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A Low-Cost Robust Configuration for the Temperature Monitoring within the Payload of any Microwave Oven with a Rotating Turntable

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Abstract. This contribution aims to be a reference to help researchers build up their own microwave heating systems for monitoring the temperature evolution of a payload with almost endlessly (limited by the batteries capacity of the measuring system) rotational movements. Its robustness is because it allows keeping sensors in place thus avoiding the fiber optics wringing/twisting while the payload is rotating. The proposed system facilitates the rotation of the temperature equipment located over the microwave oven synchronously with the payload, while its data is transferred in real time by an RF transmitter/receiver device connected to its serial data port. The fiber optic sensors deployed from the temperature equipment ports to the measuring points are arranged with the rotation axis through a hollowed shaft to minimize mechanical stresses. The equipment operation, its configuration, and the data transmissions are controlled wirelessly by a laptop computer. The prototype presented in this paper was implemented for a total budget amount of 6500€.

Keywords: microwave heating, temperature, turntable, fiber optic wringing/twisting

1 Introduction

The knowledge of the temperature evolution of a payload inside a microwave cavity while being irradiated is of interest to scientists and engineers. It can help in the optimization of thermal processing, as is tuning up microwave assemblies to improve heating uniformity, or the management of power profiles for the speed and efficiency.

When monitoring the temperature at some measuring points within a payload being heated inside a microwave oven, fiber optic sensors allow a proper performance without affecting its measurements, since their presence does not interfere with the EMF confined within the cavity due to its dielectric characteristics (low permittivity and loss factor values).

These sensors are typically thin enough to get them through the ventilation holes of the cavity and then inserted into the payload at the monitoring positions; this is the basic measurement configuration. Nevertheless, under a dynamic system where the payload is moving during the irradiation, as in domestic microwave ovens, which typically have a rotating turntable to increase the heating homogeneity, the probes will be shifted and they might be disengaged from their expected measuring points.

So, the first challenge for this kind of experimental setup is to keep the sensors in place while the payload is rotating. This is achieved by designing a robust setup where sensor positioners are able to neutralize the low mechanical forces caused by the rotating payload. The second challenge is to avoid sensor damage due to the wringing of a single fiber or twisting a bunch fiber together if attached to a fixed measuring equipment outside the cavity. This means that the experimental configuration is highly sensitive to the number of the monitoring points, their special distribution and the number of turns that the test must undergo.

In [1] an experimental study on the batch microwave heating of liquids waspresented, where 3 fiber optic sensors were used simultaneously for measuring the temperature evolution every $t_{sampling} \approx 10$s within the liquids at different locations inside a microwave cavity of 279.4 x 393.7 x 425.5 mm^3 manufactured by Cober Electronics. Its rigid measurement set-up did not allow the activation of the turntable rotation but the electromagnetic stirrer of the designed microwave oven.

In [2] the microwave heating in a domestic ovens was analyzed, using 4 fiber optic sensors with a sampling rate of $t_{sampling} \approx 2$ s over a duration $\Delta t = 30$ s in a 700 W rated power microwave oven (629 W available power measured accordingly to

IEC 60705) with a cavity of 420 x 395 x 253 mm^3 manufactured by Sharp.

In [3] 8 fiber optic sensors were used simultaneously on every experiment lasting $\Delta t = 360$ s, with a sampling rate around $t_{sampling} = 0.5$ s.

In [4] a microwave oven with a cavity 270 x 270 x 185 mm^3 was used at 600W of nominal power, to heat its contents on a turntable rotating at 5 rpm during $\Delta t = 150$ s. Records for 5 measuring points inside the sample with a sampling rate around $t_{sampling} \approx 7.5$ s are given, and the difficulty of keeping the optical probe sensor in place while the turntable was rotating was emphasized.

In [5, 6] a 1200W domestic microwave oven was used with a rotating turntable to validate its results by monitoring 6 measuring points during 4 and 6 minutes respectively using optical fiber sensors.

In [7] a single optical fiber sensor monitored the heating of a payload inside a microwave cavity with a turntable rotating at 5 rpm during $\Delta t = 30$s with a sampling rate of $t_{sampling} \approx 2$s. The fiber was introduced into the cavity through a hole at the turntable rotation axis center and a cut-off waveguide.

In [8, 9] two liters of deionized water were heated inside a microwave oven at different power levels within the range [600, 1000] W, until detecting a temperature of 50°C at any of their monitoring points with a sampling rate of $t_{sampling} = 1$s. Although in [8] a single temperature fiber optic was used, in contrast in [9] 4 fiber optic were used simultaneously. Both articles indicate that the cavity was a multimode one, but they do not mention if the microwave oven had a mode stirrer or a turntable.

In [10] i a setup was described for heating a sliced potato on a turntable rotating at 10 rpm inside a microwave oven at 300 W of effective power. Each test lasted $\Delta t = 12$s, which is two complete spins for the turntable. Meanwhile, two fiber optics monitored the temperature inside the potato with a sampling rate of $t_{sampling} = 1$s.

In [11] a setup was described using a 920 W rated microwave oven with a turntable spinning at 6 rpm. A single optical fiber was introduced inside to monitor the temperature within a potato slab for $\Delta t = 35$s.

2 Methods

The configuration schema is depicted in Figure.1. It is remarkable that the motor gear of the microwave oven, which forces the rotational movement of the internal turntable, is extracted and placed outside to be used to spin an external turntable simultaneously through a set of shafts, cogwheels and belt wheels.

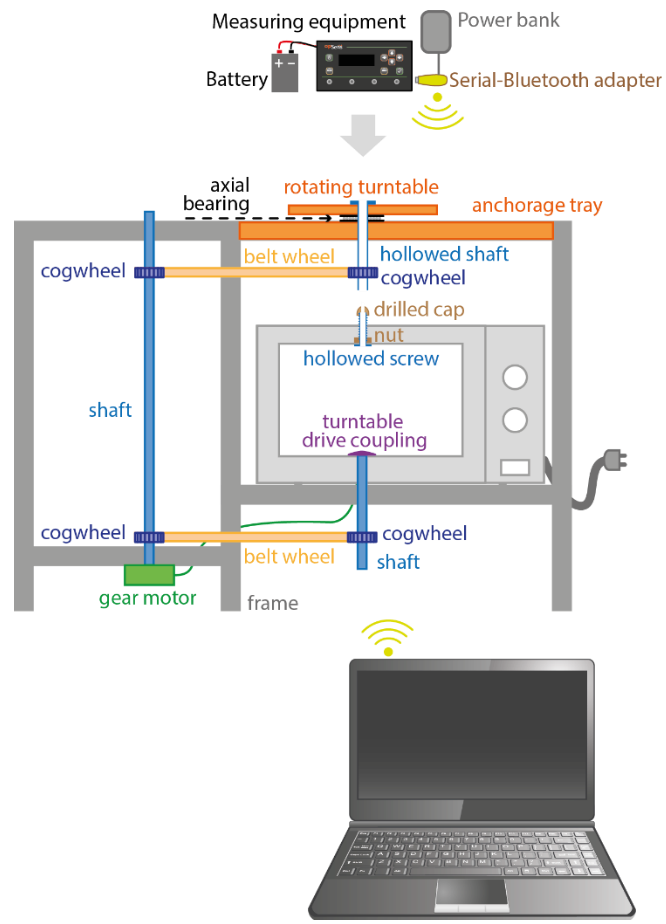

Figure 1: Schematic of the rotating monitoring setup.

The prototype was assembled using a domestic microwave oven model Samsung M1711N with a rated power of 800W, and an OpSens TempSens signal conditioner with 4 optical fiber temperature sensors as the temperature monitoring subsystem. The Figure 2 shows the implemented configuration based on the schema introduced in Figure1.

