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## EDITORIAL

I am pleased to present in this issue a contribution from Prof. Vadim Yakovlev, from the Worcester Polytechnic Institute, summarizing the activities of the 17<sup>th</sup> Seminar "Computer Modeling in Microwave Power Engineering" that was held in Bled, Slovenia, 11-12 March, 2015.

I also welcome Dr. Nguyen Tran, research director of Microwave Power Components, who presents a brief outline of the research activities on microwave heating in Australia.

Dr. A.C. Metaxas describes in the afterthought piece what happens when someone mixes graphene with a metamaterial such as metal SiO<sub>2</sub>.

I take this opportunity to wish you a good trip to Cracow and a pleasant stay in that beautiful city. See you all in Cracow!!!

**Editor**

**Prof. Juan Monzó-Cabrera**

**ETSI Telecomunicación**

**Universidad Politécnica de Cartagena (Spain)**

## 17<sup>TH</sup> SEMINAR "COMPUTER MODELING IN MICROWAVE POWER ENGINEERING"



**by Vadim V Yakovlev**

Industrial Microwave  
Modeling Group  
Worcester Polytechnic  
Institute  
Worcester, MA, USA

The 17th Seminar "Computer Modeling in Microwave Power Engineering" was held in Bled, Slovenia, 11-12 March, 2015. As all previous meetings in this series, it was an endeavor of the Industrial Microwave Modeling Group (IMMG) of Worcester Polytechnic Institute, Worcester, MA, USA. The event was organized in cooperation with Society for Industrial and Applied Mathematics (SIAM) and in partnership with the Laboratory for Simulation of Materials and Processes (LSMP) of Institute of Metals and Technology (IMP), Ljubljana, Slovenia. The seminar was made possible due to support of two industrial sponsors, MKS/Alter and SAIREM SAS. Special endorsement and sponsorship was provided by AMPERE.

The event was sub-titled "Methods and Models for Microwave Processing of Materials" and, similarly to three previous forums in this series (Bayreuth, Germany, 2012; Padua, Italy, 2013; Karlsruhe, Germany, 2014) was mostly concerned with issues in multiphysics modeling for microwave power engineering. This subject matter continues to be of a substantial interest for the modelers and researchers developing new applications of advanced modeling techniques as well as engineers and designers of microwave applicators.

The technical program contained 14 presentations which were given by the attendees from France, Italy, Slovenia, Spain, Sweden, and the US. The topics discussed in those talks included mathematical models of inverse waveguide problems and microwave sintering, computational study of heating patterns in solid-state-fed multi-source resonators, computer models of microwave plasma sources, broadband measurement of dielectric properties as well as related topics in metamaterials and steel casting.



Figure 1: At the technical session.



Figure 2: At the seminar closing.

The Seminar featured two special sessions. In the first, the seminar sponsors, MKS/Alter and SAIREM SAS, gave extended presentations of their products and services. The new SG 524 air-cooled solid-state 2.45 GHz microwave generator with adjustable power from 45 to 450 W, the device designed and manufactured by

MKS/Alter, attracted a special attention of the seminar participants. In the Panel Session dedicated to business aspects of academic research the attendees shared with each other their experience in management and practice of R&D activities in the context of the current trends as well as specific relevant European programs.



## HIGH POWER MICROWAVE RESEARCH ACTIVITIES IN AUSTRALIA

Given an exceptional location of the venue, an alpine town on the bank of Lake Bled in northwestern Slovenia, a popular tourist location in all seasons, the seminar participants had an opportunity to enjoy an exceptional social program. Bled and its surroundings, with their immense natural beauty, rank among the most beautiful European alpine resorts. It is unique with its emerald-green lake, a church on the tiny island in the middle of the lake, and a medieval 11<sup>th</sup> Century castle perched off a cliff above the lake. The guided tour for the seminar attendees started with a boat ride to the island and a visit of the island's church with its famous wishing bell. Then a bus took the participants around the lake (with a tour in the Bled castle) and to the charming medieval town of Radovljica

where the tourists were introduced into the historical traditions and activities in the area. The social program was concluded by the Gala Dinner in one of the characteristic restaurants of Radovljica.

The papers presented at the 15<sup>th</sup> Seminar in Padua are published in the Seminar Proceedings and on the web ([www.wpi.edu/+CIMS/IMMG/Seminars](http://www.wpi.edu/+CIMS/IMMG/Seminars)).

