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The SIMPLI-DEMO project

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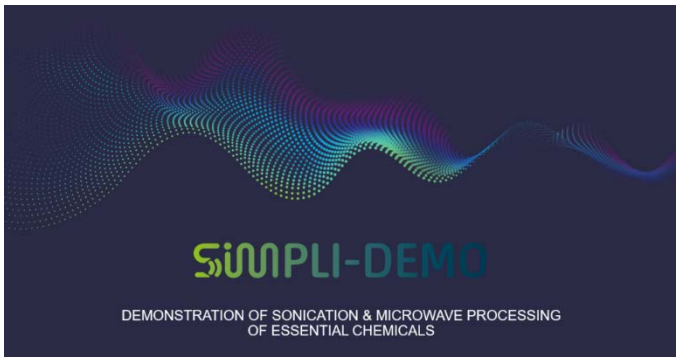

Aim

SIMPLI-DEMO – *Demonstration of Sonication and Microwave Processing of essential chemicals* – project aims at strengthening the chemical process industry and in particular the specialty chemicals and pharmaceuticals industries in its capacity to produce materials and chemicals in a sustainable and competitive way.

This contribution is made by moving from batch to continuous and modular production with flexibility being ensured by the application of alternative energy forms. Currently, the conventional technologies in the specialty and pharma sector tend to be batch-type. These technologies are combined with mechanical mixing and conduction-based heat transfer, inherently leading to poor process control. SIMPLI-DEMO's vision is that of intensified processes, where alternative energy sources enable flexible continuous technologies to achieve localized ultrasound and microwave actuation of multiphase, flow reactors powered by electricity from renewable sources for the purpose of high-value product synthesis.

SIMPLI-DEMO focuses on the synthesis of specialty polymers and particles for use in a wide variety of every-day-use products, e.g. insulation, paints and coatings, plastics, catalysts, as well as health applications, which are important domains in the chemical industry today and into the future. In this context the project follows an integrated approach along the targeted technology readiness level (TRL). SIMPLI-DEMO advances the TRL of modular flow technology for multiphase streams involving suspensions or viscous products from TRL5 (validation in relevant environment) to TRL7 (industrial system demonstration).

Concept

SIMPLI-DEMO's ambition is to present the first pilot-scale system prototype demonstration for the long-term uninterrupted modular flow operation of solids-laden and viscous-phase containing liquid process streams allowing for decentralized production. At the core of the project are four case-studies, serving as representatives for process classes of high importance in the chemical industry. The research relies on prior art up to at least TRL 4 (Experimental setup in the laboratory) to bring TRL from 5 (technology validated in relevant environment) at the start of the project to a level of 7 (industrial system prototype demonstration) at the end of the four-year project. The industrial demonstration stage will show uninterrupted production for several days to weeks, with an annual production rate of 10 to 100 ton/y.

Each of these case studies is of interest to one industrial end-user in the research consortium. The project will divide the research into two fields of application. Both in the reactive extrusion application field and in the reactive crystallization application field, the project will conduct two-case studies with a different TRL. The case studies are supported by generic and applied research on process modularity and process control & automation, including Process Analytical Technologies (PATs). In addition to the process technology oriented activities, the sustainability and techno-economic improvement is investigated that can be reached by transitioning from a batch process to a modular continuous process.

Innovation and technical progress in SIMPLI-DEMO

As an integral part of SIMPLI-DEMO's overall view of scale-up, this project uses the Modular Type Package (MTP) concept to take an innovative

modular approach to automation. MTP describes the module interfaces and functions needed for process control and for the digital integration of encapsulated equipment modules in higher-level control systems. A controller and the basic automation functionality of a modular equipment can be easily integrated into a heterogenous, vendor-independent system environment.

Within the automation engineering, the basic automation of a module can be implemented as a black box but offering service-oriented interfaces to higher-level control systems. The higher-level control systems orchestrate the modular plant units by coordinating and invoking the services provided by each module. Overall, the MTP concept paves the way of future-oriented open and flexible service-based system architectures for process control.

Disclaimer

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101058279.

