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The European Journal of Microwave Energy is born

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Editorial Board of the European Journal of Microwave Energy
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The European Journal of Microwave Energy (EJME) is a new journal from the AMPERE community that will showcase major developments from fundamental and applied work using energy in the microwave spectrum. It is run by researchers in the RF and microwave field and one of its key missions is to maintain the health of the scientific community and publishing in this area. EJME celebrates breakthroughs at microwave frequencies in all areas of scientific discovery. The journal focuses upon challenging questions and advances in science and engineering using RF and microwave energy and is highly interdisciplinary, bringing together the fields of chemistry, materials science, physics, engineering and the medical and biological sciences.

EUROPEAN JOURNAL OF
MICROWAVE
ENERGY

Logo of EJME

AMPERE 2023 saw a triumphant return to in-person events for the AMPERE organisation after the very successful virtual conference organised by RISE in Gothenburg in 2021, with over 170 attendees from more than 25 different countries descending on Cardiff in the UK for a week of fascinating and wide-ranging talks, workshops and courses. We were treated to a range of excellent presentations in plasma processing, biomass and waste processing, chemistry/biochemistry applications, design of applicators and components and industrial scale up, modelling, measurements and metrology, food processing and biological applications.

Cardiff is the capital city of Wales and is home to Cardiff University. It has a rich cultural heritage that we were delighted to share. The social programme started with a drinks reception at the Centre for Student Life, followed by an event at the historic Coal Exchange, including an astonishing and very moving performance by the Welsh National Opera (https://wno.org.uk/, please do visit them and support them if you have the chance!), and finally by our gala dinner in the beautiful surroundings of the National Museum of Wales (https://museum.wales/cardiff). The proceedings and photos from the conference are available on the AMPERE2023 website (www.ampere2023.com).

AMPERE 2023 also marked the launch of the much-anticipated new journal from AMPERE: '*The European Journal of Microwave Energy*' (EJME). There have long been discussions in the AMPERE community about creating a platform from which we can showcase the very best work in our field. Our global community, whilst broad in scope, has a unique identity that is characterised by interdisciplinary innovation and boundary-crossing research. EJME fills a gap, but importantly also complements the activities of our sister organisations within the MAJIC* confederation, with whom AMPERE works to carry out our stated mission: to promote RF and microwave heating techniques for research and industrial applications. The EJME editorial board will be working closely with our global family of research associations to promote our respective journals.

EJME is a grass-roots, diamond open-access journal. It has a free-in, free-out model that provides the opportunity to publish high quality research free of charge and makes it available for all to read at no cost. It is underwritten by Cardiff University Press (CUP), whose investment demonstrates a strong belief in the future of RF and microwave technologies. CUP also have a well-established support network and indexing strategy which provides a fertile environment for the growth of our fledgling publication. Now that the EJME website has been commissioned, the review process for the first batch of EJME papers is now almost complete, ready for the publication of the inaugural issue.

In the inaugural issue, a small number of the very best papers (top 7%) as determined by reviewers and the editorial board are being published. From these humble beginnings, ahead of the next AMPERE conference in 2025, the journal will publish a review issue, featuring reviews from senior figures in the field in key areas of microwave energy applications. If you are interested in proposing a review for this forthcoming issue, please get in touch with any of the editorial board members. It is expected that in the second phase of EJME's growth - from 2025 - more high-quality papers from our field will be published. The strength of the editorial board, bringing together the brightest investigators from around the world will give EJME a stellar start; and the lively and engaged community of AMPERE have made the success of this launch inevitable.

We are fortunate that within our global family of national microwave associations (MAJIC) we have a critical mass of supporters who are concerned with scientific excellence and the health of the scientific community. Scientific publishing is highly competitive, with large publishers consuming smaller publications, and overshadowing subject-specific scientific excellence in favour of 'bankable' reporting metrics. The advent of DORA** has in some respects led to an improvement in publishing practices and EJME aims to represent the interests of science and the scientific community by promoting excellence in innovation and research as a not for profit, free to publish and free to read endeavour.