For more information on this and previous seminars/workshops in computer modeling, contact the Seminar Founder and Chair, Vadim Yakovlev ([vadim@wpi.edu](mailto:vadim@wpi.edu)) or visit the IMMG web pages at [www.wpi.edu/+CIMS/IMMG/](http://www.wpi.edu/+CIMS/IMMG/).



Figure 3: On the Lake Bled's island.

## HIGH POWER MICROWAVE RESEARCH ACTIVITIES IN AUSTRALIA



**Dr. Nguyen Tran**  
Research Director  
Microwave Power  
Components  
Melbourne Victoria  
(Australia)

All researchers in the high power microwave fraternity of Australia are still active albeit two have gone past the retiring age.

The wide range of activities in Australia can be alphabetically summarised as follows:



Dr Graham Brodie from Melbourne University is currently working on:

1. Microwave weed control – in three separate but related projects.
2. Microwave pyrolysis of biosolids from the waste water industry
3. Microwave treatment of animal feeds

Mr David McClean from Advanced Microwave Technologies is currently involved in 4 projects.

1. Animal Stunning - The first commercial prototype has been installed in a Melbourne abattoir, awaiting final approvals from the appropriate authorities. Further development is expected once large-scale trials have been undertaken.
2. Tyre preheating of green tyres - The preheating will reduce time in the mould by 30% and energy consumption by approx. 20%. This project is currently being developed in Sri Lanka.
3. Development of a microwave cremation device, as much cleaner and faster option than traditional gas systems.
4. Completed the first industrial prototype on a microwave curing system for the manufacture of high volume cups in USA.

Professor Grigory Torgovnikov from Melbourne University, a perpetual supporter of AMPERE, has been working on improving the permeability of Norway spruce. This project has been in collaboration with the Swedish University of Agriculture since 2012 up to now. The microwave treatment of Norway spruce is for pulping purposes. The effect is energy savings in mechanical pulping. He has also

produced a couple of papers and attended a few conferences.

Dr Nguyen Tran from Microwave Power Components is pushing the boundary of high power microwaves towards higher frequencies:

1. Revisiting the exciting possibility of frequency doubling for the production of 5.8 GHz microwaves at a power level much greater than 1000 Watts based mostly on some Russian patents with the assistance of Professor Torgovnikov. Russian researchers claim that a conversion efficiency of at least 60% is possible.
2. Getting involved with high power millimetre waves (50GHz-60GHz) for the generation of few Watts power levels and cool plasma for cosmetic and medical applications. One prototype is currently on trial at a medical institute.
3. Microwave oil extraction at 12.75 GHz using a 15kW CW klystron. S-Team needs to design an auto-tuner for that frequency. Manual tuning seems too slow and antiquated to cope with chemical phase changes.
4. Popping corn kernels with focused microwaves. Popping is much faster than microwave ovens.
5. Helping a furniture company contain copious amount of leakage from a 30kW HF generator. High frequency leakage is not considered an issue in furniture `cooking.

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### EVENTS

#### **IMPI 49 Symposium**

June 16-18, 2015, Kona Kai Resort, San Diego, California, USA

The symposium will accept contributions in all areas of research, development, manufacture, engineering, specification and use of microwave and radio frequency energy systems for non-communication applications, including food technology, chemical and material processing, and new emerging technologies.

For more information please visit:

[http://impi.org/wp-content/uploads/2014/10/2015\\_Call\\_for\\_Papers\\_IMPI.pdf](http://impi.org/wp-content/uploads/2014/10/2015_Call_for_Papers_IMPI.pdf)

#### **PIERS 2015**

Top Hotel Praha,  
Prague, Czech Republic, July 6-9

Progress in Electromagnetics Research Symposium (PIERS) provides an international forum since 1989 for reporting progress and recent advances in the whole electromagnetic spectrum. Topics include radiation, propagation, diffraction, scattering, guidance, resonance, power, energy and force issues, and all other modern developments, with frequencies covering the entire electromagnetic wave spectrum (including microwave and lightwave, and beyond).

For more information please visit:

<http://piers.org/piers2015Prague/>

#### **AMPERE 2015**

**15<sup>th</sup> International Conference on Microwave and High Frequency Heating**  
Cracow, September 14 - 17, 2015.

The 15th International AMPERE conference on Microwave and High Frequency Heating will be staged at Krakow University of Technology, which is based at Krakow, Poland.