For further reading

https://simpli-demo.eu/

About the author

Georgios Stefanidis is Professor at the National Technical University of Athens (NTUA). He holds a Diploma in Chemical Engineering from NTUA and a PhD degree in the same field from the University of Gent. He has co-authored over 100 peer review publications in the broad field of Process Intensification, mostly focusing on alternative energy forms and transfer mechanisms (mainly microwaves and plasma). He is currently one of the Editors of the Chemical Engineering and Processing: Process Intensification Journal (Elsevier), Vice-Chair of the EFCE Working Party on Process Intensification and serves on the scientific committee of the Association of Microwave Power in Europe for Research and Education (AMPERE).

The LEANFA company

Marco Fiore

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LEANFA is an Italian company founded in 2014, specialized in design and manufacturing of solid-state microwave and radiofrequency amplifiers and generators, that has recently joined the renowned MUEGGE Group. LEANFA's technology has already been widely validated by several universities and research centres worldwide, and its OEM microwave generators have progressively been adopted by demanding customers involved with projects in the industrial, scientific and medical fields. LEANFA's strong point is essentially its ability to work with a small and efficient team and to count on the great skills flexibility of its young engineering team.

LEANFA's work is constantly focused on grabbing the best of the great advantages of the innovative solid-state microwave technology, especially by means of suitable software platforms that 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.

LEANFA's OEM generators are compact, lightweight and highly reliable, perfect to be quickly integrated in equipment for applications in many ISM fields (e.g., solid-state cooking, microwave chemistry, plasma generation, organic tissue ablation, automotive ignition and many others), fully

based on steady solid-state technology with high power efficiency and total parametric control. All the modules are powered by low-voltage DC supply, tested for CW and pulsed power modes and enclosed in shielded metal cases, ready for forced-air or liquid cooling with minimum assembling effort.

LEANFA also offers user-friendly evaluation kits for a quick *plug&play* assessment of the new solid-state technology and compact benchtop generators for a trouble-free laboratory use, perfect for universities and research centres that need flexible and reliable tools for their experimentation programs.

The most recent and valuable developments are mainly focused on the medical world, where LEANFA has recently completed the development of complete medical-grade equipment based on radiofrequency, microwaves and laser technologies, combining high-quality hardware construction with sophisticated software design, in line with the relevant international standards.

About the author

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 telecommunications 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.

The Muegge Group

Markus Dingeldein

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The MUEGGE Group is a leading manufacturer and supplier of function-critical industrial microwave components, systems and plasma sources with a strong global presence.

Founded in 1979 and headquartered in Reichelsheim, Germany, the MUEGGE Group employs approximately 170 people and provides solutions for a wide range of industrial applications, such as growth of lab-grown diamonds, processing of food and semiconductor components, drying processes, molecular extraction in chemistry, and hydrogen production for customers in more than 40 countries.

To serve our global customer base close to their requirements, we rely on a network of partners and operate successfully in the American market with our subsidiary MUEGGE Gerling (formerly GERLING APPLIED ENGINEERING, INC). At present, about 25 employees work at the location in California including a production facility for customized magnetrons, isolators and waveguides. Our customers can also rely on a network of competent, specialized partners in Asia.

As a strong employer in our region, it is important for us to show responsibility for the environment. To reduce our CO_2 footprint, we installed a photovoltaic system on all three building roofs in 2022, with a total output of 200 kWp. MUEGGE is a founding member of the "Unternehmensnetzwerk Klimaschutz - Eine IHK-Plattform" (Network - Corporate Network Climate Protection (klima-plattform.de)) and a participant in the UN Global Compact in Germany (MUEGGE GmbH | UN Global Compact).

Thanks to its advanced and sustainable technologies, MUEGGE is a sought-after partner in a wide range of industries and is already contributing to solutions for future topics such as

Power-to-X or lab-grown diamonds for technical applications. A special role is played by MUEGGE Food Solutions, whose solutions raise food to a new level in terms of quality, shelf life, safety and resource conservation. For example, MUEGGE technology reduces food waste and creates new possibilities for packaging high-quality food sustainably (reduction of plastic).