Planning for the first phase of EJME development (i.e. two years) of the EJME journal is centred around growth and quality, with a focus upon serving the AMPERE community. This means that the journal will be given a good platform for its first two years, with promotion planned at events around the world. Together we can build on the reputation for excellence fostered within AMPERE to produce a flagship journal that we can all take ownership of, giving our research community direct control over quality, standards and the general health of publishing in the field.

On behalf of the EJME editorial board, thank you for your continued support and contributions.

Daniel Slocombe, Adrian Porch and Georgios Dimitrakis

*MAJIC (Microwave Working Group, AMPERE, JEMEA, IMPI, CAMPA)

**The Declaration on Research Assessment (DORA) recognizes the need to improve the ways in which researchers and outputs of scholarly research are evaluated.

Why Turquoise Hydrogen is a Key Element for the Energy Transition

Alvaro Martin Ortega[1], Marilena Radoiu[2]

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Today more than 90% of the hydrogen is produced from fossil resources, mainly natural gas by high temperature processes. 50% of the annual production of more than 100 Mt is used for the production of fertilizers, and about 45% for petrochemical processes. To achieve the goal of a sustainable energy economy, hydrogen must be used as an energy carrier. To be a long lasting and sustainable solution especially for the industry, it must be produced without greenhouse gas (GHG) emission, from unlimited natural resources with no conflict of use and at affordable cost. Among all known methods for hydrogen production – see **Figure 1**, the direct decomposition of methane into hydrogen gas and solid carbon requires significantly less energy and does not emit CO_2. This process, known as methane pyrolysis, is achieved at high enough temperatures; however, it has not been deployed industrially so far and it can best be fulfilled by microwave assisted plasma, potentially coupled to nuclear power, which are able to provide large amounts of hydrogen.

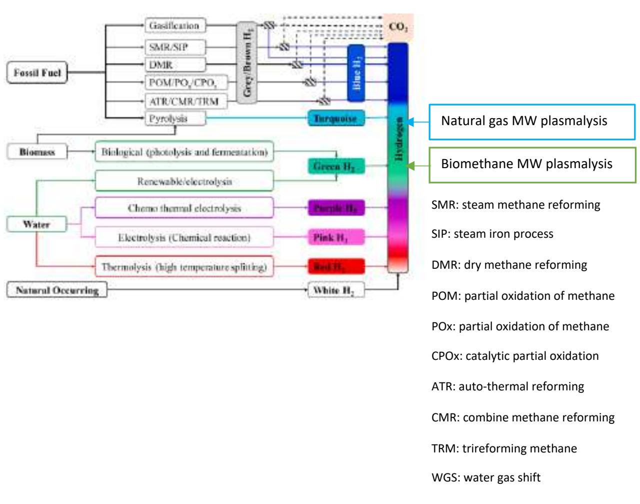

Figure 1. Hydrogen production methods vs. associated color codes (adapted from [1]).

Since early 2021, the DeepTech Sakowin Green Energy and Microwave Technologies Consulting have been working together to develop an industrial 915 MHz microwave (MW) plasmalysis system to split either natural gas or biomethane into hydrogen and carbon, yielding either turquoise or green hydrogen. Depending on the methane source, natural gas or biomethane, the plasmalysis technology is negative or neutral in terms of CO_2 emissions. The technology has the potential of using much less electricity than water electrolysis to produce the same amount of hydrogen at a more competitive cost and without using water, which is recognised as a resource whose conservation is essential in the fight against climate change. The co-production of solid carbon, which can be used in industrial and environmental applications such as electrodes for batteries, building materials and agriculture, together with the use of biomethane, which makes it possible to produce hydrogen that is not only decarbonised but also negative in terms of CO_2 emissions, makes this technology a model of energy efficiency, circularity and sustainability.

The use of a MW plasma to achieve methane decomposition allows for an efficient process by delivering energy directly to the gas (plasma) without the use of intermediate heaters or electrodes within the plasma chamber. In addition, the start-up and shut-down times of the process are virtually instantaneous, controlled by the time it takes to turn the microwaves on and off as a function of the downstream process requirements.

