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EDITORIAL

Field laser applications in industry and research

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The third international conference on *Field Laser Applications in Industry and Research—FLAIR 2011* was held in Murnau, in the region of the lakes between Munich and the Bavarian Alps. FLAIR 2011 hosted a special session on 'Optical Analytical Measurement Techniques—OPTAM' and a session with a focus on 'Stable Isotope Ratio Infrared Spectrometry—SIRIS'. Participants from universities, research institutes and industry representatives have discussed state-of-the-art laser components and analyzers for the sensitive and selective detection of molecular species. Besides the laser technology and the analytical aspects many challenging field laser applications in industry and research have been discussed, and 14 contributions have been selected and are highlighted in this *Applied Physics B* FLAIR 2011 special issue.

FLAIR provides overview lectures by international experts emphasizing integrative and multi-disciplinary approaches and, therefore, the opening talks of the conference present an overview and perspectives of emergent techniques. For 2011 the focus has been set to laser combs. The possibility of realizing a FT spectrophotometer without moving parts as we have seen in the talk by Nathalie Picqué was impressive. Aleksandra Foltynowicz explained the underlying principles, the state-of-the-art and future perspectives of frequency combs [1]. Markus Amman has provided an overview on quantum cascade lasers, VCSELs and beyond, and Bernhard Lendl reported on optical analytical measurement techniques based on such quantum cascade lasers [2]. Clemens Kaminski revisited sensing based upon super-continuum sources in gases and liquids [3]. A special focus has been set to environmental applications: Donatella Zona illustrated the roadmap towards multi-species flux monitoring sites using commercial CH_4 and N_2O laser analyzers. Richard Grant applied tunable diode lasers to study gas emissions from area sources, Gregory Santoni compared eddy covariance and auto-chamber measurements of methane isotopologues using QCLs, and Mark Zondlo provided insights from open path measurements of atmospheric water vapor and ammonia.

A highlight of the conference was the plenary talk by Chris Webster, who presented an overview starting from the Fraunhofer lines, continuing with isotope ratios and ending with their impact on understanding the formation of the solar system. Therefore, it was mandatory for the chairmen to bring Chris ad hoc to the place nearby "where it all began", as he described during his fascinating talk. Joseph Fraunhofer worked from 1809 to 1819 at the "Glashütte" (optics institute) in the Benedictine monastery of Benediktbeuern, which became a world leader in the optical industry during that time (Fig. 1). His work there brought us closer to the planets and the stars and therefore contributed to understand the formation of the solar system as we learned in the talk.

For a "firework" at the end of a conference it is always difficult to find outstanding talks, but we found two excellent speakers so that the auditorium was almost complete even at the end of the meeting on a Saturday afternoon: Dirk Richter's presentation on a compact atmospheric multispecies sensor based on DFG sources with his memorable discussion of system design criteria developed by the 'apple-design mastermind' Dieter Rams and, finally, the brilliant overview of the state-of-the-art in

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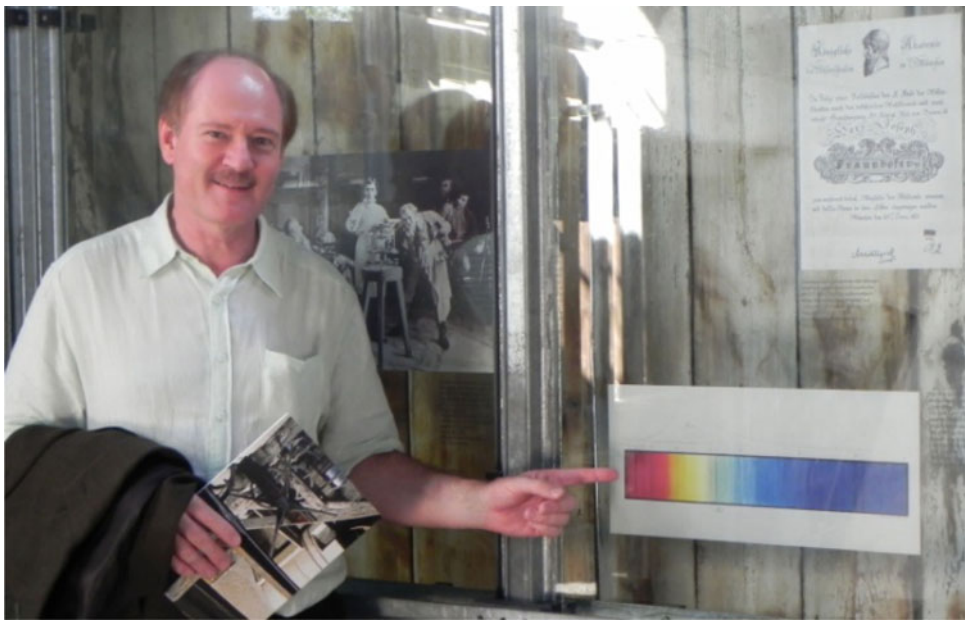

Fig. 1 Chris Webster (NASA JPL) at the Fraunhofer *Glashütte* "where it all began" (Photo by Peter Werle)

clinical breath analysis using lasers given by Gus Hancock, describing also the attempt of bringing a new solution to an old problem.