With our new member of the MUEGGE Group LEANFA, we are now also working to have the right energy in the right place at the right time with solid-state technology. Once again, a warm welcome to the great LEANFA team!

Spotlight R&D

The CiMPAS Air pasteurization tool for ready meals with its specific antenna technology is a result of our strong R&D and engineering team. Beside modeling and design of antenna systems to optimize homogenous and efficient distribution of microwave into certain processes, we are taking the generators to the next level of I4.0 to push digitalization and optimize smart processes.

To support climate-sensitive and energy related demand for new, emerging technologies, the team is working on a variety of high-power microwave driven plasma sources. The existing sources are optimized to the maximum power level with optimized conversation rate and plasma stability. In addition to the internal further development of plasma sources, individual optimizations for the customer process take place in a large number of projects. Process ranges from 0.1 bar - 5 bar, flows from 10 l/min - several 1000 l/min, power levels from 0.5 kW -100 kW, many different process gas mixtures and flow characteristics are reached.

Novel plasma source and microwave antenna concepts are discussed, designed and tested in the team in order to promote innovation through new ideas in the application of microwaves and microwave plasmas to best serve future markets.

In addition to the further development of the plasma sources and microwave components themselves, the microwave generators at MUEGGE are also continuously developed in order to offer customers the latest technological possibilities, e.g.: Optimized process stability, controllability, operability, efficiency, digital integrability and uptime. Here, a strong software and a future-oriented power electronic department ensures the successful development.

MUEGGE and its R&D team maintain close relationships to several European universities and research institutions to jointly develop in future-oriented, promising technologies. Together with the partners, more efficient photovoltaic cells are developed in the German project PlasCon. In a second project called NexPlas, funded by the German Federal Ministry of Education and Research, CO_2 and H_2 are converted into CH_3OH and O using microwave plasma processes. The use of microwave energy in industrial chemical processes is being investigated in the European project SIMPLI-DEMO. MUEGGE also participates in various projects in an advisory capacity and picks up new impulses by participating in workshops, meetings, congresses and conferences and realizes the step from the idea in the laboratory to the commercially usable innovation with academic and industrial partners.

AMPERE is a great platform to bring academia and industry closer together, which is important to combine knowledge and demand from both sides. Spoken in microwave, a great power-combiner!

Moreover, AMPERE is a great network between European and Overseas countries, which is so important in today's world.

LEANFA's R&D team in Ruvo di Puglia is working on various medical devices such as medical multi-probe applications, in addition to solid-state modules. Promising developments enabled by the extreme flexibility of parametric control of solid-state generators include advanced volumetric control of multi-probe applications and self-regulated treatments driven by real-time feedback from thermal and electromagnetic sensors. Other applications include the treatment of bone-metastases with radiofrequency, pain therapy

and lung-cancer treatment with microwave ablation.

About the author

Markus Dingeldein, pioneer and expert in microwave technology, looks back on many years of experience in the company. Over the past 27 years, the electrical engineering graduate has held various management positions in operations and sales, most recently heading the global sales organization. In the future, he will drive further internationalization.

Ricky's Afterthought:

Processing of plastic waste revisited

A.C. (Ricky) Metaxas

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We use plastics at an accelerated rate. It is everywhere, packaging in shops and in industry, in hospitals and at home. The simple fact is that we cannot do without it and searching for alternative materials can be counter-productive because of the obvious benefits of plastics. However, the numbers are staggering. A recent report quotes that 400 Mt (million metric tonnes) of plastics are produced annually with Americans having generated some 220 kg per person in 2019 while the equivalent figure in Europe was 121kg. So it is evident that we have to manage this amount of plastic and after use not to damp it in landfills or in the sea which has adverse effect in marine life and its ecosystem.

By far the most used plastics are high density and low density polyethylene followed by polypropylene and polyvinyl chloride. Other plastics include polystyrene and polyethylene terephthalate are used to a lesser extent.