The conference will be held during 14-17 September 2015. As with previous conferences in the series the first day will be dedicated to staging short course(s). Details are published online in due course at [www.ampereurope.org](http://www.ampereurope.org)

For more information please visit:

<http://ampere.pk.edu.pl>

#### **Process Intensification for safe and sustainable process reindustrialization of Europe**

September 27th-October 1st  
Nice, France

EPIC5 provides an excellent opportunity for academics, industrialists and technology providers to present the latest developments on Process Intensification in the academic and industrial sphere and communicate their present views and vision for the future to the largest possible audience. For more information please visit: <http://www.ecce2015.eu/index.php/epic5>

#### **EPM 2015, 8<sup>th</sup> International Conference on Electromagnetic Processing of Materials** Cannes, October 14-16, 2015

The conference is open for any kind of materials processing involving electric or magnetic fields. It intends to bring together people from academic institutions, industry and related equipment manufacturers.

For more information please visit:

<http://epm2015.sciencesconf.org/>



## AN AFTERTHOUGHT: ADDING GRAPHENE TO A METAMATERIAL



**A. C. Metaxas**

AC Metaxas and Associates  
Cambridge, UK

In the Afterthought article in issue 76 of this Newsletter I described the wonder material graphene which is a form of carbon, one atom thick, arranged in a honeycomb structure and exhibits some remarkable properties such as its strength, being optically transparent and its good electrical conductivity. In the Afterthought article in issue 82 I described metamaterials which are materials that are not found in nature but engineered from microscopic particles of say plastics or metals arranged in a precise geometrical structure.

What happens if one adds graphene to a metamaterial? Xiaoyong He et al (2015) at the Dept of Physics, Mathematics and Science College at the Shanghai Normal University theoretically studied the electromagnetic properties of metal SiO<sub>2</sub> graphene (MSiO<sub>2</sub>G) structure. The studied structure consists as a cross section of a metal unit cell of 100nm thick silver wires followed by an SiO<sub>2</sub> layer of 10nm thick. Then comes a graphene layer of only 0.34 nm thick and finally the base which is made of a 2 mm thick polyimide. Because of the tenability of the Fermi level of graphene the resonance of the reflected or transmitted response can be tuned in a wide range. As the Fermi level of the graphene layer increases, the resonance of the MSiO<sub>2</sub>G structure become stronger, and the resonant dips of the transmission and reflection shift to the higher frequency resulting from the fact that the dielectric constant of graphene

$$\epsilon_g = 1 + \frac{\sigma_g}{\omega \epsilon_0 \Delta}$$

decreases in the near IR spectral range. In the above equation  $\Delta$  is the graphene layer thickness and  $s_g$  is its conductivity. Graphene is able to confine surface plasmons (these are waves travelling along an interface) across the interface between it and the metamaterial. Such studies aid the design of plasmonic devices as used in biomedical sensing and optical communications. Essentially graphene plasmonics is a platform for strong light-matter interactions. Further, it has recently been reported that graphene based electronics is emerging as a serious candidate for high performance semiconductor devices down to a single molecular scale, for example, using graphene nanoribbons having a width of 2 nm (Yen Chia Chen et al, 2015).

I have always found this kind of study extremely fascinating in that one can experiment with mixing/combining all sorts of different materials to produce structures that have unique properties in parts of the electromagnetic spectrum. As far as microwave heating is concerned the examples that readily spring to mind are the inclusion of carbon black to natural, SBR or EPDM rubbers to enhance their absorption and hence enhance their pre-treatment or the addition of magnetite (Fe<sub>3</sub>O<sub>4</sub>) to plaster moulds and core mixes or indeed urea in resin adhesives in the production of wooden laminates.

There is much scope for experimentation in this area.

### References

1. Xiaoyong He, Zhen-Yu Zhao, and Wangzhou Shi, Graphene-supported tunable near-IR metamaterials, *Optical Letters*, **40**(2), pp178-18. 2015



2. Yen Chia Chen, Tin Cao, Chen Chen, Zahra Pedramrazi, Danny Haberer, Dimas G de Oteyza, Felix R Fisher, Steven G Louie and Michael F Grommie, Molecular Bandgap Engineering of synthesized graphene nanoribbon heterojunctions, **Nature Nanotechnology**, **10**, pp156-160, 2015.

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**Readers are therefore advised to consult experts before acting on any information contained in this Newsletter**

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