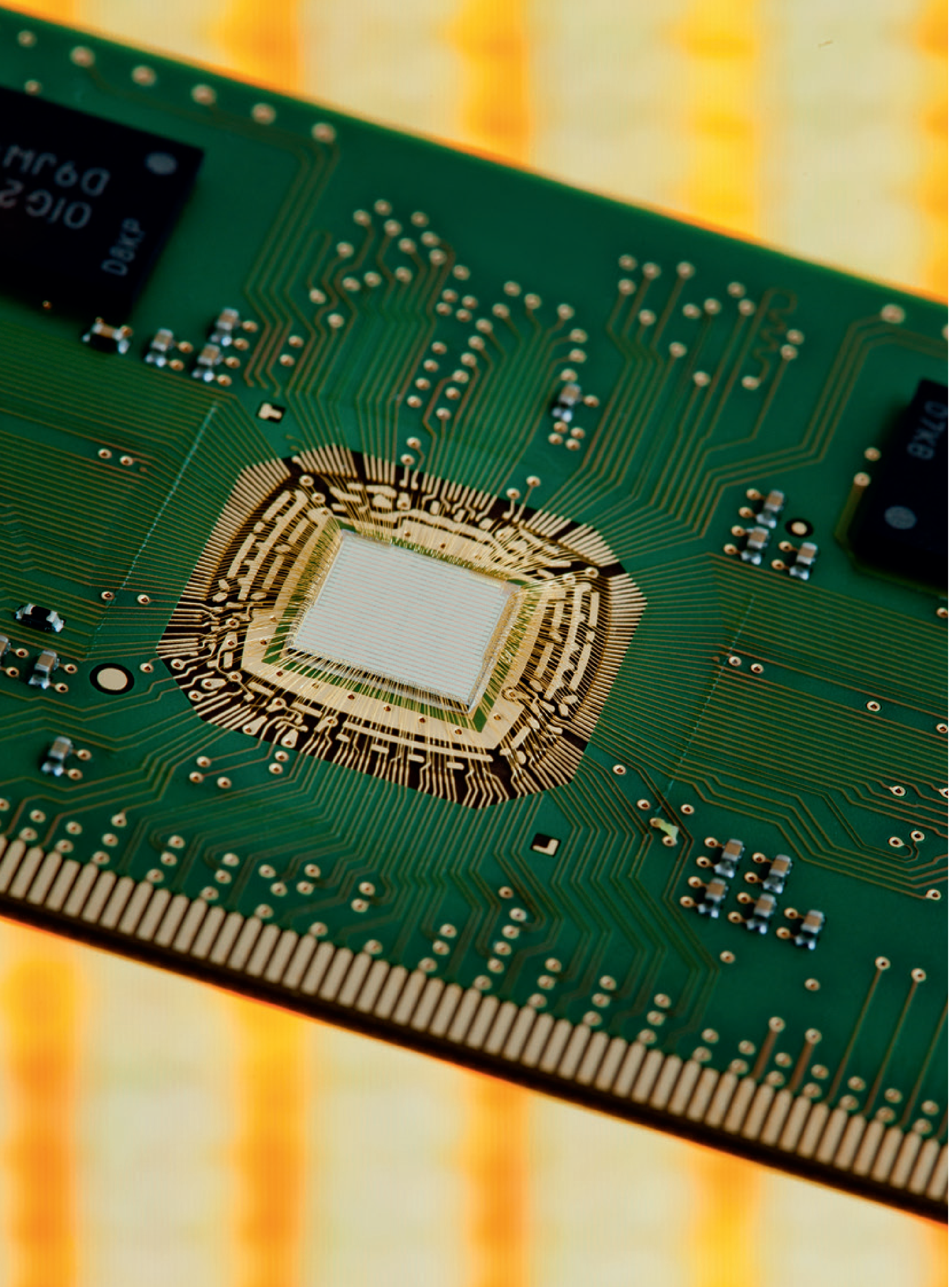
Inside the Path
A Revolution in Medical Diagnosis

Brigitte Voit is a cfaed member of the first hour. "I fondly remember the spirit of enthusiasm when we first came together and developed the unique interdisciplinary 'More-Shots-on-Goal'-approach of cfaed", the Professor for Organic Chemistry of Polymers says. Since 1997, she holds the Chair at Technische Universität Dresden in a joint appointment with the Leibniz Institute of Polymer Research Dresden (IPF), and since 2002, she is also Scientific Director of the IPF. "It is a particular challenge to work with top scientists from different faculties as well as from non-university institutions and to follow a common vision." The 50-year-old scientist has some previous experience with the German Excellence Initiative: she is also Principal Investigator of the Center for Regenerative Therapies Dresden - CRTD.