Back in the early 1980's when the "Yellow Bible" was published I wrote in Chapter 11 on Industrial Applications that pyrolysis using microwaves had been studied and specifically on page 312 microwave pyrolysis of coal in a discharge.

This Newsletter has on numerous occasions highlighted the work that emanated from the Chemical Engineering Dept at Cambridge University using high power microwaves for pyrolysis of a variety of plastic waste. This work has culminated in the company Enval which currently specialises in the processing of aluminium/plastic laminates in an applicator in the presence of carbon which acts as a catalyst absorbing the microwaves and imparting the energy to the laminates. Plastic laminate is lightweight and is preferred to other designs as it is flexible and protects the contents from oxygen, water and light. The amount of laminates that have to be processed in the UK is a staggering 160000 tonnes used in packaging of fruit juices, cosmetics and toothpaste.

The latest information is that SAIREM is supplying the magnetrons to power the propriety system. A typical Enval plant operates at a feed rate of up to 350 kg per hour, which roughly means it can process up to 2000 tonnes per annum. They collaborate with Kraft Heinz and Sonoko in the USA to investigate methods of plastic recycling and processing of the huge waste discussed above.

I am not suggesting that this is easy to achieve as I am aware that a lot of effort went into the various designs at the early stage culminating in the present system.

Conventional recycling still uses the process of pyrolysis to break down the waste to its molecular constituents by raising the temperature to hundreds of degrees C in a processor powered by gas. The main product is oil which can be refined to produce fuels or feedstock or indeed to produce more plastic. ExxonMobil announced that it was funding 13 chemical recycling units in the US capable of recycling 454000 tonnes of plastic by 2026.

I am aware that chemical recycling is not a term to be used often, as it conjures toxicity so an alternative way of expressing the same process is "advance recycling".

We must avoid just processing of waste using chemical recycling. A paper reviewing microwave pyrolysis was published recently advocating its advantages in view of diminishing fossil fuels and more to the point their escalating costs [1].

The question I am posing here is the following: with such vast amounts of plastic waste to be processed and with wholesale gas prices gone through the roof, could assisted microwave pyrolysis be once again considered by other AMPERE R&D centres in Europe as an alternative to considering conventional or advanced recycling?

For further reading

1. Review of microwave pyrolysis as a sustainable plastic waste management technique", Putri Humairah Monashofian Putra, Shaifulazuar Rozali, Muhamad Fazly Abdul Patah and Aida Idris, Journal of Environmental Management Available online 12 Dec 2021

Worldwide news in brief in the energy sector

*I hear that the first CO_2 to methanol plant has been commissioned in China. The plant uses 160000 tonnes/annum of CO_2 and produces 110000 tonnes/annum of methanol which is used as a feedstock.

*The EU commission is putting forward emergency regulation to fast track the deployment of renewable energy so that to reduce the reliance on Russian oil and gas. This will have the effect of accelerating the granting of permits and thus reducing the time for starting to build these projects.

*The first phase of a green hydrogen plant in Egypt has been commissioned and is financed by Fertiglobe, a strategic partnership between ADNOC (Abu Dhabi national Oil Company) and OCI (a producer of natural gas fertilizers and industrial chemicals) but also includes Egypt's sovereign fund. Fertiglobe is the largest seaborne exporter of urea and ammonia combined and based in Abu Dhabi, UAE. When fully operational it will deliver 150000 tonnes of Hydrogen, using its 100MW electrolysers powered by a combination of wind and solar power to the tune of 260 MW (see Newsletter Issue 107 June 2021)

*A company founded by Bill Gates in 2008, TetraPower concluded a $830m private equity raise for building a sodium fast reactor combined with a molten salt energy storage system, through its so called Natrium system. It will provide clean energy which can be very easily integrated into the power grids. Of course, it is worth stating that, when the reactor needs to be decommissioned the problem of storing the radioactive waste fuel remains.

