AMPERE NEWSLETTER

A Newsletter devoted to RF and MW heating in the range 1MHz to 20 GHz ISSN 1361-8598

www.ampereeurope.org

ISSUE 64
March 2010

EDITORIAL

This issue is delighted to welcome Dr Chris Dodds from the NCIMP at Nottingham University who describes the visit of our President and Dr Veronesi to their centre. Some very focussed R&D is carried out at the NCIMP centre with the aim to effect technology transfer of some important industrial applications using microwave energy.

Dr Feher has recently published a book entitled Energy Efficient Microwave Systems which was reviewed by myself for the publishers. Here we reproduce this review with kind permission of Springer Verlag. In this issue also Dr Rudi Emmerich describes the involvement with microwave heating at the Fraunhofer Institute in Germany.

Finally, AMPERE is very proud to announce that the RAMPAaT workshop won the prestigious IEEE MTT-S IMS 2009 Award for the Highest Quality Workshop (see page 5).

Ricky Metaxas
Editor

CRISTINA LEONELLI AND PAOLO VERONESI VISIT UK NATIONAL CENTRE FOR INDUSTRIAL MICROWAVE PROCESSING (NCIMP)

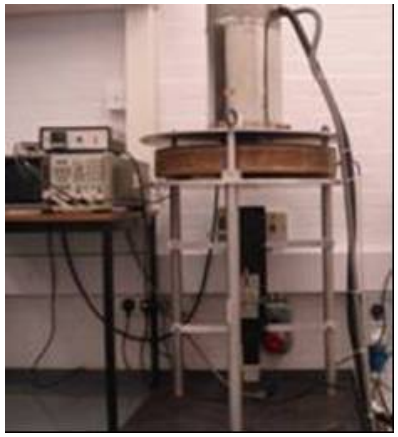
by Chris Dodds
NCIMP University of Nottingham, UK

Prof Cristina Leonelli and Dr Eng Paolo Veronesi from the Microwave Application Group at Modena and Reggio Emilia University, Italy recently visited Prof Sam Kingman and his team at The University of Nottingham.

The visit provided an opportunity to actual AMPERE President group to view the facilities at the NCIMP which include a range of dielectric property measurement techniques suitable for use across a range of frequencies and under conditions up to 1400oC, microwave systems with powers of 1-30 kW at 2.45 GHz.

They also discussed some of the recent application areas which the team at Nottingham have been working on which include microwave remediation of oil contaminated drill cuttings, and microwave exfoliation of vermiculite amongst others.

After viewing the research capabilities, some of which are pictured below, there was also an opportunity to discuss ways to foster closer links between European microwave processing research groups, some of which we hope to discuss in more detail with Ampere members in the near future.



High temperature cylindrical cavity perturbation technique for dielectric property measurements up to 1400°C

Microwave system for remediation of oil contaminated drill cuttings

Photo includes (from left) Dr George Dimitrakis, Prof. Sam Kingman, Dr Chris Dodds, Prof Cristina Leonelli, Dr. Eng. Paolo Veronesi behind a system for microwave exfoliation of vermiculite

BOOK REVIEW:
ENERGY EFFICIENT MICROWAVE SYSTEMS
BY LAMBERT FEHER

Lambert Feher
Head Industrial Microwave Technology
Forschungszentrum Karlsruhe

A new book is published by Spinger-Verlag authored by Dr Ing. Lambert Feher who is Head of the Industrial Power Technology at Institute of Pulsed Power and Microwave Technology, Forschungszentrum Karlsruhe, Germany. The book is entitled, "Energy Efficient Microwave Systems" and bears the subtitle "Materials, Processing Technologies for Avionic Mobility and Environmental Applications". Its ISBN number is 978-3-540-92121-9.

After a short chapter Dr Feher introduces the reader to the various microwave sources and points out that apart from the standard 915 and 2450 MHz frequencies using higher frequencies, say up to 30 GHz, can present certain advantages for particular applications. However, the book concludes that systems using these sources have yet to show distinct advantages of cost and homogeneity over their lower frequency counterparts as regards commercial or industrial applications.