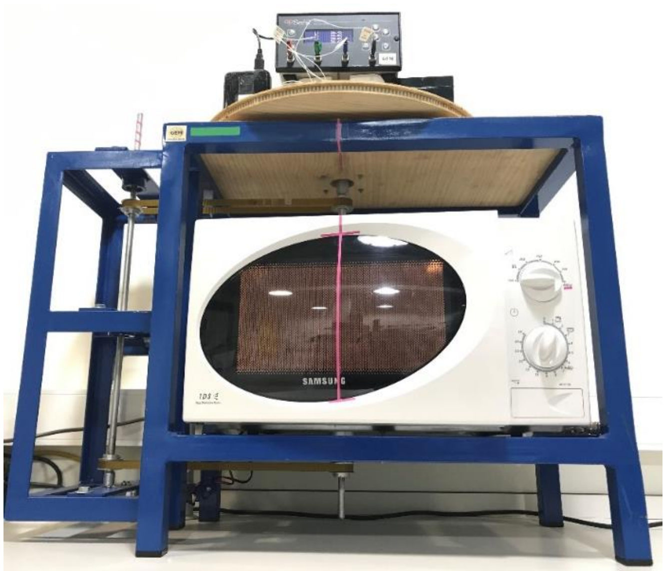

Figure 2: Prototype implemented with an 800 W power rated Samsung M1711N microwave oven and an OpSens TempSens signal conditioner with 4 optical fiber temperature sensors.

The external turntable was linked to a tray anchored to the frame through an axial bearing. This bearing allows a rotational movement with a hole in its center, where the optical fibers could transit. The fibers were introduced inside the microwave cavity through a small hole of 5 mm diameter, which is less than 1/24 of the wavelength in free space at 2.45 GHz, and less than 1/14 of the wavelength considering a dielectric constant of 3 (estimation for the fiber optic material). In the situation where a larger number of fibers is needed, a wider hole would be necessary. To avoid any microwave energy leakage a circular cut-off section has to be attached to the hole by filtering any electromagnetic mode that could propagate outwards.

Two different payload materials were considered for testing the setup: liquid deionized water (type II), and its version as a thickened form by using Agar-Agar as a gelling agent in a proportion of 4g per liter (Figure 3). The Agar-Agar used (Vahiné, a trade mark from McCormick & Company Inc.) was acquired from a local supermarket. The purpose of considering the gelled water was to study qualitatively the effect of the convective flows on the temperature evolution.

Figure 4 shows the locations of the 4 measuring points used to monitor the temperature evolution simultaneously. A lid made of Expanded Polyethylene (EPE) foam was used as the XY-plane probe positioner, while a little mark painted on the fiber optic was used as the reference to insert them into the payload at the appropriate depth.

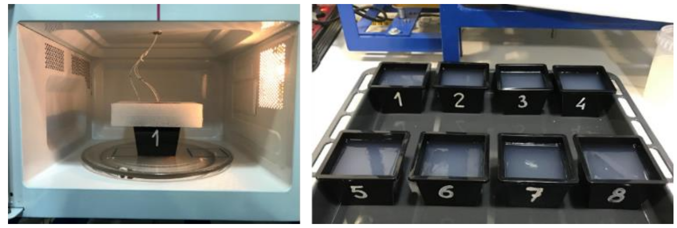

Figure 3: Microwave loaded with a sample with all the monitoring sensors arranged (left) and several samples of 4g Agar-Agar per liter of deionized water (right).

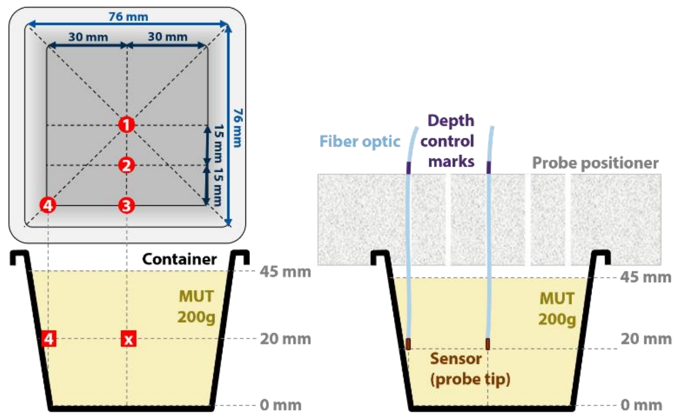

Figure 4: Probe positioner and measuring point locations.

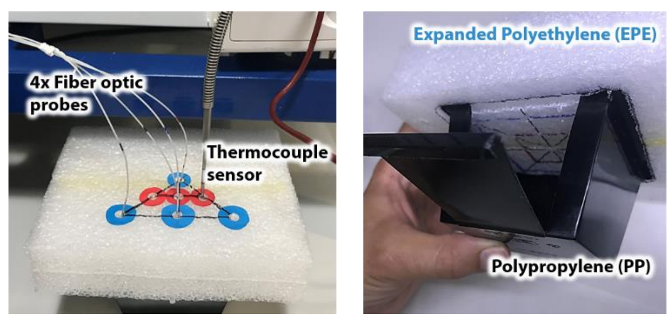

Figure 5: Detail of the lid used as the probe positioner. Thermocouple sensor was used to verify the initial temperature of the payload.

The samples were resting for several hours at room temperature before the tests. Considering that all the fiber optic sensors within the sample at the initial state should detect the same temperature, any offset deviation had to be compensated using a temperature reference. A thermocouple sensor was used to provide the temperature reference as shown in Figure 5. It was assumed that the optical probes had a linear and non-hysteresis response.

3 Results

The left part in the Figure 6 shows the raw temperature measurements of a tested sample, where it is noticeable that each sensor was reporting different initial temperatures before the irradiation. The right part of the figure shows the traces after applying the adequate compensation for each probe.

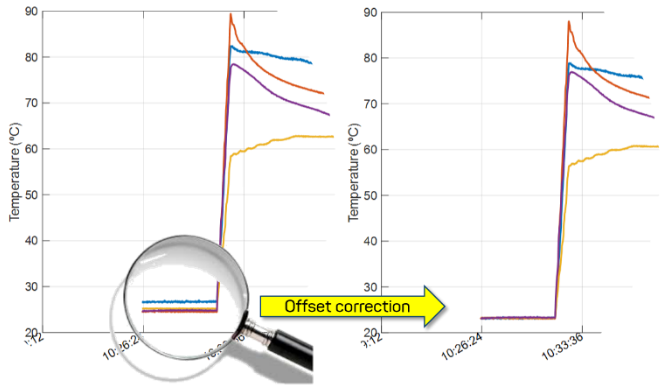

Figure 6: Fiber optics readings before (raw data) and after the offset correction.

Figures 7 and 8 compare the temperature evolution for two similar dielectric materials, deionized water and a solution of 4 g agar-agar per liter of deionized water, but with a different physical state, liquid and gelled respectively. While in Figure 7 the irradiation has been performed continuously during 1 minute at the maximum power rate available for the microwave oven (800W), in Figure 8 the response corresponds to the pulsated irradiation at a medium power rate (450W). Their heating slopes differences are emphasized in Figure 9.

4 Discussion

The comparison between liquid and gelled water shown in Figure 7 emphasizes the thermodynamic response effect due to convective flows.

During the tests, it became apparent that condensation of the water vapor occurred at the EPE lid, as it would happen with any obstacle interrupting the natural ascending vapor flow. For that reason, it was noticeable the heating of the lid at its bottom side due to the presence of water. Therefore, the evaporation (mass transfer) plays an extra role and should be considered in a study of the heat transfer of the system if a more accurate evaluation of the measurement is sought.

The ripples that are shown in Figure 8 are a consequence of the pulsated irradiation with a nominal duty cycle of 56.25% (450 W / 800 W).

Researchers must choose the appropriate fiber optic probes that are going to be exposed to microwaves, taking into account the expected temperatures they must withstand. Some manufacturers claim that their sensors are immune to electromagnetic fields. But there might be some missing information about the protective material on the sensitive tip of the probes, which could be covered with materials sensitive to absorb microwave energy due to their dielectric losses (i.e. polymer resins as epoxy, which has a complex dielectric constant of $\varepsilon_r^* = 3.5 - j0.21$ at 2.45 GHz, measurement published in [11]). So they might introduce sensing inaccuracies and their life span could be even shortened at some point.