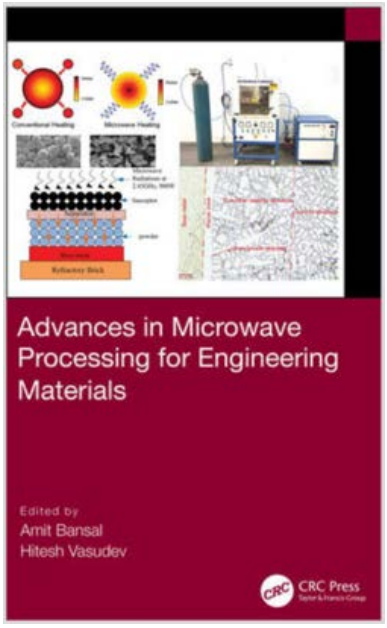
*Further to my Afterthought article in Issue 111 on the prospects of Nuclear Fusion: The Holy Grail of the Energy Crisis, the Financial Times in the UK first reported in mid Dec 2022 that 192 lasers fired their energy into a cylinder, its inner surface coated with gold. X-rays are emitted into the volume blasting a tiny pellet causing it to implode, compressing and heating up. This experiment was carried out at the National Ignition Facility at the Lawrence Livermore National Laboratory. This resulted in the release of 3.15 MJ of energy by using only 2.05MJ of laser energy to heat the fuel which was less than the diameter of a human hair. To put these vast energies into perspective the difference, 1.1MJ, is equivalent to 0.306 KWhr, a little over that which is needed to boil a kettle of water!

So the scientists claimed that for the first time more energy is released than used to produce a fusion reaction and hailed by many scientists working in this field as a tremendous breakthrough. As I understand it in this pulse-type experiment, the lasers

were fired for 100 trillionth of a sec or 10^{-10} s generating huge powers. Another aspect which has to be taken into account is the efficiency of producing the 2 MJ of laser energy bearing in mind that it required 300 MJ of input energy to get to that level of laser energy. Simply put, the lasers used were very inefficient. So this result, although significant as far as the proof of concept is concerned, scaling this to a functional fusion reactor is decades away. My personal belief is that the best way to achieve a workable fusion reactor would be to follow the Tokamak route, like the one presently being assembled near Toulouse in France and due ready for experimentation in 2025.

Book Review

A.C. Metaxas
Life Fellow St John's College Cambridge UK



Advances in Microwave Processing for Engineering Materials

Edited by Amit Bansal, Hitesh Vasudev
CRC Press, ebook published 30 Sept 2022, ISBN 9781003248743, pages 226.

This text discusses recent research techniques in the field of microwave processing of engineering materials by utilizing microwave radiation in the form of microwave hybrid heating (MHH). It is useful for industrial and household applications including the joining of materials, casting of bulk metal alloy material, drilling of borosilicate glass materials, development of cladding of different materials for friction, wear, and corrosion.
The book:

- Discusses the development of high-temperature resistant materials using microwave processing
- Covers the latest research development in microwave processing in the field of healthcare i.e. bio-medical implants
- Highlights concepts of microwave heating in joining, cladding, and casting of metallic materials
- Explains mechanisms of failure of materials and protection in a comprehensive manner
- Provide readers the knowledge of microwave processing of materials in major thrust areas of engineering applications

This book extensively highlights the latest advances in the field of microwave processing for engineering materials. It will serve as an ideal reference text for graduate students and academic researchers in the fields of materials science, manufacturing engineering, industrial engineering, mechanical engineering, and production engineering.
Chapter 3 of the book entitled "Microwave Drilling in sub-wavelength diameters" is written by AMPERE member Prof. Eli Jerby, who is also serving in the scientific committee of AMPERE.