In Chapter three the author navigates elegantly through the usual set of Maxwell equations and derives an equation for the absorbed power per unit volume in terms of the electric field and the effective conductivity. Having very briefly discussed the classical Debye relaxation of materials he puts forward a novel non-classical theory for the heating of water under microwaves, which at its heart has a quantum mechanical description. A matrix and its eigenfunctions determine the dipole character in quantum terms, while the energy eigenvalues for a rotation depend on the moment of inertia. The argument continues that in order to explain the heating of water in such a quantum treatise it necessitates the consideration of combining several single water molecules to form a compound by dynamically varying smallest droplets. The dissipation in terms of thermal energy is as a result of hydrogen bond interactions of the microwave induced rotating droplets and water molecular exchange in a Brownian-like motion.

Dr Feher proceeds to describe microwave transmission devices and microwave antennas and derives effortlessly well known relations for the power transmitted through radiating elements or slots using S-parameters and their corresponding normalized impedances. Expressions are also given for the offsets of these slots from the broad wall waveguide centerline. Some examples of S-parameters are given.

The final two chapters relate to work carried out by Dr Feher and his collaborators at the Institute on two fronts: microwave de-icing in avionic systems and the processing of

composite materials. Investigations at FZK revealed that 2.45 GHz was not suitable for de-icing and the attention was rapidly switched to frequencies in the range 22-40 GHz. Materials such as carbon or glass fibre reinforced plastics which replaced the traditional aluminum were tested in specially constructed cavities having introduced a layer of ice. After the onset of some melting the ice rapidly heated and was effectively removed from the substrate. Dr Feher then guides the reader through various arguments in relation to continuous de-icing system design for composite structures.

The book concludes with the HEPHAISTOS (High Electromagnetic Power Heating Automates Injected STructures Oven Design) for curing of carbon fibre reinforced plastics. The name is aptly chosen because as it is well known that HEPHAISTOS is the builder for the Greek Gods. In such a system the material is subjected to an initial heating and tempering phase, the injection of the resin, heating for curing and finally the cooling down phase. The specific energy consumption per curing cycle is far superior with microwaves and at present researchers are concentrating on tailored microwave processes following the availability of reliable high frequency systems. It is envisaged that this process will be adopted in the avionic industry within the next decade.

The strength of the book lies in the ease with which some complex arguments are navigated leading to equations that are used in subsequent chapters. I feel however, that this book will find a niche in specialised markets and in particular for those researchers that are concerned with the heating of composite materials with microwaves.

By Ricky Metaxas
St John's College Cambridge UK.

MICROWAVE PROCESSING AT THE FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY (ICT) PFINZTAL/GERMANY

by Rudi Emmerich
ICT Germany

At the ICT, a multidisciplinary research group has been working for more than 15 years in the field of processing with microwaves. Research and development work is focussed on thermal processing techniques involving microwaves and microwave-generated plasma-enhanced vapour deposition (PECVD). Work in the field of microwave and plasma technology extends far beyond the simple heating of dielectric materials and simple surface modification. Emphasis is placed on the homogenous and reproducible heating of dielectric materials and the special application of microwave-induced plasmas for coating. The development of these processes is closely linked with the development of new microwave introduction systems at the ICT, which can be used for heating or for plasma generation.

The research aim in the field of heating is to develop a controlled and reproducible thermal processing technique for polymers using microwaves. The starting point for this development is the measurement of the dielectric function of the materials according to temperature, at

245 GHz. On the basis of this data, the electromagnetic field of the microwave apparatus can be simulated using FEM software (COMSOL Femlab). The microwave applicator can be optimised and constructed according to this simulation. The final element of the work is process development.

In the field of PECVD the coating of polymers with a scratch-protection layer is the focus of work. The following paragraphs outline one case study drawn from each aspect of our work.