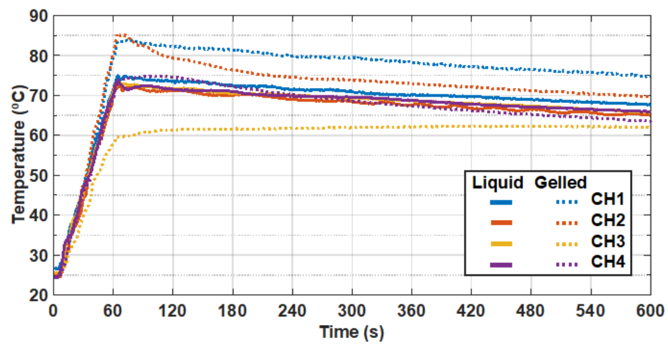

Figure 7: Payload temperature evolution comparison for 200g of deionized water in their liquid and gelled (4g Agar-Agar per liter of DI-water) versions at 4 measurement points during its continuous microwave irradiation (800W rated power) for 1 minute, and posterior resting while cooling down.

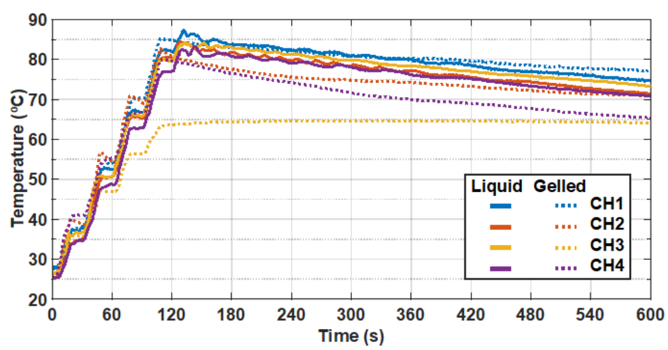

Figure 8: Payload temperature evolution comparison for 200 g of deionized water in their liquid and gelled (4 g Agar-Agar per liter of DI-water) versions at 4 measurement points during its pulsated microwave irradiation (450 W rated power) for 2 minutes, and posterior resting while cooling down.

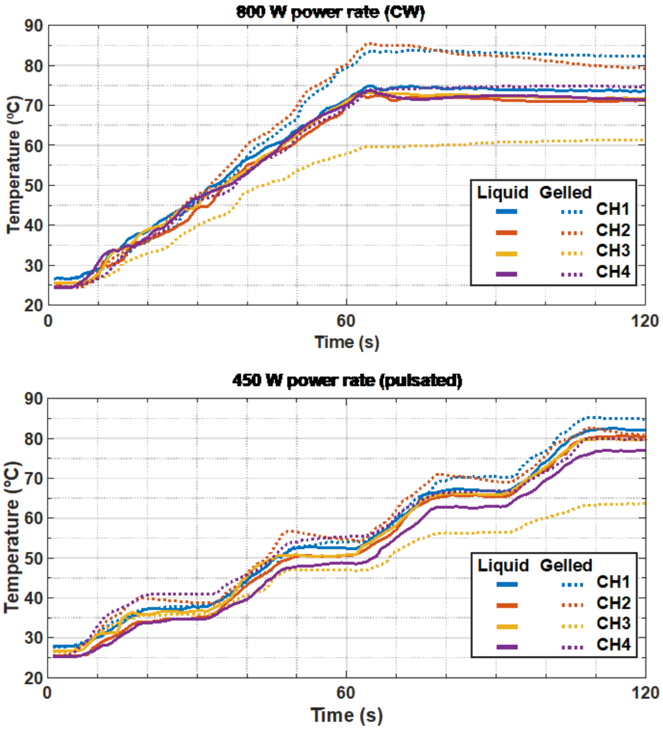

Figure 9: Heating slopes detail for the 800 W (continuous wave) and 450 W (pulsated) power rates.

It is also important to design robust holders that could keep probes in their expected locations during the test. When the payload is not solid, it might be helpful to consider coating the fiber optic probes with thin tubes made of a mechanically robust material, although one ought to leave the tip bare in contact with the payload. In favor of reducing the measurement uncertainties, the coating material should have a low loss factor (to avoid being self-heated when exposed to the microwaves) and a dielectric constant similar to the payload to minimize the interference (reflections due to impedance mismatching) with the electromagnetic fields. Moreover, to preserve the original thermodynamics, the coating material should have a similar thermal conductivity as the payload had.

Another setup strategy for the continuous monitoring of the temperature in the payload on a rotating turntable could be to ensure that the motor can rotate back and forth. By using suitable electronics, the number of turns in one direction could be compensated by forcing the same number of turns in the counter direction, so the fiber optics are acceptably twisted and untwisted continuously. Nevertheless, this strategy could introduce some artificial effects when trying to evaluate the normal operation of a commercial microwave oven dueto the introduction of (de)acceleration forces that might shake the payload, especially when it is a liquid.

Acknowledgements

This contribution was presented at the 17th International Conference on Microwave and High Frequency Heating (AMPERE2019) held in Valencia (Spain), 9-12 September, 2019. Authors wish to thank Ms. Marilena Radoiu and Mr. Robbert Schiffmann for their valuable comments. Authors would like to extend the gratitude to Mr. Juan Antonio Albaladejo-López for his help with the mechanical development of the set up.

For further reading

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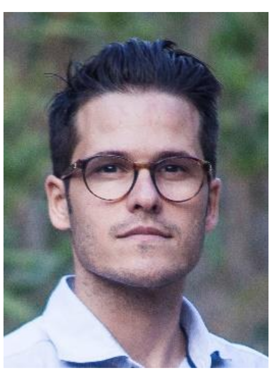
About the authors

José Fayos-Fernandez is an Associate Professor in the area of Signal Theory and Communications with the Universidad Politécnica de Cartagena (UPCT), where he joined in 2004. He received his PhD from UPCT in 2009, and an MSc in Telecommunication Engineering from Universidad Politécnica de Valencia in 2001. He has been enrolled with the Idaho State University (Pocatello, United States) in 2001, the IT'IS Foundation (Zurich, Switzerland) in 2006 and the Centro Tecnológico del Mármol, Piedra y Materiales (Cehegín, Spain) in 2013. His research concerns topics in metrology & experimental setup design, process optimization, electromagnetic (EM) material characterization, EM dosimetry and high power microwave applications. He is the investigator-in-charge of the R&D group Electromagnetismo y Materia (GEM) at UPCT since 2016, and he is also the current AMPERE General Secretary for the 2019-2021 biennium.



Juan David Reverte-Ors was born in 1982, in Cartagena (Spain). He received his MSc in Telecommunication Engineering from the Universidad Politécnica de Cartagena (UPCT) in 2009. He holds a Master in Business Administration by the Instituto Técnico de Estudios Aplicados (Spain) since 2011. He is registered with the Grupo Electromagnetismo y Materia (GEM) as a PhD student of the UPCT developing innovative applications using the microwave technology. He is the Manager of the Telecommunication Engineering professional association for the Region of Murcia (Spain) since October 2011.

Juan Monzó-Cabrera is Full Professor at the Universidad Politécnica de Cartagena (UPCT) related to telecommunication studies. He has worked as the Director of Transfer of Research Results Office and co-director of the Entrepreneurship Office at this university. He has also acted as the General Secretary for AMPERE EUROPE, as a member of the management committee of this association and as General Director of Research and Universities at the Regional Goverment of Región de Murcia.

He is part of the research group of Electromagnetism and Matter in the UPCT, activity that has combined with innovation and technology transfer.

Among other publications, he is co-author of 43 international publications in specialized scientific journals, as well as co-inventor of 11 patents. He has been a researcher in 23 projects with private financing and in 21 projects with public funding, three of them with European funds.

His research areas are related to microwave heating and drying, permittivity measurements, waveguide calibration procedures, electromagnetic compatibility and dosimetry and microwave oven design.

Report of the 17th AMPERE conference

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The 17th International Conference on Microwave and High Frequency Heating (AMPERE 2019) was held at the Polytechnic City of Innovation of Universidad Politécnica de Valencia (UPV), Valencia, Spain, during 9-12 of September 2017 and run under the auspices of the Rector, Professor Francisco Mora. This was the second time that Valencia held an AMPERE conference after the successful AMPERE 1999 conference chaired by Prof. Elías de los Reyes.

Twenty years later, the 17th AMPERE 2019 conference hosted again in Valencia more than 230 participants from 32 countries and 4 continents. Around 190 high-quality contributions including oral, posters, plenary and keynote talks, industrial exhibits and student competitions were presented during the event.