Within cfaed, Brigitte is Co-Leader of the Chemical Information Processing (CIP) Path, but she is also involved in the Organic/Polymer Path. "I am developing a new polymer bi-sensitive hydrogel actuator as base material for the chemical chip which takes over the on/off function of a logic circuit", she explains. "Thanks to cfaed, I got much more inspiration from other areas of science for my research. Especially the interaction within the CIP Path and towards the Orchestration Path to create a chemical processor is completely new." On the chemical circuit, thousands of small elements pump, dose and mix liquids, make chemical experiments and take decisions, only navigated by special chemicals. The processing power of these circuits is enormous.

"Chemical information processing is completely different to electronic information processing. Chemistry is the base of information processing of the human being", Brigitte says. "It is much more powerful than a standard computer." By understanding chemical information processing, difficult questions may be addressed, e.g., of the industry for optimizing new technical processes or for complex and quick medical diagnoses.

"I fondly remember the spirit of enthusiasm when we came together and developed the unique interdisciplinary 'More-Shots-on-Goal'-approach of cfaed."



F — Orchestration Path

Path Leader // **Prof. Dr. Hermann Härtig**, TU Dresden, Chair for Operating Systems
Path Co-Leader // **Prof. Dr.-Ing. habil. Jochen Fröhlich**, TU Dresden, Chair of Fluid Mechanics

Upcoming technologies, investigated and brought forward by the materials-inspired paths (A-E), may lead to systems with wildly varying properties and the potential to revolutionize the electronic systems landscape. Such systems could comprise, e.g., a many-core system-on-a-chip with sensors and actuators for a hydrogel steered chemical processor (Chemical Information Processing Path), carbon nanotubes as amplifiers of wireless connections to opposing processor boards but also spanning the distance between handheld devices and their infrastructure (Carbon Path), and/or extremely adjustable and reliable cores built on arrays of reconfigurable silicon nanowire gates (Silicon Nanowire Path). The core research challenge and goal of this Path is to pave the way for these highly efficient, wildly heterogeneous systems. How can applications and software systems be supported to rapidly take advantage of novel heterogeneous hardware? How can this process be automatized to minimize manual changes without losing the benefits of the underlying technologies due to additional complexities of traditional approaches? How can integration issues be identified and solved? The focus is on research of a novel hardware/software stack and to use heterogeneous, CMOS-based, many-core systems as evaluation test-bed for the future integration of novel materials. Many of the targeted solutions are inspired by nature (Biological Systems Path). For example, architectural skeletons offer a framework to formulate tasks independent of the architecture of available cores. Then, much like muscles adjust the force we apply to a glass when grasping it, the infrastructure and tools adjust these skeletons to the characteristics of the underlying cores.

Prof. Hermann Härtig

Left: 'Tomahawk2' is a heterogeneous multicore chip with dynamic software scheduling, developed by the Vodafone Chair Mobile Communications Systems.

Inside the Path

Building Harmony between Digital and Analog

Once per month, Marcus Völp visits the Kindergarten of his son. There, he explains scientific and technical phenomena in such a way that even the smallest children follow his talks with close attention. He uses sweets and pieces of cakes to illustrate portions and fractions, and shows in role plays how circuits and transistors are working. Normally, the Group Leader deals with much more complex issues – the optimization of the different hardware and software elements of a processor and the preparation for the heterogeneity of future information processing systems.

"I am extremely fascinated by the interdisciplinarity of the Cluster", the 36-year-old scientist says about the cooperation and interaction between the cfaed research paths. "We think about how to write programs for the chemical information processor which will be able to accomplish a complex medical diagnosis in a short time." The difference to conventional electronics is the challenge for Marcus: "A chemical computer deals with chemical fluids. So we must construct a kind of wet compiler."

Although Marcus was born in Frankfurt and studied Computer Science in Karlsruhe, he feels at home in Dresden. He wrote his doctoral thesis at Technische Universität Dresden, his supervisor was the leader of the Orchestration Path, Professor Hermann Härtig. Today, Marcus leads a group of young investigators who analyze the efficient connection of hardware and software components for data-intensive applications on heterogeneous multicore systems.