Case study for thermal processing techniques: *Curing polyester resins on demand – an innovative process for manufacturing large parts by flexible microwave heating*

Very large parts such as hulls or wings are of special interest because their production requires complex processes with large equipment. Vacuum-assisted resin infusion is state of the art for the manufacturing of large composite parts. These parts must be cured under very strict processing conditions in order to achieve reproducible polymerisation of the resin. The resin itself must have a low viscosity to ensure good impregnation, but also a high chemical reactivity to ensure sufficient curing, which is mostly a conflict of goals. As no appropriate and economical heating method is available, cold curing resin systems are generally used for very large composite parts.

The Fraunhofer ICT has developed a new and innovative processing technique based on microwave heating. The main idea of the new technique is the separation of the filling and impregnation of the part from the curing step. The resin is a hot curing system and is injected at low temperature. The curing is then initiated by microwaves. A new open and scaleable microwave system is developed for the homogenous and reproducible heating of large parts. The microwave system in combination with temperature-based control of the microwave power ensures a homogenous processing of the part. The microwave device itself is mounted on a robot (cf. fig.1) which scans the geometry of the part and cures the resin. The result is a large part - in this case study a boat hull - which is cured within hours instead of days. The quality of the part is expected to be superior as it has no remaining thermal stresses and has a higher degree of polymerisation than that achieved in conventional heating.

Case study for PECVD:

Microwave-generated plasmas excel in low-pressure applications because of high attainable plasma densities and low ion energies. They are highly compatible to polymer substrates and are therefore used to develop new functional surfaces, e.g., scratch resistance for automotive applications or coatings for solar cells.

In this paper we will present a microwave-generated plasma chemical vapour deposition (PCVD) process for scratch-resistant coatings on transparent plastics (polycarbonate).

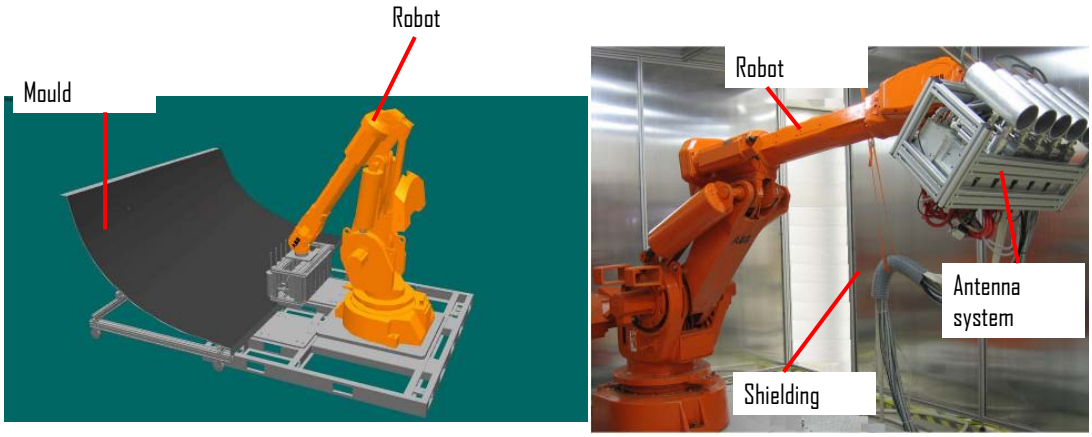


Figure 1: Microwave antenna system on a robot for curing large parts (simulation and set-up)