The program included 11 high-quality plenary lectures and keynotes in very interesting topics covering reaction engineering, non-thermal microwave effects, industrial radio-frequency and microwave heating discussion, plasma sources, microwave-assisted diamond synthesis, industrial microwave plants, applications in aerospace composite manufacturing, linear accelerators or microwave-assisted manufacturing of advanced ceramic products.

The rest of topics covered usual fields such as: microwave interaction with matter, experimental methods, industrial, medical and biological applications, permittivity measurements, microwave processing of composites, electromagnetic modelling and numerical techniques, microwave chemistry, monitoring techniques, plasma induced by microwaves, design of microwave applicators, hybrid heating processes, solid state applicators and food processing among others. I was really impressed by the high scientific and technologic level of the presentations and poster sessions, indicating a very important work carried out both at the local organization and the scientific and steering committees.

Prior to the conference, around 50 young scientists and Ph.D. students enjoyed a great opportunity to learn microwave-heating foundations and EM modelling techniques and strategies, since on September 9, 2019, the local committee organized a short course and a workshop covering both topics.

The short course is a traditional event in AMPERE conferences in order to show the young participants the foundations of microwave and RF heating systems, technologies, and applications and industrial processes.

The short course consisted of five talks by academic experts in a classroom-like format (see Figure 1). The workshop included hands-on sessions and experimental verifications allowing the participants to work (under the supervision of the instructors) with simple models, run simulations and interpret their results, showing thus a general overview of capabilities of contemporary computational tools applicable to typical scenarios in microwave-heating technology.

Figure 1: "Principles of microwave-heating technology" session during the short course

The conference began on Monday, September 9, 2019 with the opening of registration and welcome reception, which offered nice drinks, tapas and live jazz music at the innovation city building terrace.

The conference was officially opened, however, on Tuesday, September 10, 2019 by the previous President of AMPERE, Professor Cristina Leonelli, the Chairman of AMPERE 2019 Conference, Professor José Manuel Catalá-Civera and the Rector of UPV, Professor Francisco Mora, (see Figure 2) who addressed the welcome of the AMPERE and University to all the participants, exhibitors, and accompanying persons.

Figure 2: Opening Ceremony for AMPERE 2019 with Professors Cristina Leonelli, José Manuel Catalá-Civera and Francisco Mora, Rector of UPV.

The AMPERE Management Committee worked during the conference, and as usual, the meetings took place during lunches (see Figure 3) while the AMPERE Ordinary General Assembly (OGA) was scheduled just after the last Technical Session.

Figure 3: Meeting of the management committee during lunch break

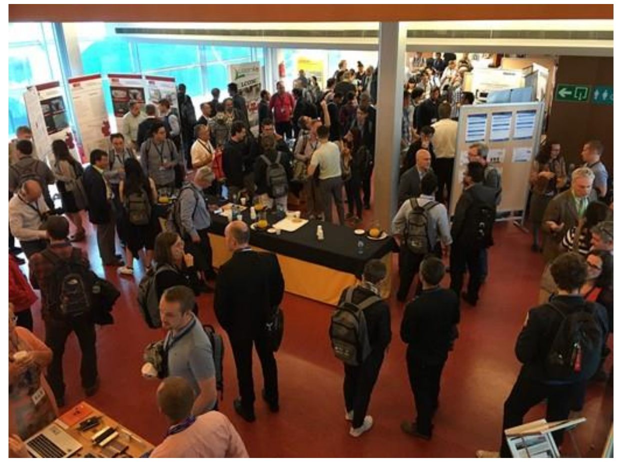

Figure 4: Industrial exhibitor room during a coffee break

During the conference, twelve exhibitors had open stands to present their new devices, equipments, instruments and solutions. The firms that sponsored the conference were Muegge, Sairem, Fricke und Mallah, S-Team, Wattsine, Q-WED, MKS, Leanfa, Püschner, HBH, Richardson Electronics and Pink RF. A great affluence of people and a close firms-attendees interaction were detected during the event (see Figure 4).

Figure 5: Attendees at the Brassa de Mar restaurant.

At the end of each day, the conference participants were invited to free dinners at different locations of the city. On Tuesday, participants were driven to Brassa de Mar restaurant next to the Beach with a lounge terrace on which a stormy weather could not spoil the high-quality food, refreshing drinks and good mood (see Figure 5). On Wednesday, everyone was invited to taste the best ingredients of the traditional Spanish cuisine and to enjoy the beautiful atmosphere and unique scenario of the Mercaders Palace. A flamenco show cheered up dinner as shown in the photo below.

Figure 6: Flamenco Show at the Mercaders Palace

The Ordinary General Assembly (OGA) of AMPERE was held on Thursday 12 and AMPERE members decided to reduce the management committee to improve decision-making and the agility of the association and the necessary changes in the bylaws. Also, the assembly elected the new president of AMPERE, Professor Georgios Dimitris to face the next challenges of our organization, thus succeeding Professor Cristina Leonelli who has so brilliantly presided over it in recent years. I would like to use these lines to thank Professor Leonelli and the former members of the management committee for their selfless work and to wish the best to Prof. Dimitrakis for the future.

Figure 7: Attendees enjoying the Gala Dinner menu

The conference was spectacularly finished with the Gala Dinner, which was held at the Oceans Restaurant in the Oceanogràfic of Valencia, the biggest aquarium of Europe faithfully reproducing the most important marine ecosystems, where attendees enjoyed a great varied choice of fish, meat and products of the Mediterranean cooking tradition (see Figures 7 and 8).

Figure 8: Attendants following the awards ceremony during the Gala Dinner

The Gala Dinner had the perfect atmosphere for the delivery of the different awards of the association. Thus, the prizes to the best article presented by a student, the best posters, the prestigious "Ricky Metaxas Young Researcher Award" and the AMPERE association medals were awarded during the coffee time.

José Daniel Gutiérrez, from Institute of Information and Communication Technologies (ITACA) of UPV, received the young researcher award. The AMPERE MEDAL 2019 was awarded to both Dr. Marilena Radoiu founder of Microwave Technologies Consulting (MTC), and Mr. Bob Schiffmann, the President of IMPI and R.F. Schiffmann Associates (see Figure 9). Both of them have been very active in a great number of research, industrial and security topics concerning the use of RF/Microwaves. Everyone at the gala dinner agreed that they were prominent personalities with a long and meritorious journey in the field of microwave heating and a history of collaboration with AMPERE beyond any doubt.

Figure 9: Dr. Marilena Radoiu and Mr. Bob Shiffmann receiving the AMPERE medals

Professor Georgios Dimitrakis, from University of Nottingham, acted for the first time as the president of AMPERE Association (see Figure 10) and helped to conduct the award ceremony together with Prof. Ricky Metaxas and José Manuel Catalá-Civera. The new President expressed special thanks to Professor José Manuel Catalá-Civera and co-chairman Prof. Felipe Peñaranda-Foix, and their research team for their continuous effort and excellent organization, stressing that the conference was a great success and very well received among all the delegates in attendance.

The President concluded with an invitation to the 18th AMPERE conference (AMPERE 2021) to be held in Gothenburg, September 2021.

For those ones wishing more information about AMPERE 2019 conference they can read both the 305 pages of the Conference Book of Abstracts that was printed in paper version or the 525 pages contained in The Proceedings of 17th International Conference on Microwave and High Frequency Heating (AMPERE 2019), with ISBN 978-84-9048-719-8, which was electronically delivered in a pen-drive.

In the personal side, AMPERE 2019 was a very important event for me, not only due to de fact that AMPERE conferences have become one of the most significant scientific and technologic events in the field of microwave and RF heating, but also because I had just returned to my University after almost four years outside the academic life. Of course, it was also a great opportunity to meet with great scientists in this field and with old friends working in similar problems as the ones I face myself in my daily routine.

Figure 10: The new president of AMPERE Association: Professor Georgios Dimitrakis

I would like to finish this conference summary with congratulations to Prof. Catalá-Civera, Prof. Peñaranda-Foix and their collaborators for their wonderful work organizing this extraordinary conference, that has yielded excellent scientific contributions, brilliant networking, fantastic social activities and a committed and efficient local organizing team. Well done, hopefully we will meet again in Gothenburg during AMPERE 2021 conference.