Previous research visits in the Netherlands, France and South Korea already broadened his horizon. With the support of cfaed, he spent six months at Carnegie Mellon University in Pittsburgh/USA from October 2013. The more than one hundred years old University is renowned for bringing groundbreaking ideas to the market and creating successful startup businesses. About 20 Nobel Laureates are amongst its award-winning faculty members. Its scientists are developing technologies to assist the elderly with household chores, respond to natural or man-made disasters and – jointly with the NASA – land a robot on the moon. "It was an interesting experience to work for a private elite university in the US", Marcus says. "I am now convinced that we in cfaed can reach a similar level of research distinction. We have the decisive expertise and knowledge in Dresden."

"I am extremely fascinated by the interdisciplinarity of the Cluster."

G — Resilience Path

Path Leader // **Prof. Dr. Christof Fetzer**, TU Dresden, Chair of Systems Engineering
Path Co-Leader // **Prof. Dr.-Ing. Eduard Jorswieck**, TU Dresden, Chair for Communications Theory

Reliable information processing with unreliable and adjustable components is investigated, taking into account the projected heterogeneity of future information processing systems and the fault characteristics of new materials-inspired technologies. The Resilience Path faces the challenge to build systems with a defined level of system failure, even though their single components vary in their individual failure and reliability behavior. Already today, reliability issues lead to diminishing performance returns when transitioning to smaller CMOS gate lengths. Soon the costs of traditional resilience mechanisms will cancel most of the benefits gained from transitioning to a new technology. The goal of the Resilience Path is to keep the costs of resilience as low as possible by focusing on flexible, application-specific, adaptive resiliency mechanisms. The Resilience Path is driven by the hypothesis that a sufficient cost reduction can be achieved by combining the best ideas that exist on different hardware and software sublayers of an information processing system. A variety of ideas have been proposed to improve the resilience on each sub-layer using their own resilience mechanisms. To achieve a substantial cost reduction, it needs not only novel mechanisms but also the orchestration of these mechanisms in an intelligent way. The general approach to reduce the cost is to dynamically adapt the degree of resilience to the current needs of the application. For example, a banking and a gaming application executed within a browser have different requirements: The banking application needs to be optimized for integrity, and the gaming application for speed. To allow for such optimizations, the resilience requirements of an application need to be explicitly stated. In the simplest case, an application will select its current resilience requirements from a set of prespecified resilience classes.

Prof. Christof Fetzer

Left: In the Center for Information Services and High Performance Computing (ZIH) resilience is a key factor.

Inside the Path

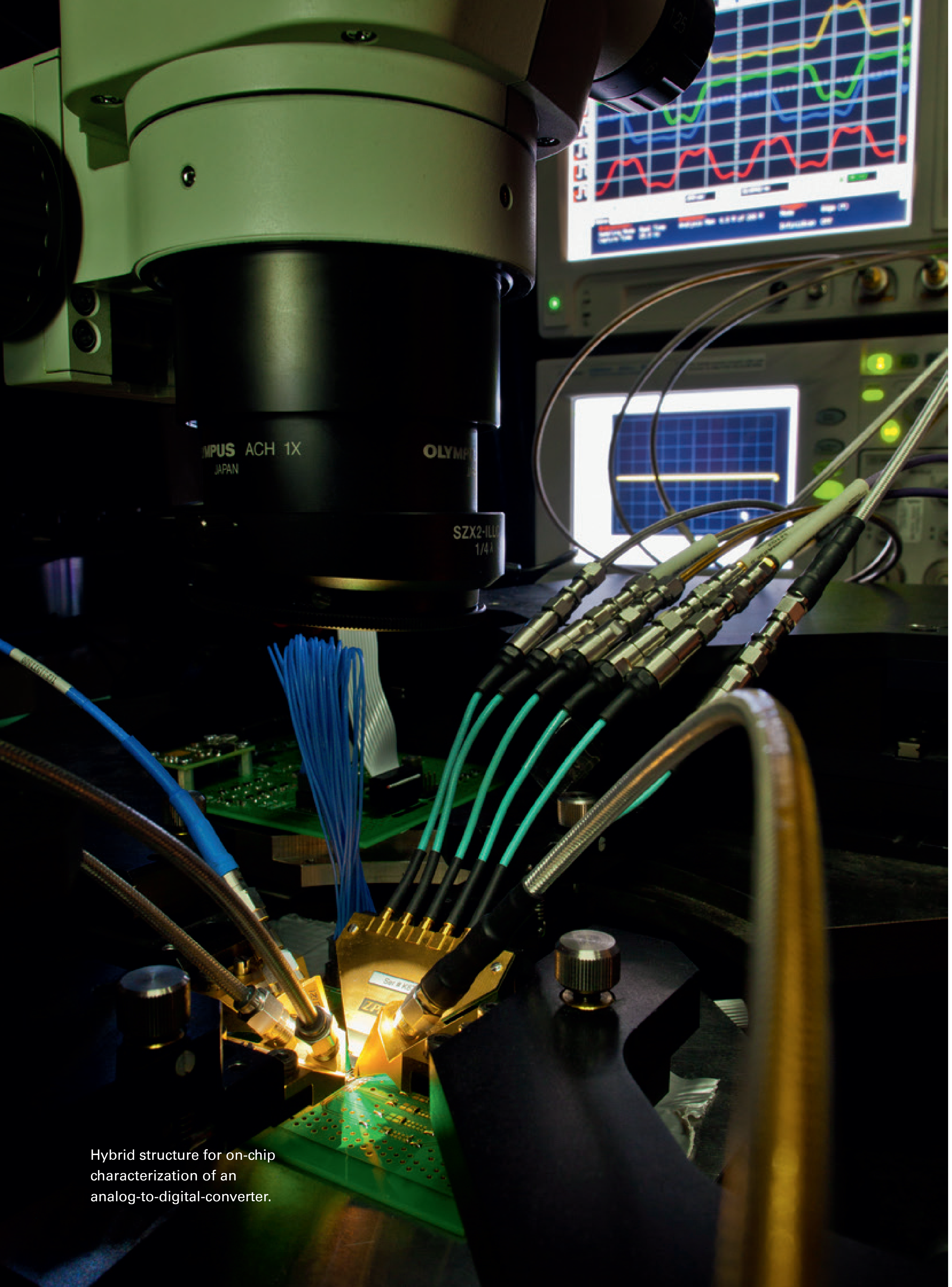
Silicon Saxony – Well-known in Tehran, Iran