In this context, we had the opportunity to present an experimental study of the methane plasmalysis process at the recent 19th AMPERE conference in Cardiff. We presented the results of an optical emission spectroscopy (OES) study of the MW plasma under different pressure, MW power and gas mixture conditions. The results not only allowed a determination of the plasma temperature in the centre of the microwave plasma reactor, but more importantly, it opens the door to future studies where the spatial distribution of the temperature can be determined.

Our presentation was just one of many dedicated to making the industry as a whole more efficient and CO_2-free, a quest for which, as we saw during the AMPERE 2023 conference, microwave technology offers enormous potential.

As shown in **Figure 2** Sakowin's equipment is compact, modular and stackable. It can be integrated into existing gas infrastructure, for on-site and on demand hydrogen production, with capacities ranging from 200 kg H_2/day to hundreds of tons of H_2/day.

For more details: www.sakowin.com; www.microwavetechs.com

Figure 2. Photo of the R&D Team at the inauguration of the industrial test site, 27th September 2023.

For further reading

1. Faisal S. AlHumaidan, Mamun Absi Halabi, Mohan S. Rana, Mari Vinoba (2023) Blue hydrogen: Current status and future technologies, Energy Conversion and Management, 283, 116840, https://doi.org/10.1016/j.enconman.2023.116840.

About the authors

Dr. Alvaro Martin Ortega is a senior researcher at Sakowin Green Energy, France, having joined the company in March 2021. Dr. Martin Ortega obtained his Ph.D. in plasma physics from the University of Grenoble in 2017, while working at The European Synchrotron Radiation Facility (www.ESRF.fr). His professional experience includes two postdoctoral positions at French laboratories in Grenoble (2017-2018) and Toulouse (2018-2020), investigating innovative applications of plasma sources for CVD diamond deposition and electric space propulsion.

Dr. Marilena Radoiu is the founder of Microwave Technologies Consulting, France. She has more than 25-year experience in the development of microwave assisted technologies applied to chemical synthesis, biomass extraction, plasma, food etc. Her work has included engineering and development of novel industrial and scientific standard and custom-tailored equipment and processes. Dr. Radoiu is a Chartered Scientist and fellow member of several professional associations, including the Royal Society of Chemistry and the Association for Microwave Power, Education and Research in Europe (AMPERE).

EU Project TITAN – 915 MHz Microwave-Assisted Catalytic Production of Green Hydrogen

Marilena Radoiu

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Microwave Technologies Consulting is pleased to announce its participation in the EU HORIZON-CL5-2021-D2-01, Cross-sectoral solutions for the climate transition, with project TITAN - Direct biogas conversion to green H_2 and carbon materials by scalable microwave heaTed catalytIc reacTor for soil Amendment and silicoN carbide production (https://titan.cnrs.fr/). TITAN is a Research & Innovation project (Grant agreement 101069474) funded by the European Climate, Infrastructure and Environment Executive Agency (CINEA).

Started in September 2022, the 48-month project aims to develop an innovative 915 MHz microwave-assisted catalytic process for the production of cost-competitive hydrogen from biogas together with integrated carbon sequestration.

With a consortium of seven partners from France – CNRS-IRCELYON and Microwave Technologies Consulting, the Netherlands – Process Design Centre bv and ESD SIC bv, Belgium – European Biogas Association, Germany – University of Hohenheim, Soil biology & Biogeophysics team, and Poland – Warsaw University of Technology, Faculty of Chemical and Process Engineering, TITAN addresses the direct conversion of biogas (~40-50% CO_2 and 50-60% CH_4) *via* dry reforming + water shift reaction into valuable carbon materials and a H_2-rich stream using a 915 MHz heated fluidised bed catalytic reactor, see **Figure 1**.