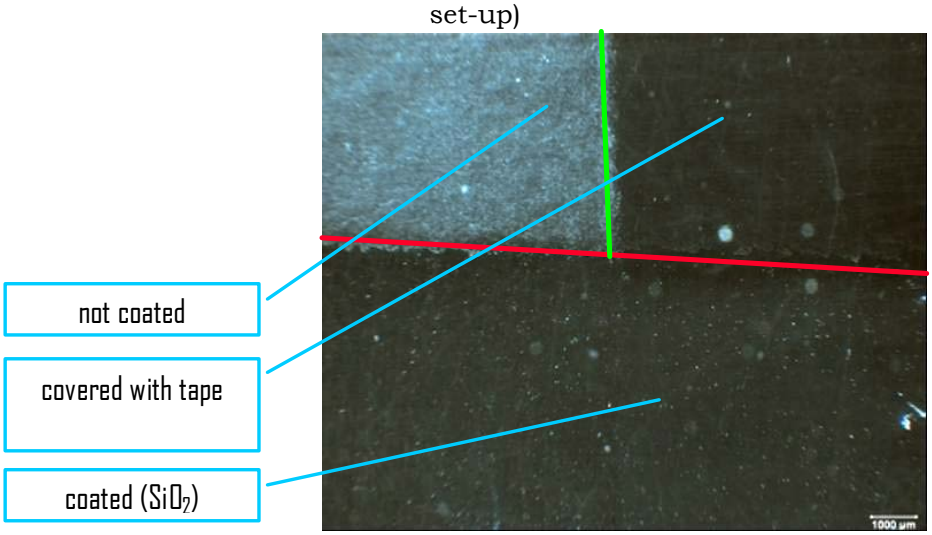


Figure 2: Comparison of coated and uncoated polycarbonate after a pebble test

The principle chemical reaction is given by:

$(CH_3)_3Si\text{-}O\text{-}Si(CH_3)_3$ (**g**) + n O_2 (**g**)+ plasma energy → SiO_2 (**s**) + y H_2O (**g**) + z CO_2 (**g**)

The vaporized siloxane (**g**aseous) reacts with the oxygen (**g**aseous) under plasma energy to form quartz (**s**olid), gaseous water and carbon dioxide (**g**aseous). The quartz is deposited on the polycarbonate substrate.

Using scalable plasma sources, e.g. an array of Duoplasmalines®, the process is applicable to large parts such as windshields.

With such an array of 8 lines, a high rate of about 3 µm/min was achieved for the deposition of SiO_x- coatings on polycarbonate. They are highly transparent (98%) and clear (1% haze). This procedure is an environmentally-friendly alternative to the lacquering of plastics.

The coating has been demonstrated for example in a pebble test (fig.2). It can clearly be seen that the coating protects the polycarbonate from scratching.

NEWS

RAMPANT WORKSHOP WINS PRESTIGIOUS IMS 2009 AWARD

The Workshop entitled, "***Recent Advances in Microwave Power Applications and Techniques*** (RAMPAnT)" which was held as a part of the International Microwave Symposium (IMS) in Boston, MA on June 12, 2009 won the IEEE MTT-S IMS 2009 Award for the Highest Quality Workshop.

This event was initiated, proposed and organized by Malgorzata Celuch of Warsaw University of Technology and Vadim Yakovlev of Worcester Polytechnic Institute.

The full-day workshop program featured 10 extended talks that were given by Paolo Veronesi, University of Modena and Reggio Emilia; Aly E. Fathy, University of Tennessee; Sébastien Vaucher, EMPA; Wojciech Gwarek, Warsaw University of Technology; José Catalá-Civera, Technical University of Valencia, Monika Willert-Porada, University of Bayreuth; Matthias Graf, Fraunhofer Institute for Chemical Technology; Vadim Yakovlev, Worcester Polytechnic Institute; Yoshio Nikawa, Kokushikan University; and Lambert Feher, Forschungszentrum. In their statement, the IEEE MTT-S IMS 2009 Technical Program Committee emphasized that all 19 IMS Workshops were evaluated against a number of criteria including the feedback from the workshop attendees.

Congratulating the organizers, speakers and participants of the RAMPAnT Workshop with this remarkable recognition, AMPERE considers this Award as an encouraging sign indicating that IEEE's Microwave Theory and Techniques Society finds the initiative of bringing the area of microwave power engineering to the group of regular IMS technical disciplines definitely worthy and the initial steps in implementation of this initiative highly successful.

AMPERE is proud to see many its members involved in this project and hopes that this growing interaction with IEEE, the world's largest professional association, will be really fruitful and stimulating for the entire microwave power community. Detailed RAMPAnT Workshop Program can be seen at:

http://www.ims2009.org/workshop_descrip.htm

Complete Workshop description including speakers abstracts are available at:

http://www.ims2009.org/pdfs/workshop/WFA/WFC.pdf

EVENTS

IMPI SHORT COURSE

April 22 & 23, 2010 in Minneapolis MN.