"Dresden is really 'state of the art' in microelectronics", Siavash Ghiasvand says, an ambitious 28-year-old PhD student of computer science from Tehran. The Iranian applied for PhD positions in the USA and in Dresden. "Saxony was my favorite after the Californian Silicon Valley", he says. "Here are so many computer companies producing top hardware. This is an optimal base for me as a software specialist."

Siavash completed his Master of Science at the School of Computer Engineering and Distributed Systems at the Iran University of Science and Technology in Tehran. Currently, he is writing a research proposal for his doctoral thesis in the Resilience Path. His supervisor is Professor Wolfgang E. Nagel, director of the Center for Information Services and High Performance Computing of Technische Universität Dresden. Since August 2013, Siavash is working here as a research associate. "The support I had before and just after my arrival in Dresden was a great help", the young Iranian tells. "With the help of the Welcome Center of the University, I immediately found an apartment in Dresden-Neustadt – a great place to live for students." Now, he discovers the city by bike: "I did not expect Dresden to be such a beautiful place." Siavash enjoys his new home town. "Even the weather is much better than I thought." He joined campus sport courses and will participate in German language courses sponsored by cfaed.

The problem of resiliency in high performance computing fascinates the young computer expert: "There is a tradeoff triangle between performance, costs and resiliency", he says. "For future systems, we must develop additional flexible and adaptive resilience mechanism, to keep high performance computing affordable." All going to plan, Siavash will complete his PhD until 2017.

"I did not expect Dresden to be such a beautiful place."



Hybrid structure for on-chip characterization of an analog-to-digital-converter.

H — HAEC Highly Adaptive Energy-Efficient Computing

Speaker // **Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis**, TU Dresden, Vodafone Chair Mobile Communications Systems
Representative Speakers // **Prof. Dr.-Ing. Wolfgang Lehner**, TU Dresden, Chair of Databases // **Prof. Dr. Wolfgang E. Nagel**, TU Dresden, ZIH, Chair for Computer Architecture

The DFG Collaborative Research Center (CRC 912) 'Highly Adaptive Energy-Efficient Computing' (HAEC) complements the Cluster as Path H. HAEC focuses on large-scale, multi-chip computing platforms with wireless and optical inter-chip interconnects and on hardware/software adaptation methods for a new quality of energy-efficient computing. A straightforward way for improving energy efficiency is to reduce the energy consumption of every individual hardware component in a system. However, rather than ignoring the characteristics of applications, user communities, and contexts, HAEC strives for a comprehensive application-aware approach.
As computational problems require the parallel execution of computational operations with complex and problem-specific intercommunication patterns, HAEC's research focuses on highly adaptive hardware interconnection systems capable of adapting to software needs to achieve a substantially higher level of efficiency than currently possible with fixed connections. In addition, energy efficiency is addressed by novel software-level adaptation schemes focusing on the utility of applications under different environmental conditions. This requires system states of applications and hardware to be monitored and strategies for improving application utility at runtime, taking into account optimizations from these two ends. On the hardware side, a novel, highly adaptive and energy-efficient interconnection architecture is investigated and shall be demonstrated in the third 4-year phase of HAEC (2019 – 2023).
The understanding generated here can have major impacts on the other system-oriented paths and is challenged in a much wider context, e.g., new devices from the materials-inspired paths might be integrated into HAEC's computing platform. Therefore, the CRC is scientifically linked to cfaed, even though it is organizationally independent.

