

## **Summary of the international summer school on Physics at Nanoscale, 12th to 17th June 2017, Devet Skal, Czech Republic**

### **Abstract**

Thin films and nanostructures play a key role in the photovoltaic energy conversion. The Institute of Physics of the Czech Academy of Sciences organized a summer schools on physics of nanostructures, surfaces and thin films. The school was a continuation of summer school series held every three years in the Czech Republic which aim to present current trends of research at both tutorial as well as state-of-the-art level.

Special attention in the school programme was paid to the renewable energy and photovoltaics. The school thus became a part of outreach activities of H2020 project **NextBase** (<http://nextbase-project.eu/>). The part of the school focused to photovoltaics was about a third of the school programme, with two speakers from the NextBase consortium (Lars Korte and Olindo Isabella). The other prominent speakers on photovoltaics were David Cahen (Weizmann Institute) and Pere Roca i Cabarrocas (CNRS, Ecole Polytechnique), but there were important links with plasmonics (Olivier Martin, EPFL) and silicon nanophotonics (Uriel Levy, Hebrew University).

The school was twinned with the [Photovoltaic Systems Summer School 2017](#) organized by TU Delft, which offered a direct hands-on experience with modern photovoltaics.

### **School overview**

The school was organized as 16<sup>th</sup> IUVSTA summer school. The school organization relied on the Czech Physical Society, the Czech Vacuum Society and last, but not least, a group of the academic research institutes and universities listed at the school web page ([iss.fzu.cz](http://iss.fzu.cz)).

The school brought together 150 people (14 speakers, 112 participants and 24 company representatives and). The school attendees came from 18 countries (Austria, Belgium, China, Czech Republic, France, Germany, India, Iran, Israel, Italy, Luxembourg, Poland, Russia, Slovenia, Spain, Switzerland, the Netherlands and U.S.A.).

The school is traditionally designed in such a way that the **lectures at the school** are given only by invited speakers, eminent scientists in their fields. Each speaker gave two lectures of 50 minutes each, with the first introductory part followed by more advanced topics scheduled usually half a day or a day later to provide time for the speaker – audience discussion.

On Tuesday June 13<sup>th</sup> the participants presented their research during the **poster session** with over 60 posters, which were judged by an international committee composed of the invited lecturers and a student, none of them connected to the organizers.

**School excursion** took place during the free afternoon on Wednesday June 14<sup>th</sup> to Ždírec nad Sázavou, where the participants have seen that high tech production may be represented even by the wood-processing industry.

The **company evening** took place on Wednesday June 14<sup>th</sup> as a small exhibition where 27 companies presented their products or profiles. In addition, three companies brought their microscopes for demonstrations in the course of the school, allowing the participants to get hands-on experience (MT-M with Bruker AFM microscopes, RMI with NT-MDT AFM and WITec with an AFM/Raman setup for microspectroscopy).

The **panel discussion** took place on the evening of Thursday June 15<sup>th</sup>, moderated by Pavel Krečmer (CEITEC) with participation of Prof. Paul Weiss (UCLA), Roland Wiesendanger (Hamburg University) and Andrei Kirilyuk (Radboud University, NL). Another panelist was prof. Christian Teichert (Montan University, Leoben) who took part on behalf of IUVSTA. The discussion was attended by majority of the students who discussed whether academic or industrial career would be attractive and valuable.

Following the past experience, we do not prepare proceedings of the school. Instead, the participants can download the lectures of the speakers from the cloud.

### **Role of the summer school in the research environment**

Two Czech research infrastructures were involved in the school organization: Central European Institute of Technology - Brno University of Technology ([www.ceitec.eu](http://www.ceitec.eu)) and Laboratory of Nanostructures and Nanomaterials ([lnsm.fzu.cz](http://lnsm.fzu.cz)) of the Institute of Physics, Czech Academy of Sciences.

The interest in energy conversions made the school part of the activities of the research framework of the Czech Academy of Sciences called [Strategy AV 21](#), namely its research programme Effective energy conversion and accumulation.

### School topics

The school was kicked off by a lecture by **Paul Weiss (UCLA, U.S.A.)** who presented a tutorial on patterning across scales and on atomically precise nanoscale assemblies in which cooperative functions may become basis for the future nanoelectronic devices.

The role of nanostructures in energy conversion was introduced by **Dave Cahen (Weizmann Institute, Israel)**, who reviewed the amazing developments in solar cells during the last decade. In his following talks he focused on the halide perovskites, a new comer to the photovoltaic race with potential to revolutionize the field, and on electronic processes in nanostructures, in particular in electron transport across proteins.

**Pere Roca i Cabarrocas (CNRS, Ecole Polytechnique, Palaiseau)** brought the attention to silicon, the mainstay of the modern electronics, and presented plasma processes used at silicon thin film depositions and nanostructuring.