About the author

Juan Monzó-Cabrera is Full Professor at the Universidad Politécnica de Cartagena (UPCT) related to telecommunication studies.

A more detailed CV is given on Page 6.

Highlight of Summer School in High Energy Processing Ultrasound & Microwave Technologies 2019 in Cracow, Poland

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The **fifth Summer School in High Energy Processing Ultrasound & Microwave Technologies** was held from June 26th- 28th, 2019 at the Cracow University of Technology (CUT), Kraków, Poland, under the local chairmanship of Prof. Dariusz Bogdal. The event was co-organized and co-sponsored by the European Society of Sonochemistry (ESS) and the Association of Microwave Power in Europe for Research and Education (AMPERE). It was the second time when Cracow University of Technology had the honor to host and organize the **Summer School in High Energy Processing Ultrasound & Microwave Technologies**.

Figure 1: Group photo of Summer School attendants at the Faculty of Chemical Engineering and Technology building

The previous workshop and meeting was organized in September 9th-12th, 2015. This year the same, young organizing committee including Ph.D. W. Kasprzyk, Prof. K. Matras-Postolek, M.Sc. Filip Koper, M.Sc. S. Sovinska, M.Sc. A. Żaba, M.Sc. L. Janus and M.Sc. J. Radwan-Pragłowska, supported by Prof. Bogdal, with great enthusiasm and commitment cared about the participants and courses of the entire meeting. The lectures and workshops were held in the Faculty of Chemical Engineering and Technology and the Faculty of Environmental and Power Engineering buildings on the campus of CUT. The 3-days programme of the Summer School brought together 44 Young Scientists including Ph.D. students from 11 European Universities including University of Turin (Italy) – 2, Münster University of Applied Sciences (Germany) – 1, AGH University of Science and Technology (Poland) – 1, CUT (Poland) - 25 and Warsaw University of Technology (Poland) – 2, Yuriy Fedkovych Chernivtsi National University (Ukraine) – 2, Lviv Polytechnic National University (Ukraine) – 1, Kyiv National Taras Shevcenko University (Ukraine) – 3, KU Leuven (Belgium), University of Surrey (Great Britain) – 1 and from South America from State University of Campinas (UNICAMP) in Brazil – 3 persons (see Fig. 1 and 2).

Figure 2: Students participating in the Summer School in High Energy Processing Ultrasound & Microwave Technologies at CUT

Figure 3: Lecture given by Prof. M. Ashokkumar

Figure 4: Prof. Muthupandian Ashokkumar from University of Melbourne

The presentations covered principles and applications of leading edge technologies in modern chemical processing, specifically the use of microwaves and ultrasounds. Speakers alternated between the techniques, addressing the key workshop theme of process intensification in a range of applications, while commercial manufactures of ultrasonic and microwave apparatus gave practical laboratory demonstrations. The Summer School was officially opened at the first day by the President of AMPERE, Prof. Cristina Leonelli, Chairman, Dean of the Faculty of Chemical Engineering and Technology, Prof. Dariusz Bogdal, and Prof. Muthupandian Ashokkumar who on behalf of President of European Society of Sonochemistry Prof. Jean-Yves Hihn welcomed all the participants and exhibitors.

The schedule was as follows. Ph.D. Rachel Pflieger (French Alternative Energies and Atomic Energy Commission, France) gave an introduction to ultrasound principles, with examples taken from lab to industrial scale. Ph.D. Marcus Franke (Friedrich Schiller University Jena, Germany) introduce the hydrodynamic cavitation aspect. Prof. Crisitina Leonelli (University of Modena, Italy) described aspects of microwave- enhanced inorganic chemistry, covering solid-state reactivity, combustion systems and ceramic processing, paying attention to practical and safety aspects. Prof. Witold Łojkowski (Institute of High Pressure Physics Polish Academy of Sciences, Poland) gave a talk about the microwave-assisted synthesis of hydroxyapatite nanoparticles for medical applications and samples mineralization under microwave conditions. Next day, 27th of June Prof. Muthupandian Ashokkumar returned to discuss ultrasonic synthesis of functional bio- and nanomaterials, as well as application of ultrasound in food processing (see Fig. 3 and 4). Prof. D. Bogdal (Cracow University of Technology, Poland) gave an introduction of microwaves in polymer and hybrid materials synthesis and processing, and Prof. K. Matras-Postolek (Cracow University of Technology, Poland) discussed microwaves in semiconducting nanoparticle preparation. The last day Prof. Muthupandian Ashokkumar discussed the ultrasonic synthesis of polymers, Ph.D. Rachel Pflieger gave "Ultrasound: a tool for advanced features energy and environmental applications", "Challenges of microwave solvothermal synthesis of nanoparticles". Ph.D. Sylwia Dąbrowska (Institute of High Pressure Physics Polish Academy of Sciences, Poland) reported on "Mechanism for sonocoating of materials with nanoparticles". Ph.D. Urszula Szałaj (Institute of High Pressure Physics Polish Academy of Sciences, Poland) and Ph.D. Marek Piątkowski (Cracow University of Technology, Poland) gave an introduction to the modification process of biopolymers under microwave irradiation.

A key aim of the Workshop was to let attendees compare the features of the two key techniques, to provide a cadre of young researchers with this relatively uncommon blend of knowledge. To this end, there were two afternoon sessions in the Summer School dedicated to practical demonstrations of commercial ultrasonic and microwave apparatus, the group of attendees being split so that everyone had an opportunity to learn each methodology. The lectures were followed by short presentations and the practical laboratories from some exhibitors: Selva, Ertech and SinapTec who discussed and presented their latest developments.

The weather was excellent (more than 40°C), that's why cold drinks and air conditioning allowed participants to survive this three intensive days. Despite the sweltering heat there was a good spirit in the school, with communal mealtimes allowing attendees and presenters much opportunity for scientific interaction and feedback. During the Summer School the young scientists had great opportunity to reinforce from lectures and practical demonstrations their basic knowledge and skills in the field of advanced applications of microwaves and ultrasound techniques.

About the authors

Katarzyna Matras-Postołek, chemist by education, graduate of Cracow University of Technology (CUT). In 2006-2012, she worked as a scientist at Münster University of Applied Sciences in Germany. In 2010 she completed Ph.D. at CUT. In 2013, after almost 7 years of work in Germany, she returned to Poland to CUT. In 2019 she obtained her habilitation at Rzeszow University of Technology. Currently, Katarzyna Matras-Postołek works as professor at the Faculty of Chemical Engineering and Technology, CUT. Katarzyna Matras-Postołek has received a number of scholarships, e.g. scholarship for outstanding Ph.D. students in Germany DAAD (2007), and scholarship for outstanding young scientists in Poland (2016). In 2015, she was awarded the TOP 500 Innovators programme in Poland within she took part in a 9-week internship at University of California, Berkeley, USA. Since 2014, she is a visiting professor at University of Jinan, China. Since 2019 she is a scientific committee member of the AMPERE organization.

Dariusz Bogdal graduated from Cracow University of Technology (Krakow, Poland), obtained PhD diploma from Jagiellonian University (Krakow, Poland), and Doctor of Science (DSc) diploma from Warsaw University of Technology (Warsaw, Poland). He has more than 30 years of experience in Organic and Polymer Chemistry. He works extensively on the application of phase-transfer catalysis (PTC) and microwave irradiation to organic and polymer synthesis as well as polymer modification. His research interest also includes applying microwave-assisted reactions to polymer chemistry e.g., reactions on polymer matrices, preparation and modification of polymers, preparation and investigation of polymers for dental materials and optical devices. He worked as a Research-Fellow at Clemson University (Clemson, USA), Imperial College (London, UK), Napier University (Edinburgh, UK), and Karolinska Institute (Stockholm, Sweden). He is the author and co-author of books published in Elsevier and Blackwell-Wiley: "Microwave-assisted Organic Synthesis: One Hundred Reaction Procedures" (2005) and "Microwave-enhanced Polymer Chemistry and Technology" (2007), six book chapters and over 150 papers and review articles.