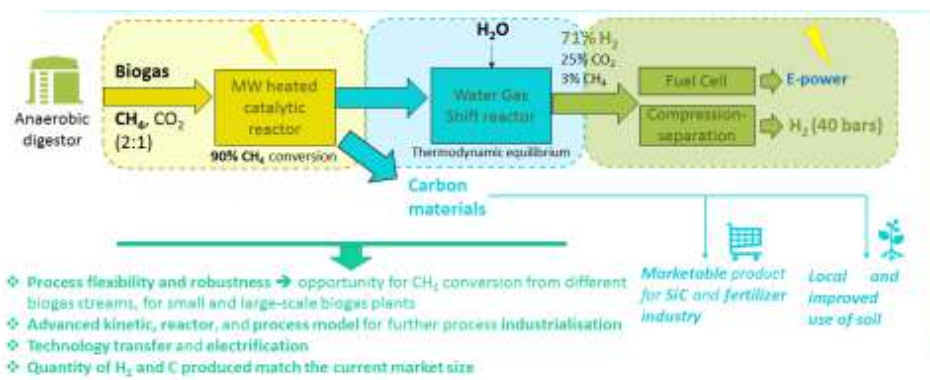

Figure 1. TITAN concept for the conversion of biogas using 915 MHz microwave-assisted catalytic processing.

The main objectives of the project are:

- Development of suitable non-toxic catalysts and electrified microwave enhanced fluidised bed reactors for energy efficient conversion of biogas to hydrogen.
- Develop models for process design, optimisation and scale-up;
- Validate techno-economic solutions and environmental, resource and social acceptability;
- Investigate the economic potential of the resulting carbon materials for use in agriculture for soil improvement and for the production of silicon carbide materials;
- Elaboration of a roadmap for the long-term reduction of greenhouse gas emissions.

Funded by the European Union

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Development of Microwave Applications in Biomass Conversion – from Lab to Pilot Scale

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Europe's transition towards climate neutrality and circularity is underway.

In the current context, our group CHEMPOWER, from the Faculty of Power Engineering of the National University of Science and Technology Polytechnic of Bucharest, is permanently preoccupied to find new research opportunities through the conversion of biomass into energy and valuable compounds. Our main interest is the application of conventional and emerging technologies for the valorisation of biomass such as plastics, wood, organic residues, food waste. Our laboratory is equipped for the following activities: thermo-physical-chemical characterisation of solid and liquid fuels; determination of flue gas composition; thermogravimetric analysis of solid fuels; preparation of bio-oils for obtaining biofuels; combustion/pyrolysis/(steam)-gasification experiments in reactors with continuous operation and in batches; CO_2 capture processes with different types of solvents and under different process conditions; modelling and simulation of CO_2 capture processes.

A selection of available pilot and lab-scale installations: i) pilot installation for pyrolysis, gasification and combustion processes. - electrically heated rotary kiln 30 kg/h, temperature up to 1100ºC; ii) CFBC for co-combustion, gasification (circulating fluidized bed) - 10 kg/h, temperature up to 900ºC; iii) pyrolysis reactor – 10 kg/h, temperature up to 700°C; iv) microwave generators 5kW, 915 MHz magnetron based, 600 W, 915 MHz solid state, and 3 kW, 2.45 GHz; magnetron based; v) tubular batch reactor for pyrolysis, gasification and combustion processes; vi) calcinations oven Nabertherm.

A selection of the analytic equipment: micro GC; calorimeter; flue gas analyzer Testo 350xl; gas chromatograph – mass spectrometer; thermo-gravimetrical differential analyzer TG-DTA; spectrophotometer with atomic absorption; FT-IR spectrophotometer; UV-VIS spectrophotometer.

In the last six years we have won two European projects: *Production of BIOfuels through innovative pyrolysis/gasification methods and advanced TECHNOLOGIES* (**Figure 1**) and *Green chemistry and thermochemical processing, a convergent approach towards biobased chemicals and hydrogen synthesis, ConverGreen*.

Logo of the BIO Nov PyroTECH project.