Call for Papers

IMPI 57

Categories & Topics

IMPI 57 will bring together researchers, technologists, engineers and industry professionals from across the globe to share the latest research and developments in microwave and radio frequency power applications, including food technology, industrial applications, solid state, chemical, plasma, materials processing and emerging technologies. Topics include, but are not limited to:

FUNDAMENTALS AND MODELING

- Dielectric and Other Material Properties
- Dielectric Sensing and Imaging Techniques
- Modeling, CAD and Optimization

INDUSTRIAL PROCESS EQUIPMENT

- Industrial High Power Equipment and Process Control
- Solid State Microwave Technology
- Microwave Process Scale Up

INDUSTRIAL APPLICATIONS

- Biomedical & Medical Applications
- Microwave and Plasma Chemistry
- Chemical Engineering and Catalysis
- Hydrogen Technologies
- Biomass and Waste Processing
- Metallurgy and Mineral Processing
- Material Science and Engineering
- Biological and Environmental Applications
- Microwave Plasma Applications

FOOD SCIENCE & TECHNOLOGY

- Biological Applications
- Industrial RF & Microwave
- Processing of Food
- Microbiological Testing
- Microwavable Packaging
- Microwave Ovens: Design, Standards and Safety
- Product Validation
- Food & Agriculture
- Nutritions
- Trends in Microwave Cooking
- Food Safety Using Microwave Technology

RESEARCH AND EMERGING TECHNOLOGIES

- High Energy Research (e.g. accelerators)
- Wireless Power Transfer
- Directed Energy (e.g. weapons)
- Deep Space Applications (e.g. thrusters)

AMPERE 2023

19th International Conference on Microwave and High Frequency Applications (AMPERE 2023)

September 11-14 2023, Cardiff UK

High quality submissions will be invited to provide a full article, to be published in the inaugural edition of the new journal from AMPERE, to be launched in 2023.

Topics are focused on recent Advances in Microwave and HF applications including, but not limited to:

- Food Processing and Process intensification
- Biomass and waste processing
- Chemistry/biochemistry and processing
- Medical and Biological Applications
- Design of Applicators and Components
- Solid State Technology
- Dielectric and Magnetic Material Properties and Measurements
- Measurements and Metrology
- EM Modelling and Numerical Techniques
- Material interaction
- Industrial Equipment and Scale-up
- Frequency Sources and Power Supply Design
- Energy Production (including renewable energy and chemicals)
- Plasma phenomena and processing
- Terahertz and Millimetre Wave Applications

Important dates:

Submission of abstracts	March 10th
Acceptance notification	May 5th
Early bird rate ends	June 2nd
Registration for authors closes	June 30th
First day of conference	September 11th

To submit your abstract please visit our webpages at:
www.ampere2023.com

MS&T23, Rustum Roy Symposium

Meeting	**MS&T23: Materials Science & Technology**
Symposium	**Processing and Performance of Materials Using Microwaves, Electric and Magnetic Fields, Ultrasound, Lasers, and Mechanical Work – Rustum Roy Symposium**
Sponsorship	ACerS Basic Science Division ACerS Manufacturing Division
Organizer(s)	**Morsi Mohamed Mahmoud,** King Fahd University of Petroleum & Minerals **Dinesh Agrawal,** Pennsylvania State University **Guido Link,** Karlsruhe Institute of Technology **Motoyasu Sato,** Chubu University **Rishi Raj,** University of Colorado **Christina Wildfire,** National Energy Technology Laboratory **Zhiwei Peng,** Central South University
Scope	This symposium focuses on the discovery of novel processing methods, manufacturing, and performance of materials systems under the influence of microwaves, electric and magnetic fields (ac or dc), laser, ultrasound and mechanical energy. The symposium explores the fundamental science and mechanisms underlying these processing methods. Phenomena where electric and magnetic driving forces are coupled with mechanical and chemical effects will be emphasized especially at the system level. Sessions at the symposium will cover but not limited to the following topics: (i) Microwave Materials Processing, (ii) Electric Field Assisted Sintering, (iii) Phenomena in Li+ Batteries, (iv) Biological Phenomena in Electric and Magnetic fields, and (v) Microstructure Evolution and Phase Transformations under the influence of Electric and/or Magnetic fields.
Abstracts Due	04/03/2023
Proceedings Plan	Undecided

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.

AMPERE Newsletter is an ISSN registered periodical publication hence its articles are citable as references. However, the Newsletter's publication criteria may differ from that of common scientific Journals by its acceptance (and even encouragement) of news in more premature stages of on-going efforts.

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 Chief in the e-mail address below.

AMPERE Disclaimer

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