Prof. Gerhard Fettweis

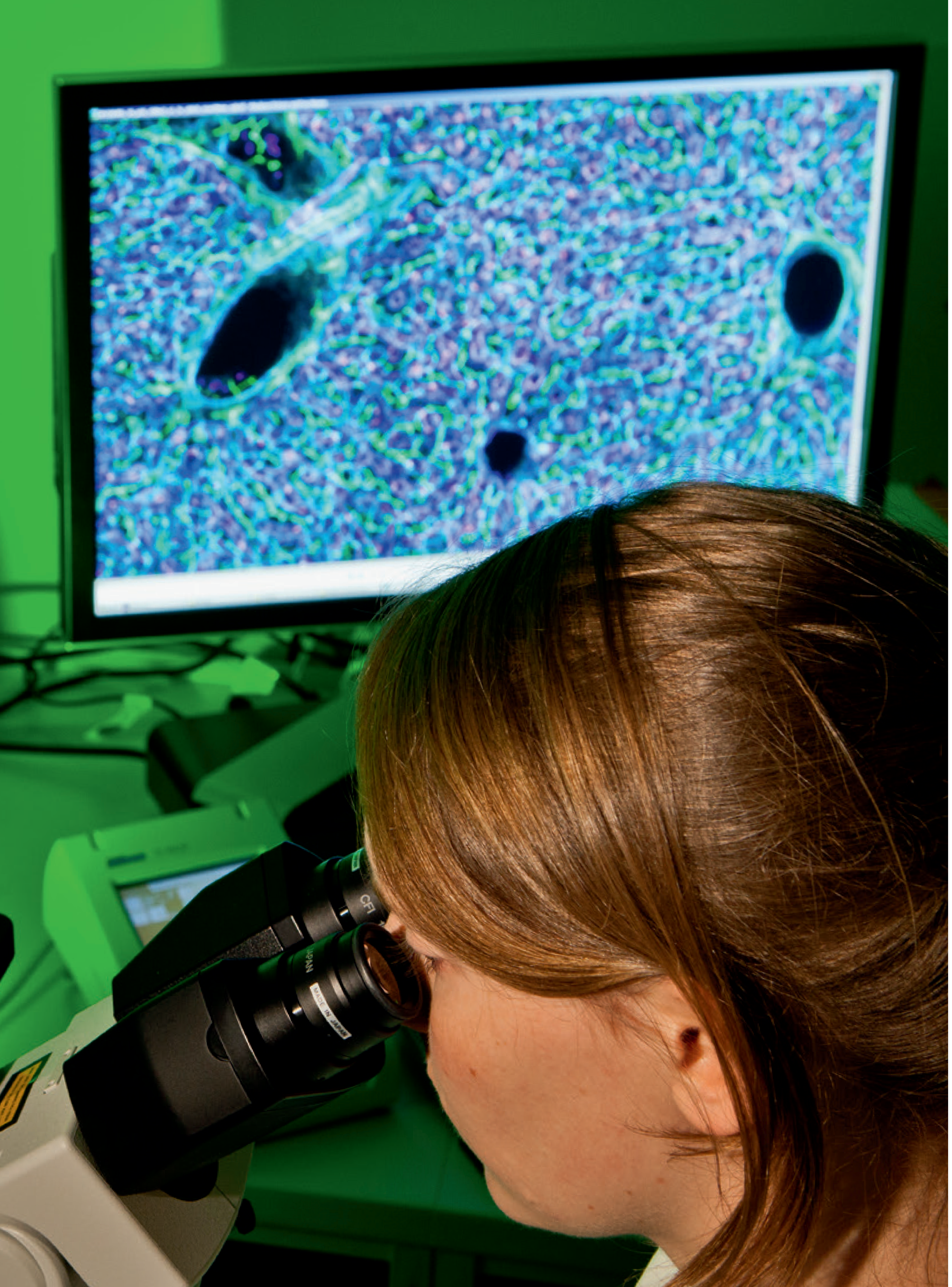
“Science is very competitive.
You must always be visible
with excellent results.”