The main objective of the recent ConverGreen project is to create a research group of excellence at the National University of Science and Technology POLITEHNICA Bucharest in the field of bio-products and hydrogen production, based on fundamental research leading to innovative processing techniques that will contribute to future scientific advances. Both projects are dedicated to microwave heating, studying the properties of the material and simulating the designs, devices and processes using COMSOL multiphysics software.

During the projects, the group leader, Prof. Dr. Eng. Cosmin Marculescu, has established partnerships with renowned universities, namely Biological and Agricultural Engineering, LSU* & LSU Agricultural Centre and AGH University of Science and Technology, Krakow, Poland.

These collaborations increased the international visibility of the Romanian team through the publication of 20 research papers and four patents.

Participants to the CoverGreen project.


Further participants to the CoverGreen project.

* Louisiana State University

About the author

Dr. Mariana Patrascu received her Ph.D. from the Faculty of Applied Chemistry and Materials Science, University POLITEHNICA of Bucharest, Romania in 2012. In 2021, she completed a post-doctoral study with the Faculty of Power Engineering, University POLITEHNICA of Bucharest. She is an associate of CHEMSPEED Ltd., Bucharest – Research & Development Laboratory in the field of microwave and ultrasound technology and from 2022 an Associate Professor at the Faculty of Power Engineering, National University of Science and Technology Polytechnic of Bucharest. She is a Fellow of the Royal Society of Chemistry. Her research focuses on microwave and ultrasound assisted processes and technologies. Mariana is (co-)author of more than 32 national patents and 5 international patents, 35 scientific publications in peer-reviewed journals and collaborator/leader of 20 research projects. During more than 25 years of activity in the field of microwave and ultrasound chemistry, she has been awarded 10 gold medals at the International Exhibition of Inventions in Geneva, Switzerland and at the World Exhibition of Innovation, Research and New Technology "Eureka", Brussels and at the IX Edition of the International Exhibition of Inventions and Innovations "Traian Vuia", Timisoara in Romania.

The Irene Joliot-Curie 2023 Prize

Marilena Radoiu

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I am delighted to share with all AMPERE colleagues and friends that on 21st November 2023, I was awarded the Irene Joliot-Curie 2023 prize in the category Femme, Recherche et Entreprise (Woman, Research and Enterprise) during a prestigious ceremony held at the Institut de France in Paris (https://www.institutdefrance.fr/decouvrir-le-palais). This prize was awarded by the French Academy of Sciences and the French Ministry of Higher Education, Research and Innovation.

Since its creation in 2001, the Irène Joliot-Curie Prize has promoted women in science, research and technology and has rewarded over 60 women scientists with exemplary careers in public and private research from all scientific disciplines.

Should you like, below is the translation of my portrait published on https://www.academie-sciences.fr/fr/Laureats/laureates-2023-du-prix-irene-joliot-curie-anne-canteaut-virginie-galland-ehrlacher-claire-de-march-laurette-piani-marilena-radoiu.html:

"Marilena Radoiu is interested in the research and development of innovative processes and the design of equipment using microwave processing technologies. Her aim is to bridge the gap between academia and industry in the research, development, demonstration and industrial scale-up of microwave-assisted technologies with applications in the fields of synthetic chemistry, environment - particularly with regard to the production of green hydrogen, agri-food, semiconductors, pharmaceuticals and cosmetics. Through collaborations with universities and companies of all shapes and sizes around the world, she strives to bring academia and business closer together, to establish a link between science and business, innovation and commercialisation, and above all to educate the younger generation in the transition to more sustainable technologies aimed at improving the energy consumption, processing time and environmental footprint of industrial processes".

Ricky's Afterthought:

Is turquoise Hydrogen a "Game Changer" in the Net Zero Quest?

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In my afterthought piece in Issue 107 I discussed the importance of hydrogen as the fuel of the future as a replacement for natural gas particularly for meeting the stated goal of net zero by 2050. Well, in the past year there has been a revival in the use of hydrogen as the fuel of the future by introducing yet another form of it called turquoise hydrogen. Let me recap about how hydrogen is produced.