Topic: "*Developing Microwavable Products for Quality and Safety*"

The three instructors are Peter Peshek (General Mills), Bob Schiffmann (R.F. Schiffmann Associates, Inc.) and David Baron (Safety Consultant).

For more information:
http://www.impi.org

ACES 2010

26th International Review of Progress in Applied Computational Electromagnetics, Tampere Finland, 25-29 April 2010

For more information visit:
<http://aces.ee.olemiss.edu/conference.php

HES-10: HEATING BY ELECTROMAGNETIC SOURCES

Induction, Dielectric, Conduction & EMP
Padua, May 19-21, 2010
www.die.unipd.it/dipartimento/eventi/hes10
Universita' degli Studi di Padova
Dipartimento di Ingegneria Elettrica
Secretariat of HES-07
Via Gradenigo, 6/a
35131 - PADOVA (Italy)
tel. +39-049-827.7591/.7708/.7506 fax. +39-049-827.7599
e-mail: hes10@die.unipd.it

PIERS 2010

27th Progress in Electromagnetics Research Symposium (PIERS)
5-8 July, 2010 Cambridge USA.

For more information on this and other PIERS venues visit:
http://piers.mit.edu/piers/

IMPI SYMPOSIUM

44rth Annual Microwave Power Symposium
14-16 July, 2010
Curtis Hotel, Denver Colorado, USA
Phone: +1 (804) 559-6667
Fax: +1 (804) 559-4087
info@impi.org

IDS 2010

17th International Drying Symposium, 3-6 October 2010, Magdeburg, Germany.

Deadline for abstract submission: January 18, 2010

For more details contact:
www.ids2010.de or
Sabine Urbanczyk
DECHEMA e.V.
Forschungsförderung und Tagungen/ Research Management and Conferences
Theodor-Heuss-Allee 25
60486 Frankfurt am Main/Germany
http://www.dechema.de
Tel.: +49-69-7564-295
Fax: +49-69-7564-176
Email: urbanczyk@dechema.de

WORKSHOP ON MICROWAVE & WASTE TREATMENTS

To be held as part of the *Hazardous of Industrial Waste Management* (HIWM) Conference
Chania, Crete, Greece, Oct 5-8, 2010
Visit http://www.hwm1.tuc.gr for more information

MICROWAVE/FLOW CHEMISTRY CONFERENCE 2011

Sharm el Sheikh, Egypt, Feb 25-28, 2011.
C. Oliver Kappe
Chairman
Zing Conference on Microwave and Flow Chemistry 2011
Sharm el Sheikh, Egypt,
February 25-28, 2011
www.maos.net
<http://www.maos.net/

13TH INTERNATIONAL AMPERE CONFERENCE 2011

Microwave and High Frequency Heating, September 2011
Toulouse, ENSEEIHT, France

The Management Committee of AMPERE is pleased to announce that the13th International AMPERE conference on Microwave and High Frequency Heating will be staged in Toulouse during Monday 5 to Thursday 8 September 2011.

The conference will be held at the Ecole National Superieure d'Electrotechnique, d'Electronique, d'Informatique, d'Hydraulique, et des Telecommunications

For details contact:
Prof Jun-Wu Tao
ENSEEIHT
2, rue Charles CAMICHEL
B.P. 7122
31071 TOULOUSE Cedex 7
FRANCE
Telephone: +(33) 361388499;
Email: tao@laplace.univ.tlse.fr

or visit www.ampereeurope.org

GCMEA 2012 MAJIC 2st

Global Congress on Microwave Energy Applications
Long Beach California USA
Organised by Microwave Working Group
International Committee Chairperson
B Krieger Cober Electronics USA
http://wwwjemea.org./majic2012/

The information contained in this Newsletter is given for the benefit of AMPERE members

All contributions are believed to be correct at the time of printing and AMPERE accepts no responsibility for any damage or liability that may result from information contained in this publication

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

Association of Microwave Power in Europe for Research and Education (AMPERE Europe)