During the FLAIR industry session the contributing exhibitors have highlighted their recent achievements. Starting with laser sources, Yoshiki Nishida (NTT Electronics) introduced wavelength conversion lasers for gas sensing and Naota Akikusa (Hamamatsu Photonics) described recent developments for quantum cascade lasers and IR-detectors. Markus Ortsiefer (Vertilas) presented recent achievements and frontiers for VCSELs in TDLS applications, and Lars Hildebrandt (Nanoplus) explained novel tunable multi-segment quantum cascade lasers. Three broadband quantum-cascade lasers covering a range from 6 to 12.6 μm have been presented by Antoine Mueller (Alpes Lasers). Extending the wavelength tuning and power capability of CW OPOs was the contribution brought to us by Paul Hoffman (Lockheed Martin Aculight), and Sam Crivello (Daylight Solutions) showed a series of applications of external cavity quantum cascade lasers. Johannes Kunsch (Laser Components) explained new micromachined microphones with piezoresistive readout for photoacoustic gas sensors. Frank Jäger (Delta Analytics) compared isotope and trace gas measurements from FTIR and NDIR instruments. Low power, low cost, optical multi-gas sensors suitable for spaceflight have been introduced by Joerg Kutzner (Vista Photonics), while Michael Frish (Maxion Techologies) described TDLAS Analyzers for energy production, transmission and storage. Peter Geiser (Norsk Elektro Optikk) presented a fiber-coupled near-infrared carbon monoxide spectrometer for harsh environments, and Wolfgang Ziegler (Siemens) discussed instruments for reliable and quick ppm analysis of carbon monoxide by use of in situ TDL spectroscopy. In the industry environmental analysis session Hamish Adam (Boreal Laser) focused on fugitive emission mapping using a small number of laser paths and James Scherer (Thermo Fisher) on MIR difference frequency laser-based sensors for ambient CH_4, CO and N_2O monitoring. Doug Baer (Los Gatos Research) described recent advances in instrumentation based on cavity enhanced absorption spectroscopy and Barry McManus (Aerodyne Research) new quantum cascade laser-based trace gas instruments. George Burba (LI-COR Biosciences) reported applications of a new open path instrument to measure environmental methane flux by eddy covariance.

FLAIR hosted 49 invited and contributed talks and more than 80 poster contributions on a variety of developments and applications, but also about optical techniques exploiting light sources other than lasers—like non-dispersive Infrared (NDIR) and Fourier Transform Infrared (FTIR) spectrophotometers—which allowed the audience to compare different approaches to trace gas detection. Frequently, scientist familiar with lasers do not really consider old, but well-established technologies. Revisiting these techniques as in the talks on the NDIR technique by Dayle McDermitt with a focus on theory, calibration and performance of the LICOR gas analyzers and by Michael Zöchbauer (Sick-Maihak) on industrial applications, both perspectives helped to clarify pros and cons of the different approaches.

Besides the scientific presentations and the industry exhibition at the conference center, the participants had the possibility to join an excursion to the KIT field site for

high-tech environmental research. The site is located in a bog, where laser sensors are being used for integrated Land–Atmosphere Surface Exchange Research (iLASER). Different instruments manufactured by FLAIR exhibitors were operated there under field conditions by company representatives performing measurements of the ecosystem-atmosphere exchange of the greenhouse gases CO_2, CH_4 and N_2O inside the canopy and from towers using the eddy covariance technique. Only groups up to 10 people at a time are allowed in the beautiful natural reserve, where the field measurement site is located—so it has been a long day for the exhibitors at the field site, but they have been remunerated by a spectacular sunset (Fig. 2).