Hydrogen can be readily produced by electrolysis of water by passing electricity through an electrolyser. If the latter is powered from excess renewable energy, such as wind or solar, the resulting hydrogen is termed green hydrogen. This process however is very expensive and would make the viability of hydrogen at present as a replacement for natural gas difficult to justify.

Alternatively, hydrogen is produced by steam reforming, that is, by blasting methane, the main constituent of natural gas, with steam to produced hydrogen and carbon monoxide, in the following process:

$$CH_4+H_2O= CO +3H_2$$

If in this process the waste is released to the atmosphere then the product is termed grey hydrogen whereas if the waste is captured and geologically stored (CCS) it is then called blue hydrogen.

Pyrolysis

On page 312 of the yellow bible I refer to pilot scale research where microwave energy was used to produce carbon black and hydrogen from burning methane, CH_4. Well this idea has been revived, however, this time the electrical energy input to the reactor comes from renewable energy so the system consists of a bubble chamber reactor with molten tin operating at over 1000ºC with electricity coming from wind or solar energy. When the gas bubbles burst in a process of the kind called pyrolysis, methane splits into its molecular constituents whereby the hydrogen is released and the solid carbon, in the form of pure crystalline carbon, is obtained as a powder. The hydrogen produced in this way is termed turquoise to differentiate it from grey, green and blue hydrogen. The important aspect of this process is that it does not release any CO_2 in the atmosphere. In addition, if biogas or biomethane is used for methane pyrolysis and CO_2 is taken from the atmosphere, the process even has a negative carbon balance.

Usage

Turquoise hydrogen could be used for all forms of transport including aviation or private cars, in industrial processing and for heating. The solid carbon could be used as a powder for pigments, lightweight design, polymers, in the aluminium, steel and construction industries and replace graphite in batteries. There are also lots of high-tech applications being considered at present.

It must also be stressed that the carbon produced by methane pyrolysis is made by chemical synthesis and may replace carbon from natural sources in the future, further reducing CO_2 emissions. The production of carbon black will be an added advantage and alter the economics of the whole process because it will be selling a high value product. Some companies are developing turquoise ammonia, used in fertilisers, which entails using hydrogen produced from splitting methane using renewable energy.

Hydrogen Europe, an association which represents the interest of the hydrogen industry and its stakeholders and promoting hydrogen as an enabler of a zero-emission society, states that hydrogen is now regarded as a key fuel in the race to reach net zero targets across the globe. Turquoise hydrogen may offer one more way of hitting these targets faster and sooner, as well as being a sustainable business over the long term.

Hydrogen Europe

Stephen Jackson, Chief Technology & Market Officer for Hydrogen Europe, in relation to the third edition of Hydrogen Europe's Clean Hydrogen Monitor has said: "that it provides a window for stakeholders into the ins and outs of the sector's development in Europe. We hope you will find it useful as we continue to work towards our common goals. The time is now for the deployment of European hydrogen projects. We must turn our hydrogen plans from pipe dreams to pipelines, and we must do it fast." He recently added, "Turquoise hydrogen made from pyrolysis is an efficient, clean – potentially even carbon negative – and cost-effective production method that, if properly deployed, will play an important role in growing the hydrogen market and achieving our energy-transition goals."

Life Cycle Assessment

A Life Cycle Assessment, where evaluations are made of the cumulative environmental impact, for methane decomposition into hydrogen and carbon coproduction has been assessed throughout the years from an energetic and economic perspective, but rarely from an environmental perspective over a life cycle. Many advocate that this is vital in assessing whether turquoise hydrogen can play a significant role in the future and whether it could really be a "game changer" in meeting the net zero goals.

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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).

New structure of the AMPERE Newsletter

At a management meeting during AMPERE23 it was decided that in view of the introduction of the new scientific Journal entitled "European Journal of Microwave Energy" supported by CUP, no technical papers will be published in future Issues of the Newsletter. Instead, AMPERE welcomes submissions for short bios on individuals, articles, research proposals, projects, briefs as well as news.

AMPERE Disclaimer

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.

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