An overview of the European Microwave Week 2019

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The **European Microwave Week 2019** certainly represents one of the most important world events in this year about state-of-the art microwave technology and applications. The event, organized by EuMA (European Microwave Association), includes three conferences (European Microwave Conference, European Microwave Integrated Circuits Conference and European Radar Conference) and the European Microwave Exhibition with more than 300 exhibitors coming from Europe, USA and Asia. The 2019 edition counted more than 4000 attendees coming from all the five continents, attracted both by the magic environment of Paris and by the numerous opportunities to learn about innovative microwave devices, systems and applications.

The Conference and the Exhibition have both been a unique opportunity to know about new products and recent technological developments and to network with academics, professionals and entrepreneurs. The event also offered a forum for discussing trends and exchanging scientific and technical information.

As easily expected, the **hot topics** around the discussions, the presentations and the exhibited products were mainly linked to 5G mobile networks, to latest-generation semiconductor devices and production processes, to unmanned vehicles and to advanced military hardware/software for both airborne systems and ground stations. Special focus has been dedicated to active antenna systems and dynamic filtering approaches and very interesting new instrumentation has been presented, featuring Terahertz support and advanced automated testing functionalities.

Coming to the topics linked to the AMPERE activities and interests, the exhibited high-power microwave systems dedicated to **dielectric heating** fully reflected the current wind of change in the technology of high-power microwave generators. In particular, the major semiconductor devices manufacturers clearly showed the current contention between the LDMOS and GaN technologies, both aiming at high performances, efficiency and long-term reliability.

LEANFA, one of the latest AMPERE affiliates, is totally focused on the design and production of **solid-state microwave generators** and its OEM modules have collected the interest of several visitors who are currently involved in projects in the Industrial, Scientific and Medical fields. An additional confirmation about the global interest in innovative and efficient solid-state microwave solutions comes from the admission of LEANFA's presentation "How Distributed Software Systems Boost Solid-State Microwave Technology" within the **MicroApps 2019** program (see photo below). MicroApps is a technical forum featuring a wide range of practical application papers and workshops describing novel products, technologies, and processes, as well as keynote talks by known experts in the RF/MW industry. LEANFA's presentation emphasized that the great advantages of the new solid-state microwave technology can be fully exploited only if **suitable software platforms** are co-designed with the microwave generators, opening the doors to a virtually infinite series of easily customizable applications, which are at the same time very user-friendly and allowing processing accuracies so far unimaginable.

Figure: Marco Fiore at the EuMW2019

About the authors

Marco Fiore received his M. Sc. degree in electronics engineering at Politecnico di Bari, Italy. He has worked for more than 15 years in the field of digital tele-communications and broadcasting, from design tasks to operational management, always dedicated to implement deep interaction between high-frequency power electronics and programmable digital devices. He is co-founder of LEANFA in 2014, fully devoted to foster new business opportunities in Industrial, Scientific and Medical fields by means of innovative solid-state generators powered by distributed software applications.

Ricky's Afterthought:

Seminal discoveries

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As I write this piece, it is interview week for entrance into St John's College. There are many sombre faces of young aspiring interviewees, criss-crossing the various courtyards to locate the rooms where these university entrance interviews are being held throughout this week some extending to the next. As in some subjects the ratio of numbers interviewed to those offered places is four to one, no wonder these youngsters feel apprehensive.

When I was Pastoral Tutor, it was my job to welcome the youngsters and make them feel as comfortable and relaxed as possible under the circumstances before they proceeded to their next interview comprising of a panel of academics firing questions on their chosen subject. However, at the end of my pastoral speaking, metaphorically a sort of warm-up interview, I used to ask one or two probing questions such as, I quote "When you arrive at your chosen university, not necessarily this one, you will no doubt benefit greatly from that institution over and above excellence in education such as networking opportunities with your peers as well as establishing lifelong friendships and participating in many sporting activities. What, in return, would you offer back to that institution?" This startled my interviewees and was often followed by a longish awkward silence. However, after some reflection, they often responded well.

Another revealing question I used to pose was, I quote "In your opinion what do you regard as the most important scientific discovery ever?" Incidentally, there were those who had done their homework and found out from my website that my area of research was connected with the use of electrical energy and rapidly responded "Electricity" brimming with confidence.

Well, let me expand my last question and pose it to our AMPERE readers as a New Year Quiz. My question to you is the following: "Could you list the 20 seminal scientific discoveries that have shaped our world from prehistory to artificial intelligence which strongly influenced later developments, in terms of thoughts, ideas, gadgets and equipment, small or large?"

Before you continue to read this Afterthought article, do try to write down your 20 seminal moments in history and then compare with Mary Cruse's 20, which I have summarised below following publication of her book, **"An Illustrated History of Science: From Agriculture to Artificial Intelligence"**. Mary Cruse's list is as follows:

- **Sumerian Sickle** a tool dating some 3000 BC used in agriculture.
- **Edwin Smith's Papyrus** discovered around 1600 BC, concerning the diagnosis and curing of many diseases. It focussed on scientific knowledge rather than magic and superstition.
- **Euclid's 'Elements'**. This comprises of thirteen books on geometry and mathematics, which appeared around 300 BC.
- **Gutenberg's Printing Press** which was introduced in Europe around 1439 AD. Although not revolutionary at the time, it laid the foundations of scientific cooperation by rapid dissemination and communication of scientific findings and ideas.
- **Medieval Islamic Astrolabe** (1480) often referred to as the astronomical computer, which measures the altitude of objects.
- **Galileo's telescope** (1610) where in its refined version offered a magnification of 30 times and able to observe objects, such as the moons of Jupiter which could not be seen by a naked eye.
- **Hooke's microscope** (1665) where for the first time, very small items in our biological systems could be clearly seen.
- **Watt's steam engine** (1781) assisting the expansion of many industries such as cotton, brewing and textile.
- **Edward Jenner's lancet** (1796). He was a physician whose experiments with his lancet paved the way to what we now know as vaccination.
- **Darwin's "On the Origin of Species by means of Natural Selection",** (1859) laying the foundation of evolutionary biology.
- **Faraday's disc generator** (1831) leading to the understanding of electromagnetic induction and electric power generation.
- **Tyndall's radiant heat generator** (1859) measuring the absorptive power of gases in the atmosphere, leading to understanding the greenhouse effect.
- **William Röntgen's X-rays** (1895) used routinely now for medical treatment.
- **Marconi's wireless** (1896) with which he transmitted a radio signal across the oceans.
- **Alexander Fleming's penicillin mold** (1935). Not long after this discovery, penicillin was refined into a drug form saving close to a billion lives.
- **Hedy Lamarr's torpedo system** (1942), the film star together with composer George Antheil developed a frequency hopping technique allowing missiles to switch over different radio frequencies.
- **Rosalind Franklin's diffraction image** (1952) as a result of firing X-rays onto an object. This image helped Watson and Crick discover the structure of the DNA.
- **Saturn V rocket** (1964) used for exploring the moon.
- **Intel 4004 processor** (1971), the first microprocessor comprising over 2000 transistors compared to today's units edging towards a billon transistors.
- **Large Hadron collider** (2010), CERN's powerful accelerator, used to fire proton beams at each other for the study of fundamental particles.

When I first came across this list, I thought that there were some obvious omissions. For example, my list would have included Newton's law of general gravitation (1687), Planck's proposition that radiation is quantized (1900), Einstein's general theory of relativity (1915), splitting of the atom (1917), the discovery of the transistor at Bell Labs (1947) and Penzias and Wilson's discovery of the Cosmic Background Microwave Radiation (1964). Perhaps this reflects my background in Electrical/Physics subjects but hey, we all have our own idiosyncrasies.

It would be interesting to read what your list of twenty looks like. Drop us a line and we could include these in Issue 102 of our Newsletter.

