Editorial

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Photonics in security systems

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When exploring the role of photonics in security systems, a sentence from the novel *Effi Briest* written by Theodor Fontane comes to mind: *It's so hard, what to do and what to leave. This is too big a subject.*[1] Indeed, security is a big subject of our contemporary life. Its significance depends on the system context: cyber space, authentication, communication infrastructure, transportation, disaster management, forensics, surveillance, environmental protection, to name just a few examples. In each field photonics plays an important role in its ability to provide diagnostic tools with high sensitivity and selectivity. Especially, the possibility to separate spatially the information gathering interaction from the processes of detection and information extraction makes photonics an ideal tool for non-contact and remote sensing.

It was our task as guest editors to narrow down the big subject into a few topics in order to present a comprehensible collection of papers. Biased to some extent by our own area of expertise we invited colleagues working in the fields of hyperspectral and active spectroscopic sensing, autonomous vehicle navigation, optical materials manufacturing, and electronics to contribute to this special issue of photonics in security systems.

Securing those places where people meet and interact such as transportation hubs or public areas without encroachment on the general personal rights is a task of immanent importance for every society worldwide. Video surveillance to monitor structural changes and the behavior of people is very popular. In the future, imaging in the visible spectral band will be supplemented by hyperspectral recording and processing of information to generate additional features for the classification of events. Helge Bürsing and Wolfgang Gross from the Fraunhofer IOSB lead into the series of papers with a short tutorial on hyperspectral imaging techniques and security related applications.

Information about the chemical nature of substances dispersed in the air or contaminating surfaces will become available through the application of spectroscopic remote sensing techniques. The infrared spectrum covers the so-called fingerprint region of most hazardous substances and is therefore well suited for spectroscopic classification. The letter of Kenneth Hay and colleagues from Cascade Technologies/Emerson Process Management and the Swedish Defence Research Agency describes an open path analyzer based on quantum cascade laser intra-pulse absorption spectroscopy and a related system concept for the detection of gas plumes emanating from illicit manufacturing sites of an improvised explosive device. The research paper by Frank Duschek and coworkers from the German Aerospace Center, Institute of Technical Physics, and the Friedrich-Loeffler-Institute, Institute of Bacterial Infections and Zoonoses, presents a stand-off sensor applying laser-induced fluorescence to detect and classify bacteria suspended in the atmosphere at distances from 20 m up to 100 m. Active mid-infrared hyperspectral imaging and backscattering spectroscopy of contaminated surfaces is the topic of the contribution by Jan Jarvis and collaborators from the Fraunhofer-Institutes for Applied Solid State Physics IAF and Optronics, System Technologies and Image Exploitation IOSB. They use a wideband tunable external cavity quantum cascade laser and a novel background extraction algorithm based on the adaptive target generation process in order to acquire and analyze the data.

In the succeeding triplet of papers researchers from Thales Research and Technology together with partners from other institutions share their insight into infrared component technologies. In a common effort, François Gutty, his coworkers from Thales Research and Technology TRT, the III-V lab, and the Fraunhofer IAF developed a high peak-power laser system tunable from 8 to 10 μm by amplifying the radiation of a broadly tunable external cavity quantum cascade laser in an optical parametric

1 Theodor Fontane (1819–1898) was a German journalist, novelist and poet. The sentences are from chapter 15 of his novel *Effi Briest* and read in the original German language: "Es ist so schwer, was man tun und lassen soll. Das ist auch ein weites Feld". One of the guest editors (HDT) provided the translation, fully aware of the fact that the context of the conversation between Effi Briest and her father might suggest a different view.

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amplifier based on quasi phase-matching in orientation-patterned gallium arsenide. Jérôme Bourderionnet leads the team that demonstrated a beam steering functionality in the mid-infrared spectral range by taking advantage of well-proven steering techniques in the near infrared spectral range and the subsequent frequency conversion in a specifically designed Fourier transform optical parametric oscillator. Arnaud Peigné and his colleagues realized an adaptive holographic interferometer relying on an optically addressed liquid crystal spatial light modulator operating at 1.55 µm. This technique can be used, for example, with complex wave fronts of a speckled laser beam reflected by a highly scattering surface even in the presence of slow perturbations induced by the environment.

When the application of a remote sensing device is difficult or even impossible, for example, in buildings, the photonic diagnostic tool has to be brought near to the object of interest. This task is preferably carried out by autonomous vehicles. Anko Börner and collaborators from the German Aerospace Center, Institute of Optical Sensor Systems, built a navigation system based on a technical copy of the human head. The major components of the system are a stereo camera (eyes), an inertial measurement unit (vestibular system of the ear) and a computer (brain). In their paper, the authors explain the working principle and the most important basic algorithms.

Widely tunable hyperspectral sensors require broadband optical materials. Chalcogenide glasses are emerging as important enabling materials for low cost broadband optics by virtue of their ability to be mass produced and molded into near net shape lenses. In their paper, Andrea Ravagli et al. from the University of Southampton, Optoelectronics Research Centre, introduce a new family of chalcogenide glasses which offer enhanced transmission between 0.5 and 15 µm and improved thermal and mechanical properties.

The final paper of this collection introduces an example of photonics in the context of authentication systems. Sven Frohmann and his colleagues from Technische Universität Berlin, describe a photon emission microscope for picosecond imaging of hot carrier luminescence in integrated circuits in the near-infrared spectrum. The microscope allows for the semi-invasive analyses of functions in fully operational ICs on the gate or transistor level, in particular decoding crypto-algorithms which are implemented in security applications such as smart cards.

In closing the editorial, we thank the authors, the reviewers, and the *Advanced Optical Technologies* team for their support in building this collection of papers covering diverse aspects of photonics in security systems. Dear reader, this big subject also gives you a chance to contribute with your expertise. Please take a few moments to explore this option.

Hans Dieter Tholl received a Diploma in physics in 1985 and a PhD in Optical Physics in 1990, both from the Technical University (RWTH) of Aachen. He was awarded the Borchers Medal of the RWTH for his outstanding PhD Thesis. In the years 1990/91 he was Assistant Research Professor at the University of Nevada. From 1991 to 1995 he served as a coordinator for projects in optical metrology at the Technical University of Aachen. He joint Diehl in 1995 and became Head of the Optronics and Laser Techniques section in 1998. At Diehl, H.D. Tholl serves as chief engineer and manager in national and European projects related to active and passive optronics. In addition to his industry position, he lectured in Wave Optics, Laser Theory and Laser Applications at the Technical University of Ravensburg-Weingarten in Germany.

Heinz-Wilhelm Hübers received the diploma degree and Dr. rer. nat. degree in Physics from the Universität Bonn, Germany, in 1991 and 1994, respectively. In 2009 he received the Habilitation degree from the Universität Stuttgart. From 1991 to 1994, he was with the Max-Planck-Institut für Radioastronomie in Bonn, Germany. In 1994, he joined Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center, DLR) in Berlin, Germany, becoming head of department in 2001. From 2009 to 2014 he has been Professor of Experimental Physics at Technische Universität Berlin, Germany, and head of the department “Experimental Planetary Physics” at DLR. In 2014 he became director of DLR’s Institute of Optical Sensor Systems and a Professor at Humboldt-Universität zu Berlin. His research interests are in optical sensor systems, in particular for the terahertz spectral region, and application of these systems in astronomy, planetary research and security. Professor Hübers received the Innovation Award on Synchrotron Radiation (2003) and the Lilienthal Award (2007).