Inside the Path
On the Science Road

To be part of cfaed, Meik Dörpinghaus moved from the Rhineland to Saxony. Before joining the DFG Collaborative Research Center HAEC, he was a postdoctoral reasearcher at RWTH Aachen University. “In Aachen, I have also worked in a Cluster of Excellence, therefore I know the inspiring atmosphere of such a unique research institution.”

With his special knowledge in communication and information theory, Meik coordinates the design of the new wireless and optical interconnection structure within HAEC. Within cfaed, he appreciates the Cluster’s approach to interdisciplinarity. “Normally, you are enclosed in your research community. Here is so much interaction between the different faculties and institutions, between engineers and natural scientists – between researchers who would have never even spoken to each other without cfaed.” Now, Prof. em. Heinrich Meyr, supervisor of his PhD in Aachen and one of cfaed’s Grand Professors, is also his mentor in Dresden. These outstanding experts from Germany, Switzerland, France, USA, Canada and Israel support the young cfaed research talents in their career development.

“Science is very competitive”, Meik says. “You must always be visible with excellent results.” But he likes the challenge. “cfaed gives me a real chance to envisage the professorship.” Thus, he is just preparing a six-month-visit to the USA. “I am looking for a research opportunity at a renowned institution at the American West Coast.”



I — Biological Systems Path

Path Leader // **Prof. Dr. Marino Zerial**, Director, Max Planck Institute of Molecular Cell Biology and Genetics
Path Co-Leader // **Prof. Dr. Ivo Sbalzarini**, Research Group Leader, Max Planck Institute of Molecular Cell Biology and Genetics

The unifying idea behind this Path is to analyze several examples from biology where there is a transformation from one length scale to another that leads to emergent behavior. Emergence means that the properties at the larger scale are in some way qualitatively different from those at the smaller scale. The difference could be that the system changes from analog to digital (e.g., a decision was made), from digital to analog (e.g., turning on a finite set of genes leads to a graded protein concentration), or from quiescent to oscillatory (e.g., triggering a cellular oscillation within the ear). Such changes in scale are ubiquitous in biology: molecules → organelles → cells → tissues → organisms. How robust (reliable) are these transformations, how is robustness achieved with small numbers of unreliable components, and how can a biological system maintain continuity of function even though the individual components are constantly replaced? From the point of view of cfaed, it is interesting to know how biology solves problems of scaling and complexity. This is because electronic systems operate in different modes of computation (analog/digital) and on different scales of implementation. For instance, analog transistors on the device level are used to make digital decisions on the circuit level. Hence, it is interesting to understand how biological networks implement the switching between different domains, and to compare biological systems to electronic systems in terms of their efficiency (e.g., energy consumption) and robustness. Biological systems are among the most complex systems known, and it is possible that universal principles will emerge that can provide insight into the increasingly complex engineering systems of the future.

Prof. Marino Zerial

Left: In the Max Planck Institute of Molecular Cell Biology and Genetics: Looking for inspirations by analyzing the communication between cells.

“Mathematics is just like a real language, but it is also a precise analysis tool.”

Inside the Path

A Bridge between Nature and Engineering

For Haralampos (Babis) Hatzikirou, mathematics is just like a real language. “But it is also a precise analysis tool”, the 35-year-old Greek scientist says. In cfaed, he uses complex algorithms to ‘translate’ biology for engineers. In the Biological Systems Path, the focus lies on solutions offered by the processes in nature for technique-related problems. “Our goal is the profound understanding of cell decision making in multicellular systems by means of multiscale mathematical modeling”, Babis says.

Initial results in collaboration with the Resilience Path show that intercellular dialogs are a paradigm of especially efficient communication. Another important source of inspiration of Babis’ group is the zebrafish retina development, in collaboration with the Max Planck Institute for Cell Biology and Genetics. “The dynamic dialog between cells and their micro environment makes multicellular systems fascinatingly complex”, he adds. The communication between neighboring cells should inspire cfaed researchers to find innovative new approaches in their technological fields. “This is very interesting”, Babis says, who already has a lot of Dresden experience.