For further reading

"An Illustrated History of Science: From Agriculture to Artificial Intelligence" Mary Cruse, Arcturus Publishing, November 2019

Upcoming Events

4GCMEA 2020 4TH GLOBAL CONGRESS ON MICROWAVE ENERGY APPLICATIONS

The 4th Global Congress on Microwave Energy Applications

CALL FOR PAPERS

Important Dates

- Abstract Submission Deadline
  March 15, 2020
- Acceptance Notification
  May 10, 2020
- Registration Deadline
  July 15, 2020
- Conference Date
  August 17-20, 2020

The Global Congress on Microwave Energy Applications (GCMEA) is the "Olympic Event" for worldwide researchers and engineers working on the relevant fields of microwave/RF power applications. It happens every 4 years in a different continent. Sichuan University together with the China Association of Microwave Power Applications (CAMPA) is pleased to announce that the 4th GCMEA will be kindly hosted in Chengdu, Sichuan, China during Aug. 17-20, 2020.

The scope of the Conference is concentrated on microwave energy applications, and includes:

- Microwave/RF plasma
- Microwave/RF chemistry& metallurgy
- Microwave/RF chemical engineering
- Microwave/RF applications in environment engineering
- Microwave/RF applications in medicine and biology
- Microwave/RF assisted materials science and engineering
- Microwave/RF assisted food science and engineering
- Interaction mechanism of Microwave /RF and substances
- Dielectric and magnetic properties measurement
- EM modeling and numerical techniques
- Design of microwave/RF applicators and components
- Microwave/RF sources and power supply
- Microwave chemistry devices and working stations
- Microwave/RF processing design and optimization
- Microwave/RF industrial equipment and scale-up
- Industrial applications of microwave /RF energy
- Radiation safety and standards
- Other relevant topic

Submission:

1. Abstract should be around 200-300 words. Please prepare it as per the template (click to download).
2. Online submission: https://easychair.org/conferences/?conf=4gcmea2020

Registration	Early Bird Rate (Before June 1, 2020)	Regular Rate (June 2, 2020 ~ July 15, 2020)
Regular Registration	4000 CNY/570 USD	4200 CNY/600 USD
Student Registration	2250 CNY/320 USD	2450 CNY/350 USD

Sponsored By

JEMEA · International Microwave Power Institute · AMPERE · CAMPA 中国微波能应用协会 · Microwave Working Group

The Association for Microwave Power in Europe for Research and Education (AMPERE) is pleased to announce the 18th International Conference on Microwave and High Frequency Applications: AMPERE 2021, the largest event in Europe dedicated to scientific and industrial applications of microwave and radiofrequency power systems. The conference presents the status and trends in the multidisciplinary fields of microwave and radiofrequency applications, such as heating, sensing and processing. It includes microwave sources, antenna beams, dielectric properties, material processing, modelling, and high-power systems and technologies. The 18th AMPERE conference will also highlight topics of medtech and metrology.

The AMPERE conference is a unique opportunity for the presentation and discussion of the most recent advances in microwave technology and its applications. The conference provides many opportunities for researchers and engineers from academia and industry to exchange innovative ideas, discuss collaborations, and to network with international experts in a wide variety of specialties of microwave and high frequency technologies at both scientific and industrial scale.

More than a conference

AMPERE2021 will be more than a conference, it will be a meeting point for science, business and education.

A short course and a modelling workshop will be organized on the first day, and booths will be available for company exhibitions on all days of the technical presentations.

Bookmark www.ampere2021.com to stay updated, or email your questions to ampere2021@meetx.se

Chalmers University of Technology, Gothenburg

The conference will be held on 13-16 September 2021 at Chalmers University of Technology. Chalmers was established in 1829 and is one of the leading technical universities in Sweden.
Gothenburg is located on the west coast of Sweden and is easy to reach through its international airport that has direct flights from most major European cities. The industry includes automotive, food industry, communication, shipping, medtech and defense, all with different interests in the development of microwave technologies

XIX International UIE Congress
Evolution and New Trends in Electrothermal Processes
UIE 2020, 9.-11. September 2020 in Plzeň, Czech Republic

The history of the International UIE Congress is over 80 years long. The first event took place in La Haye, Netherlands, in 1936. Then, World War II interrupted all scientific meetings in Europe, so that the second Congress took place only in 1947, symbolically at the same place. Since this year, a series of 16 events of this kind were organized worldwide in 3 to 6-year intervals. The last ones took place in Durban / South Africa 2004, Krakow / Poland 2008, St. Petersburg / Russia 2012 and Hannover / Germany 2017. Now, the Czech Committee of Electroheat and the University of West Bohemia organize the XIX International UIE Congress on Electrotechnologies for Material Processing in Pilsen (Czech Republic) from 9th to 11th September 2020. In recent years, around 140 professionals from both the industrial and academic worlds have participated in the Congress. There are colleagues from the field of heat treatment of metals, induction heating, and other areas. The blending of practitioners and academics is both beneficial and inspiring for both.

Main Topics

Possible topics for submissions include, but are not limited to, the following:

- Material processing by heating and melting
- Magnetohydrodynamics in industrial processes
- Production processes for innovative materials and products
- Process control and optimization
- Energy efficiency and sustainability of industrial thermal processes
- Efficient and sustainable energy management of buildings

IMPORTANT DATES

1. 2. 2020	Two-page abstract deadline
7. 1. 2020	Opening of the system for abstracts submission
6. 1. 2020	Add the templates for WORD and LATEX (see)

UIE 2020 IS ORGANIZED BY

FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITY OF WEST BOHEMIA

ČKET

Conference Website

https://edison.fel.zcu.cz/html/uie2020/

Public Funded Project within the AMPERE Community

Development of an Efficient Microwave System for Material Transformation in Energy Intensive Processes for an Improved Yield

1 The Project

The DESTINY project aims to realize a functional, green and energy saving, scalable and replicable solution, employing microwave energy for continuous material processing in energy intensive industries. The target is to develop and demonstrate a new concept of firing for granular feedstock to realize material transformation using full microwave heating as alternative energy source and complement to the existing conventional production. The DESTINY system is conceived as cellular kilns in a mobile modular plant, with significant advantages in terms of resource and energy efficiency, flexibility, replicability, scalability and a reduced environmental footprint.

The influence of the DESTINY solutions in terms of stability, process efficiency and characteristics of raw materials, intermediate/sub/ final products will be investigated to improve performance of the industrial processes within 3 industrial sectors (Cement, Ceramics and Steel). New heating technologies, monitoring systems and numerical simulation tools will be used to drive the design and to excel in the outcome.

The industrialization and sustainability of DESTINY high temperature microwave technology will be assessed through the evaluation of relevant key performance indicators (KPI)s with life cycle methodologies. With the final aim of ensuring a large exploitation and market penetration for DESTINY, technology-based solution business models, economic viability and replicability analysis will be conducted. For guaranteeing industrial transferability, appropriate exploitation and dissemination activities have been defined during and even after the end of the project.

2 Objectives

The DESTINY project aspires to introduce a "first-of-a-kind" high temperature microwave processing system at industrial level offering a variety of vital benefits to energy intensive sectors: reduced energy consumption, lower lifetime operating costs and enhanced sustainability profile.

The DESTINY system is conceived as cellular kilns in a mobile modular plant as shown in Figure 1, designed to cover the "material feedstock-firing-product storage" process in a unique clean system with increased production flexibility. Working with throughputs ranging from 10% to 100% capacity should be enabled without any major loss of the overall process performance.

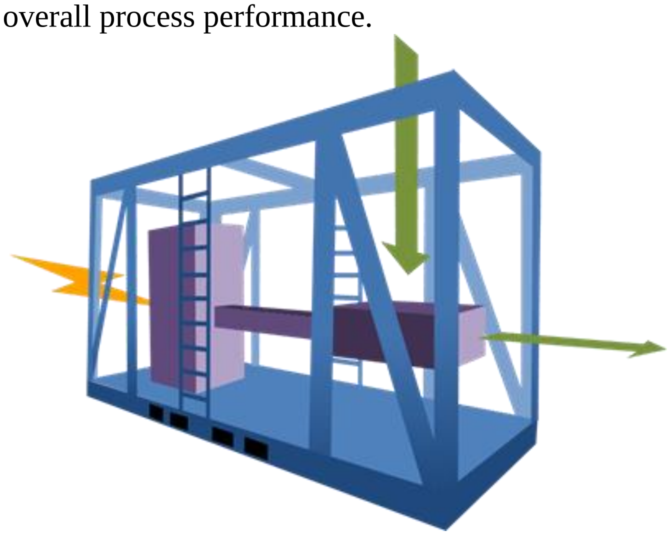

Figure 1: Portable microwave concept for pilot scale demonstration

Objectives focus towards the improvement of efficiency ratios in the following areas:

- Flexibility of ±30% to energy input within RES (Renewable Energy Sources) fluctuations time

frames without significant losses in specific energy efficiency
- Improvement in energy efficiency of 40% (depending on different industry and product applications)
- Improvement in terms of resource (fuel) efficiency exceeding the value of 40%
- Decrease in CO_2 emissions by 45% (without considering the electricity generation at steady state)
- Decreased OPEX and CAPEX by 15%.

