

Featured Researcher

Research Assistant Professor Tino Hofmann

<http://ellipsometry.unl.edu>

Originally from Grimma, Germany, Tino Hofmann has been generating excitement in the ellipsometry community with research in Terahertz spectroscopic ellipsometry (THz-SE). His experience with ellipsometry started as a graduate student at the University of Leipzig in 1999. There, he employed far-infrared ellipsometry to study InAs monolayers for his diploma thesis research titled “Infrared Spectroscopic Ellipsometry and Raman Spectroscopy on III-V-Semiconductor Superlattices.” His advisors were Profs. Bernd Rheinländer and Mathias Schubert and the experimental data were acquired with the far-infrared ellipsometer prototype built by Dr. Daniel Thompson at the University of Nebraska-Lincoln. Back then, the main research interests were phonon frequencies, strain, free-charge carrier properties and intra-band transitions. The far-infrared is important as lower frequencies can interact with these heavier semiconductor atoms.

Tino later received his Ph.D. for “Far-infrared spectroscopic ellipsometry on A-III B-V semiconductor heterostructures.” Most of his research revolved around phonon resonances and free-charge carrier properties in III-V semiconductor heterostructures, but also optical birefringence caused by CuPt-ordering in ternary and quaternary alloys in the visible spectral range. The samples were grown in Leipzig by one of the pioneers of metal organic vapor phase epitaxy – Dr. Volker Gottschalch. In the beginning, he was working on an in-house setup to determine the small birefringence of CuPt-ordered GaInP and AlInP in the visible spectral range. His advisor, Mathias Schubert, had designed the setup for transmission experiments, and Tino was developing the software which allowed them to make reflection measurements using on-sample calibration schemes for the optical elements. They used HP-VEE (a visual software development environment) running on a 486 PC to control the hardware. Patience was a necessity!

Collaboration with Professor Schubert continues today, but half way around the globe as both have relocated from Leipzig to the University of Nebraska-Lincoln (UNL). Tino and two graduate students of the UNL



Tino with graduate students, Alex Boosalis (left) and Philipp Kühne (right), standing behind their THz-SE.

Complex Materials Optics Network (Philip Kühne and Alex Boosalis), are working together with Schubert on the development and application of THz-SE. This intriguing new spectral range considers wavelengths in millimeters rather than microns or nanometers. They currently focus on the application of ellipsometry in the 3 to 0.2 mm (0.1 to 1.5 THz) wavelength range for the investigation of semiconductor materials. Tino feels that ellipsometry in this long wavelength range is still in its infancy – maybe comparable to the stage where infrared ellipsometry was about 15 years ago. The materials being investigated range from silicon junctions (where carrier profiles in multilayer structures are determined) to two-dimensional electron gasses in high mobility electron AlGaIn/GaN transistors and even graphene (a monolayer of graphite).

The THz spectral range offers numerous interesting “playgrounds” for ellipsometry. The precise determination of optical properties in the THz spectral range is very important. Tino sees much potential in determining electrical properties in a frequency domain which has

unique applications in the semiconductor industry, especially with the unique ability to provide information on multi-layered structures. The THz group has not yet looked at the optical response of organic molecules, but initial absorption measurements have shown intermolecular vibrations in the THz spectral range. This area is of great interest in pharmaceutical industries and life sciences in general.

Tino has already been recognized for his unique contributions to the field of ellipsometry. At the 5th International Conference of Spectroscopic Ellipsometry (ICSE-V), he received the Paul Drude Award, which is given “to a young scientist for exceptional contributions to the development and application of spectroscopic ellipsometry.” Tino was selected “for his unique contributions with strong focus on development of far infrared and Terahertz ellipsometry, the optical Hall effect and numerous applications on the determination of phonon and free charge carrier properties in semiconductor layer structures”. A full description of the award recognition and selection can be viewed at www.icse-v.org. Of this award, Tino states, “It is a great honor to receive this award from our community. Of course the work was only made possible in collaboration with friends and colleagues at many places, but mostly the Universities of Nebraska-Lincoln and Leipzig, and the Woollam Co. I have the great honor of working together with Mathias Schubert and Craig Herzinger for a long time now. One can hardly imagine a better combination of mentors!”

While Tino attends many conferences (including American Vacuum Society, Materials Research Society, and American Physical Society), he has enjoyed the past ICSE meetings tremendously because of the small conference size, broad range of ellipsometry applications, and high quality presentations. Tino recognizes the importance of international conferences in education, and supports international conference participation for his graduate students.

Tino’s free time is dedicated to his family. He and his wife, Juliane, enjoy time with their 18-month old son, Oswin. In particular, the Hofmanns enjoy the outdoors and visiting national parks. They have been on several hiking trips to national parks in California and Colorado, and have planned a summer 2011 RV trip to national

parks of the Canadian Rockies. His favorite park thus far is Redwood National Park in northern California, where “walking underneath the giant trees (many of them exceeding 100 m in height) is a wonderful experience and hard to cast in words.”

Dr. Hofmann’s friends at JAWCo foresee his research having a monumental impact on future SE applications, perhaps even as monumental as one of the California redwood trees.

References

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On contact free measurements of carrier profiles in silicon:

T. Hofmann, et al., “Hole diffusion profile in a p-p+ silicon homojunction determined by terahertz and midinfrared spectroscopic ellipsometry”, *Appl. Phys. Lett.* **95**, (2009) 032102.

On magneto-optic THz ellipsometry to study free-charge carrier properties:

T. Hofmann, et al., “Terahertz magneto-optic generalized ellipsometry using synchrotron and blackbody radiation”, *Rev. Sci. Instrum.* **77**, (2006) 063902.



Tino and Juliane in one of their favorite US national parks: Redwood National Park in California. Behind them, you can see a (very small) part of a coastal redwood tree.