From 2004 to 2009, he wrote his PhD thesis in Mathematics at Technische Universität Dresden. After working as a Postdoc in Biomedical Informatics in the USA and at the Helmholtz Center for Infection Research in Braunschweig, he returned to Saxony as a Research Group Leader of cfaed. He attracted international young talents to his Group M³s – Multiscale Modeling of Multicellular Systems – with the help of cfaed. “It is a great honor for me to be part of the Cluster”, he says. “I like this intensive interdisciplinary dialog and the exchange between the best heads of their fields.”

dcn — Dresden Center for Nanoanalysis

Scientific Coordinator // **Prof. Dr. Ehrenfried Zschech**, Division Director Nanoanalysis and Testing Systems, Fraunhofer Institute for Ceramic Technologies and Systems, Dresden

The Dresden Center for Nanoanalysis is an interdisciplinary technological platform of Technische Universität Dresden and cfaed in the field of nanoscale materials analysis. The vision of the highly motivated DCN team is to establish it as an internationally visible center of competence in the field of 4D materials analysis as well as a European user center. Leading-edge research is performed in the field of three-dimensional imaging and analysis of kinetic processes in materials and structures down to the atomic scale. The first research projects of the newly formed center focus on the study of solid-state physical phenomena and processes in innovative electronic devices based on one-dimensional nanostructures such as silicon nanowires and carbon nano-tubes as well as nanoscale sensors. These devices are expected to have a much higher performance than current CMOS devices and sensor systems. The analytical results will be interpreted jointly with researchers of the Silicon Nanowire and Organic Paths. In November 2013, two novel analytical tools, a scanning electron microscope with a focused ion beam (SEM/FIB) and a sub-micrometer X-ray tomograph, were installed. The DCN team works closely together with non-university institutes in Dresden, linked within the so-called DRESDEN-concept. The strong collaboration with the Dresden Fraunhofer Cluster Nanoanalysis (DFCNA) is particularly focused on applied materials-related research for a broad range of new applications in the fields of automotive, mechanical engineering, logistics, energy, sensor technology as well as medical engineering and health monitoring. Strategic partnerships with innovative companies have been established to align the research with industrial needs.

Prof. Ehrenfried Zschech

Left: Researchers of the DCN analyze images taken by a scanning electron microscope.

Research Group Leaders

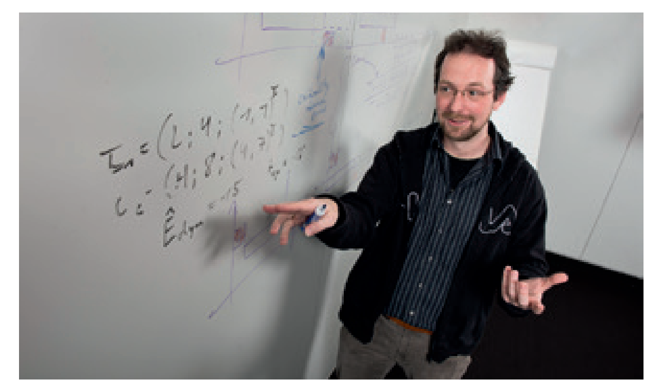
Dr.-Ing. Martin Claus cfaed Module Leader, Carbon Path since 2013 // Visiting researcher at University of Brasília, Brazil since 2012 // Postdoctoral Fellow at TU Dresden since 2011 // PhD studies in Electrical Engineering, TU Dresden 2006-2011 // Teaching Assistant in Electrical Engineering, TU Dresden 2005-2006 // Diploma studies in Electrical Engineering, TU Dresden, 1999-2004 // Born in Dresden, Germany 1979

Dr.-Ing. Meik Dörpinghaus cfaed Postdoc, CRC HAEC since 2013 // Postdoctoral researcher at RWTH Aachen University 2010-2013 // PhD studies in Electrical Engineering and Information Technology, RWTH Aachen University 2004-2010 // Diploma studies in Electrical Engineering and Information Technology, RWTH Aachen University 1997-2003 // Born in Gummersbach, Germany 1976

Dr. Haralampos Hatzikirou cfaed Research Group Leader, Biological Systems Path since 2013 // Helmholtz Center for Infection Research, Braunschweig 2011-2013 // Research Fellow, Pathology, University of New Mexico, Albuquerque, USA 2010-2011 // Postdoctoral Fellow, Biomedical Informatics, University of Texas, Houston, USA 2009-2010 // PhD studies in Mathematics, TU Dresden 2004-2009 // MSc in Industrial Mathematics, TU Kaiserslautern 2001-2004 // Diploma studies in Mathematics, Aristotle University of Thessaloniki, Greece 1996-2001 // Born in Thessaloniki, Greece 1978