3 Expected Impacts

Manufacturing is the driving force behind Europe's economy. Within a context of climate change legislation, volatile energy prices and increased environmental awareness, modern manufacturing must focus on the introduction of modern and renewable energy solutions as well as on sustainability and eco-efficiency.

In order to achieve further significant energy reductions, it is necessary to target the most energy intensive parts of the production chain such as the firing processes. In this sense, the new system proposed in DESTINY will be a clear opportunity to improve the current industrial heating processes.

The DESTINY concept is indeed a paradigm change: it enables new small-low cost solutions for new processes or to retrofit existing plants. The system is designed as a modular unit to create any production capacity required by clients on-site.

Due to a reduced size, it offers a production on demand, delocalised and with high flexibility of production and portability, it gives the chance to develop new business strategies and allowing increased flexibility of the energy input. Thus, the DESTINY concept perfectly fits to energy efficiency policies for the performance of the next generation renewable based electricity grids. Due to the novelty of DESTINY's outcomes, it is expected to have a high potential for market application covering a real need and demand from energy intensive industries processing raw materials.

4 Results

DESTINY will deliver a new eco-efficient solution based on microwave technology and being developed to design a new radical versatile process that will able to face different industrial sectors.

The aim of the project DESTINY is to get the technology much closer to an industrial production rate guaranteeing scalability, replicability and robustness. Moreover, the fully electrical DESTINY module has the final goal of a reduced direct dependence of energy intensive industries on fossil fuels; thus, the idea contributes to reach the Paris agreement goals.

DESTINY will give energy intensive sectors the chance to replace their standard heating technologies averagely cutting by 30% the required energy for production [kWh/kg] decreasing the CO_2 emissions in more than 40%, and with additional proportional derivate reduction of SO_x and NO_x. The specific results expected in the project are:

- A portable "ready-to-use" container size microwave pilot plant (prototype) with a production capacity higher than 20 kg/h by a single cell kiln, and able to reach working temperatures over 1000 °C
- With a design enabling an array of microwave kiln cells considering 130 kg/h per cell, which can be able of commercial operational production rates
- With a minimum of 30% of energy savings on the process (due to the use of microwave technology and the use of advanced control strategies)
- Reducing operation costs between 15-30%
- Implementation of a "switch-and-go" processing concept
- A minimum of 10 times faster heating up of the production process
- Reducing SO_x, NO_x, CO_2 and CO emission in 40% (minimum)
- Avoiding combustion (also via targeted new emission monitoring and control strategies, with high reduction of particle matter)
- Guarantee safe operation for operators and surrounding in all the applications of the MW technology in its working environment and in compliance with related EU directives and recommendations
- User manuals, best practices, health and safety documentation
- Success KPIs assessment

The DESTINY concept will be proved in two demo sites located in Spain and Germany covering high energy demanding sectors of strategic interest as Ceramic (Pigments), Cement (Calcined clay) and Steel (Sinter, iron pellets/sponge iron (DRI), ZnO) to validate the critical parameters of the developed technology in relevant environment. It will be implemented as two feeding modules per demo site and one mobile microwave kiln module and product treatment.

Considering the improvements in the DESTINY's MW process, an exploitation strategy will be developed to maximize the potential of the project results analysing and evaluating the possible exploitation routes, the target users and markets, and reviewing all internal or external aspects from the potential business viewpoint.

5 Technology

The aim of DESTINY is applying non-conventional energy sources to energy intensive industrial processes. The use of systems based on electricity like the MW considered in the project is a true alternative to fossil energy sources (natural gas consumption) enabling the integration of renewable electricity and providing significant advantages in terms of resource/energy efficiency and operational flexibility.

6 Novelty

An extensive list of innovations regarding various system aspects will be put in place in order to demonstrate an operational prototype of the new process in industrial scale related to: 1) Reactor, feeding system and plant integration, 2) Microwave technology, 3) Concept of application, 4) Monitoring and control, 5) Industrial use.

1) Related to the reactor:
   - A new smart kiln cell system concept for ultrafast industrial firing production.
   - Cool kiln with no-thermal inertia and with flexibility of production with no loss in process performance or energetic efficiency (from 10 to 100% of their capacity).
   - New compact modules consisting of a closed system of feeding, thermal transformation and storage.
   - Smart reactor systems adapted to different raw materials treatment (fluidised/rotary design).
   - Easily integrable on current industrial sites by using advanced manufacturing process.
   - A multilevel adaptive heating control system for reactors fully integrated.
   - A system useful for both upstream and downstream industrial processes.

2) Related to microwave technology:
   - A new concept of electromagnetic field distribution suitable to heat low and very low susceptible dielectric materials.
   - A new concept of microwave applicator able to heat on continuous flow poorly absorbent dielectric materials that increase their properties with temperature.
   - Enabling the use of a high electrical field power application on dielectric materials avoiding runaway and gas ionizing.

3) Related to the microwave concept application:
   - A new heat supply (by microwave) and reduction process of ceramic materials.
   - Modular and containerised application for fast track industrial implementation.
   - New ceramics for microwave processing under extreme thermal-mechanical-dielectric conditions, keeping the best performance on both technical and economic aspects.

4) Related to the industrial use:
   - Adapted to demand (switch and go, production on-demand), flexible production (from 10 to 100%), modular (reliable and replicable array of microwave kiln cells).
   - Production on site of demand.
   - A new production process for eco-products with a more efficient and sustainable performance than current processes.
   - Recycling of residues and by-products.
   - Products (not existing nowadays) with new properties based on the heating production process.
   - Micro-plant for the development of new or tailored special products.

5) Related to monitoring and control:
   - Soft-sensors for material temperature and emission targeted to control the system.
   - Multilevel control sensor technologies for the MW system.
   - Control system specialised to match the high flexibility of the new technology with the demands of renewable electricity grids.

7 Consortium

The DESTINY consortium is formed by 14 experienced partners (see Fig. 2) with proved capability to develop and achieve the objectives of the project covering a wide geographical representation from 9 European countries of the best research organizations, technology & service provider, and industrial end users.

The multidisciplinary roles guarantee a deep knowledge and best available skills in the essential parts of the developments (materials development, microwave technology, environmental/cost/social life cycle analysis, health & safety, industrial processes for cement/ceramics/steel, business exploitation, etc).

Figure 2: DESTINY consortium

For further information:

Website: www.destiny2020.eu
Email: info@destiny2020.eu.eu
Twitter: @destiny2020
LinkedIn: https://www.linkedin.com/groups/13691277/

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About AMPERE Newsletter

AMPERE Newsletter is published by AMPERE, a European non-profit association devoted to the promotion of microwave and RF heating techniques for research and industrial applications (http://www.AmpereEurope.org).

Call for Papers

AMPERE Newsletter welcomes submissions of articles, briefs and news on topics of interest for the RF-and-microwave heating community worldwide, including:

- Research briefs and discovery reports.
- Review articles on R&D trends and thematic issues.
- Technology-transfer and commercialization.
- Safety, RFI, and regulatory aspects.
- Technological and market forecasts.
- Comments, views, and visions.
- Interviews with leading innovators and experts.
- New projects, openings and hiring opportunities.
- Tutorials and technical notes.
- Social, cultural and historical aspects.
- Economical and practical considerations.
- Upcoming events, new books and papers.

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We believe that this seemingly less-rigorous editorial approach is essential in order to accelerate the circulation of ideas, discoveries, and contemporary studies among the AMPERE community worldwide. It may hopefully enrich our common knowledge and hence exciting new ideas, findings and developments.

Please send your submission (or any question, comment or suggestion in this regard) to the Editor in the e-mail address below.

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