**Gareth Parkinson (TU Vienna)** has proceeded to metal oxides and their surfaces, in particular magnetite, with a fascinating perspectives to single-atom catalysis of carbon monoxide.

**Fabian Menges (IBM Zurich)** brought up the topics in physics of thermal transport and its role in nanotechnology.

**Erik Reimhult (BOHU Vienna)** bridged the gap between materials science and biotechnology during his lectures on Colloids and nanoscale interactions in biological systems, where interesting analogies could be seen with the silicon nanostructures presented by Pere Roca. The talks reached multifunctional use of magnetic nanoparticles and even to the topics of nanocolloids for health (and hazard).

The school programme could not miss optical phenomena at nanostructures, starting with the presentation of **Olivier Martin (EPFL, Lausanne)** on non-linear plasmonics, which ranged over second harmonic generation in multi resonant structures, including cooking recipes for their preparation (and possible pitfalls or recipe disasters).

The topic of magnetism came back with **Andrei Kirilyuk (Radboud University)** who lectures on Structure and magnetism of atomic clusters, including ultrafast processes at Laser induced magnetization dynamics and switching.

Most of the topics above came to a synthesis in the lectures of **Roland Wiesendanger (Hamburg University)** on an microscopic investigations of antiferromagnetic nanostructures, ranging From the Smallest Building Units to Model-Type Atomic-Scale Spintronic Devices, including spin chains.

The photovoltaic energy conversion came back in the talks of **Lars Korte (Helmholtz Zentrum Berlin)**, who illustrated the record efficiencies reached by the current silicon heterojunction based photovoltaics, which is reaching close to the physical limits.

The optics of the solar nanostructures and in particular the classical  $4n^2$  absorption limit were explained and demonstrated by **Olindo Isabella (Technical University Delft)**.

Nanostructures based on materials with reduced dimensionality were subject of **Thomas Michely (Cologne University)**, which ranged from 2D layers to 1D wires and 0D clusters.

Excursion away from elemental semiconductors was guided by **Ferdinand Scholz (Ulm University)**, who told the story of GaN, showing that it is presently the most important semiconductor after silicon. The related heterostructures may enable breach of the boundaries of even GaN technology, namely the UV light sources.

Finally, **Uriel Levy (Hebrew University of Jerusalem)**, took the audience back to silicon, but silicon in perspective of upcoming photonic and plasmonic applications.

### **Presence of industry at the school**

The school relied also on support of the companies without whom we would not be able to keep a very low school registration fee (~320 Euro), which is necessary to make the school affordable to students. Bringing the students together with the company representatives serves one more important purpose of establishing future contacts or perhaps careers.

The traditional industry evening took part on Wednesday with participation of the following companies:

ActivAir	<a href="https://www.activair.cz/">https://www.activair.cz/</a>
Crytur	<a href="https://www.crytur.cz/">https://www.crytur.cz/</a>
Devmatech	<a href="https://devmatech.pl/">https://devmatech.pl/</a>
HVM Plasma	<a href="http://www.hvm.cz/">http://www.hvm.cz/</a>
IONTOF	<a href="https://www.iontof.com/">https://www.iontof.com/</a>
Measurement Technic Moravia	<a href="http://www.mt-m.eu/">http://www.mt-m.eu/</a>
Meopta	<a href="http://www.meopta.com/">http://www.meopta.com/</a>
Nenovision	<a href="http://www.nenovision.com/">http://www.nenovision.com/</a>
ON Semiconductor	<a href="http://www.onsemi.com/">http://www.onsemi.com/</a>
Optik Instruments	<a href="http://www.brukeroptics.cz/">http://www.brukeroptics.cz/</a>
Pfeiffer Vacuum Austria	<a href="http://www.pfeiffer-vacuum.com/">http://www.pfeiffer-vacuum.com/</a>
RMI	<a href="http://www.rmi.cz">http://www.rmi.cz</a>
TESCAN	<a href="http://www.tescan.com/">http://www.tescan.com/</a>
Thermo Fischer Scientific (FEI Czech Republic)	<a href="http://www.fei.com/">http://www.fei.com/</a>
Uni-Export Instruments	<a href="http://www.uniexport.co.cz/">http://www.uniexport.co.cz/</a>
SVCS Process Innovation	<a href="http://www.svcs.cz/">http://www.svcs.cz/</a>
Specion	<a href="http://www.specion.biz/">http://www.specion.biz/</a>
TESTE	<a href="http://www.teste.cz/">http://www.teste.cz/</a>
Vakuum Praha	<a href="http://www.vakuum.cz/">http://www.vakuum.cz/</a>
Vakuum Servis	<a href="http://www.vakuum-servis.cz/">http://www.vakuum-servis.cz/</a>

In Prague on 17<sup>th</sup> September 2017

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and

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On behalf of the school organizers:

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