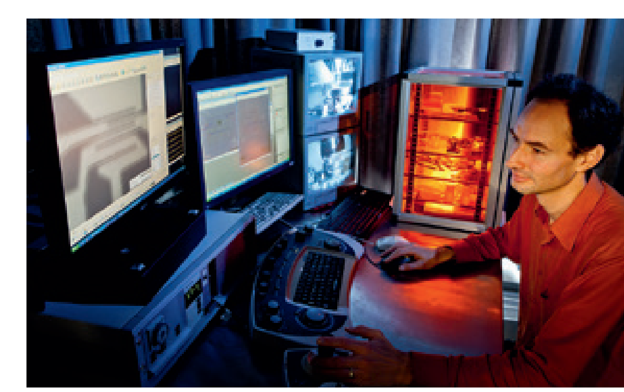
Dr.-Ing. Sascha Hermann cfaed Technology Platform Leader, Carbon Path since 2013 // Group Leader CNT integration and applications, Center for Microtechnologies, TU Chemnitz since 2011 // PhD studies in Electrical Engineering, TU Chemnitz 2006-2011 // Diploma studies in Physics, TU Chemnitz 2000-2005 // Born in Schlema, Germany 1981

Dr. Thorsten-Lars Schmidt cfaed Research Group Leader, Biomolecular Assembled Circuits Path since 2013 // Postdoctoral Research Fellow, Wyss Institute for Biologically Inspired Engineering at Harvard, Boston, USA 2010-2013 // PhD studies in Chemistry, Goethe University Frankfurt a.M. 2006-2010 // Diploma studies of Chemistry, University of Bonn 2000-2005 // Born in Medias, Romania 1979



Dr. Marcus Völp cfaed Postdoc, Orchestration Path, Leader of Young Investigators Group IMData since 2013 // cfaed Postdoctoral Research Scholar at Carnegie Mellon University, Pittsburgh, USA 2013-2014 // Postdoc at TU Dresden since 2011 // PhD studies in Computer Science, TU Dresden 2003-2011 // Diploma studies in Computer Science, Universität Karlsruhe 1997-2003 // Born in Frankfurt a.M. 1977

Dr.-Ing. Walter Weber cfaed Research Group Leader, Silicon Nanowire Path since 2013 // Senior Scientist at NaMLab gGmbH since 2008 // PhD studies, TU München, Institute for Nanoelectronics, research conducted at Infineon and Qimonda 2004-2008 // Diploma studies of Electronics Engineering, TU München 1999-2004 // Born in Mexico City, Mexico 1978



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Research Group Leader (Multiscale Modeling of Multicellular Systems)
Dr. Thorsten-Lars Schmidt
Research Group Leader (DNA Chemistry)

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cfaed has set up a Distinguished Lecture Series where world-known scientists, including Nobel Prize Laureates and Nobel Prize Nominees present their research. The series, which is open to the public, continuously attracts renowned experts. Previous guest speakers were:

27 November 2013
Prof. Sir Christopher Snowden
President Universities UK and President and Vice-Chancellor of University of Surrey, UK
The Electronic Adventure – Engineering a Better Future

25 April 2013
Prof. Serge Haroche
Nobel Prize Laureate Physics (2012); Chair of Quantum Physics, Collège de France, Paris, France
Particle Control in a Quantum World

27 February 2013
Univ.-Prof. em. Dr. Dr. h.c. Detlev Riesner
Heinrich-Heine-University Düsseldorf, Germany; Co-Founder of Qiagen N.V.
Viroids and Prions – Basic Research on Infectious Molecules and its Impact in Platform Technology, Diagnostics and Therapy

10 October 2012
Dr. C. Mohan
IBM Fellow and Former IBM India Chief Scientist, IBM Almaden Research Center, San Jose, California, USA
Implications of Storage Class Memories on Software and Hardware Architectures

11 May 2012
Prof. Moshe Y. Vardi
Rice University, Houston, USA
From Aristotle to the Pentium

25 October 2011
Prof. Albert Fert
Nobel Prize Laureate Physics (2007); Université Paris-Sud/Unité Mixte de Physique CNRS-Thales, Orsay, France
Spintronics: Electrons, Spins, Computers and Telephones

Imprint

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Picture Credits All Photos: Jürgen Lösel, except pg. 4 & 8: Frank Johannes, pg. 6: Lothar Sprenger, pg. 7: Stephan Floss, pg. 36 & 53: Ken Andreyo

Printing Belzing Druck GmbH, Dresden
Circulation 1000

DRESDEN, 2014

cfaed is funded by the Excellence Initiative of the German Federal and State Governments.

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