At FLAIR 2011 instruments have been described, suitable for operation under very different conditions, with detection limits well below the ppbv range. It is interesting to note that the majority of these instruments exploit an old, simple, but robust detection technique, namely direct absorption. There has been tremendous effort in the past to develop detection techniques and lasers, to increase the performance in absorbance measurements and in some of them the chairmen have been involved [4–8]. First field instruments used lead-salt diode-lasers or had to adopt room temperature NIR lasers, emitting in the region of molecular overtones or. The weak line strength of NIR absorption bands and the requirement of liquid nitrogen motivated scientists and manufacturers to search for improved detection techniques and new laser devices, finally leading to the breakthrough of quantum cascade lasers. With respect to direct absorption, modulation techniques lose the information about the absolute scale. Michael Nikodem has illustrated a detection technique, which could solve this problem, based on the variation of dispersion index caused by absorption [9]. With respect to an innovative interaction path, posters from Andreas Hangauer, Jia Chen and Johannes Herbst described applications of hollow fibers, and Nwaboh et al. compared the measurement of CO_2 in a multipass cell and in hollow-core photonic bandgap fiber at 2 μm [10].

Murnau is a little town in the holiday region around *lake Staffelsee*, a piece of "picture book" Bavaria, where artists like Kandinsky, Münter and Horváth lived and found inspiration in the picturesque landscape at the foothills of the Bavarian Alps with its romantic lakes and unique moorlands. FLAIR is an ideal place for scientific discussions in an informal atmosphere for furthering Laser Applications in Industry and Research as a cross-disciplinary science. Most of the hotels are close to each other, located in a charming pedestrian zone next to the conference center. This allowed us to keep the participants in close contact for a week. Bavarian cuisine and lakes have been the *fil rouge* of the social part of the conference. The conference has started with the registration at the *Griesbrau* brewery, where the participants could join a guided tour on the production of bier, and where a traditional Bavarian style dinner was served. The excursion "*bog′n′beer*" had its starting site at *Lido Biergarten*, on the southern banks of the *lake Starnberg*, where the conference participants could discuss and exchange information, while waiting for their departure for the trip to the nearby field monitoring site. The conference dinner has been served on board of a catamaran (Fig. 3), cruising all around the *lake Starnberg*. The sunset in 2011 has moved from the Zugspitze—the top of Germany as seen in 2009 [11]—to the hills around this beautiful lake.

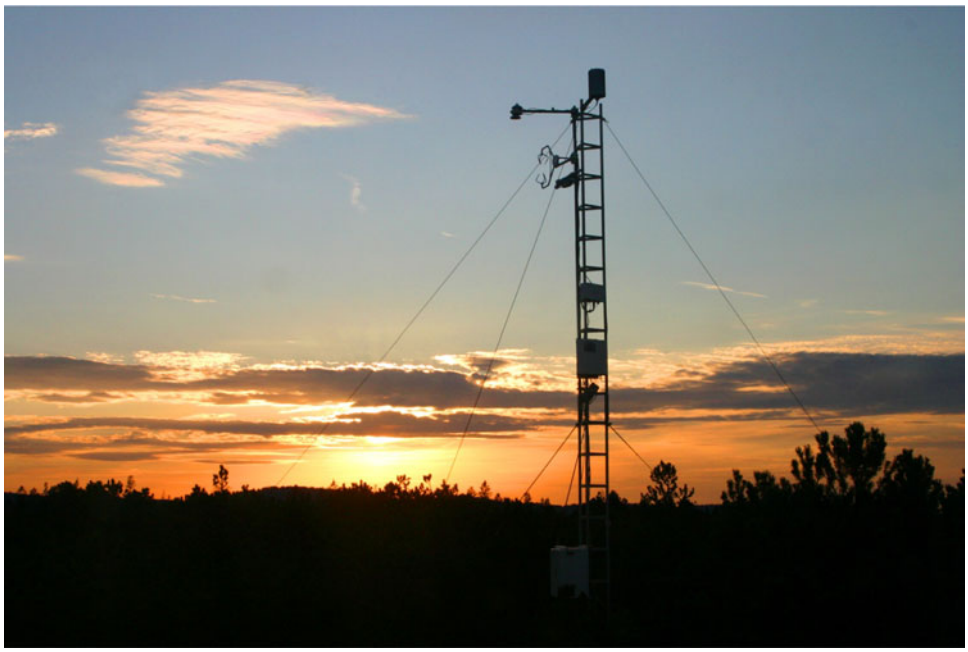

Fig. 2 FLAIR 2011 sunset excursion to the bog (Photo by Barry McManus)

Fig. 3 FLAIR 2011 conference dinner "all in the same boat" (Photo by Peter Werle)

At FLAIR 2011 researchers and industry could talk, listen and develop innovative projects on all aspects of spectroscopic analysis. Again FLAIR brought our research aims together, and allowed networking among different applications and scientific disciplines. Many of the conference social events where all this happened would not have been possible without the financial support beyond the registration fees. The chairmen acknowledge the financial support of the supporting companies and exhibitors:

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