



IMPI's

55TH ANNUAL MICROWAVE POWER SYMPOSIUM (IMPI 55 VIRTUAL SYMPOSIUM)

June 28-July 1, 2021



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Presented by the
International Microwave Power Institute

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FEATURED SPEAKERS



Jon Binner
Keynote Speaker
University of
Birmingham, United
Kingdom



Ralph Bruce
Invited Speaker
RWBruce Associates,
LLC, USA



Candice Ellison
Invited Speaker
National Energy
Technology
Laboratory/LEIDOS,
USA



Matt Krieger
Invited Speaker
Cober Inc., USA



Satoshi Horikoshi
Invited Speaker
Sophia University,
Japan

EXHIBITORS



MONDAY, JUNE 28, 2021

All times shown are Eastern Daylight Savings Time; Exact times of presentations are subject to change.

10:00am - 1:00pm **SHORT COURSE: Solid State RF Energy Delivered** (Optional – additional fee)

Solid state RF energy offers very high-fidelity control over the properties of RF/microwave signals which are used to “process” loads inside applicators. Energy delivery dynamics range between micro Joules to mega Joules per process unit time. Control over frequency and phase is needed in order to get the RF power into the load; either via single channel frequency adaptive tuning or multi-channel, high power combining.

This workshop will introduce the necessary concepts of solid state RF energy generation; applicator types and RF power feeding architectures will be presented. Furthermore, control strategies for efficient and successful energy delivery for a range of applications/applicators will be shown. Amongst those are cooking, plasma generation, lighting, and small- and large-scale heating.

1:00pm - 1:30pm **BREAK**

1:30pm - 3:30pm **SOLID STATE RF ENERGY SECTION BUSINESS MEETING**

5:00pm - 7:00pm **Virtual Welcome Reception/Happy Hour**
VIRTUAL EXHIBIT HALL OPENS

TUESDAY, JUNE 29, 2021

8:30am - 9:00am **Virtual Coffee Break**

9:00am - 9:05am **Welcome & Introductions**
Bob Schiffmann, RF Schiffmann Associates, Inc. USA
Graham Brodie, University of Melbourne, Australia

SESSION: CERAMICS & INDUSTRIAL PROCESSING I

Session Chair: John F. Gerling, Gerling Consulting

9:05am - 9:50am **KEYNOTE ADDRESS: Creating Materials for High and Ultra-High Temperature Applications using Microwaves and RF**

Jon Binner, University of Birmingham, United Kingdom

There is an increasing demand for advanced materials, for aerospace and other applications, with temperature capability ranging from 1200oC to approaching 3000°C and able to survive highly corrosive environments whilst subject to intense heat fluxes and mechanical stresses. The interaction of environmental conditions together with the requirement that dimensional stability is maintained makes the selection of suitable materials extremely challenging. This paper discusses the design, development, manufacture and testing of ceramic matrix composites based on C and SiC fibres and with a matrix infiltrated by either RF- or microwave-heated chemical vapour infiltration (CVI). These composites will form a suite of materials suitable for application in severe aerospace environments.

TUESDAY, JUNE 29, 2021, CONTINUED

All times shown are Eastern Daylight Savings Time; Exact times of presentations are subject to change.

9:50am - 10:20am **INVITED: Preliminary Considerations for Microwave Consolidation/Sintering of Lunar Regolith Simulant**

Ralph W. Bruce, Ph.D.¹, Martin Barmatz, Ph.D.², Edwin Ethridge, Ph.D.¹, Michael R. Effinger³, Dan Hoppe, Ph.D.², John Huleis², William Kaukler, Ph.D.⁴, Tom Meek, Ph.D.¹, Doug Rickman, Ph.D.⁴, Javier Sanchez⁴ and Holly Shulman, Ph.D.⁵

¹RWBruce Associates, LLC, Joelton, TN, USA, ²Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, ³NASA-MSFC, Marshall Space Flight Center, AL, USA

⁴Jacobs Space Exploration Group, Huntsville, AL, USA, ⁵DrHollyShulman, LLC, Alfred, NY, USA

2.45 GHz microwaves have been applied to lunar regolith simulant JSC1-A resulting in densification. Simulations using COMSOL and HFSS validate this approach.

10:20am - 10:40am **Performance Validation and Life Expectancy Qualification of a 6kW, 2,450 MHz Magnetron at ~109% of its Maximum Rated Microwave Power**

Mohammad Kamarehi¹, Ken Trenholm¹, Francesco Braghiroli², Ilya Pokidov¹, Joe Desjardins¹, Francesco Garuti²

¹MKS Instruments / P&RGS, Wilmington, USA; ²MKS Instruments / Alter Products, Reggio Emilia, Italy

A selected 6kW magnetron was life tested at ~109% of its maximum rated microwave power for over 5,000 hours continuously. The evaluation was to validate the magnetron performance at higher rated power in order to deliver a true 6kW of power to the application loads. The results indicated that the magnetron operating parameters, such as efficiency, frequency, and filament integrity, changed by less than 1% of their original values.

10:40am - 11:00am **Kinetic study of microwave-assisted infrared drying of germinated lentils**

Tahereh Najib¹ and Venkatesh Meda¹ ¹University of Saskatchewan, Canada

The germinated lentils were dried by a microwave-infrared (MW-IR) oven with the maximum power of 700 and 750 W, respectively. The kinetic study shows that the Page model is the best thin-layer equation to describe drying at all MW/IR powers; and based on Fick's law although higher MW/IR powers give a higher diffusion coefficient, the balance between these powers is important in diffusion ability.

11:00am - 11:20am **Microwave assisted curing process for thermosetting polymers**

Carlos J. Cancio¹, Stephan Holtrup² and Klaus Werner²

¹Bodus GmbH, Aarau, Switzerland ²pinkRF, Nijmegen, Netherland

Solid state MW generators were used to irradiate polymer matrix based composite samples at 2.45 GHz. The samples were placed in a waveguide with an in-situ monitoring of the samples' surface temperature. A reduction in curing time compared to conventional methods was clearly observed. A microstrip test setup was used to determine the dielectric properties of the epoxy during the curing process.

11:20am - 11:30am **BREAK**

TUESDAY, JUNE 29, 2021, CONTINUED

All times shown are Eastern Daylight Savings Time; Exact times of presentations are subject to change.

11:30am - 1:00pm

Designing the Microwave Processing System: A Master Class

Robert F. Schiffmann¹, John F. Gerling² and Matt Krieger³

¹R.F. Schiffmann Associates, Inc; ²Gerling Consulting; ³Cober Electronics, USA

This discussion will describe all the components necessary for designing a properly operating industrial microwave processing system, including equipment for generating and applying microwave power, conveying products, tuning and protecting the equipment, etc. It will also describe the PLC/HMI systems and their components for monitoring the components and ensuring successful systems operations.

SESSION: AGRICULTURAL APPLICATIONS

Session Chair: Graham Brodie, University of Melbourne

7:30pm - 8:00pm

Virtual Meet & Greet

8:00pm - 8:20pm

Microwave treatment effect on faba bean and wheat grains' nutritive value as animal concentrate feed

M. S. R. Shishir^{1,3,*}, G. Brodie², B. Cullen², and L. Cheng¹

¹The University of Melbourne, Melbourne, Dookie Campus, VIC 3647, Australia.

²The University of Melbourne, Parkville, VIC 3010, Australia.

³Department of Animal Nutrition, Bangladesh Agricultural University, MYM 2202, Bangladesh

Faba bean and wheat grain were treated with 1.4 kW microwave oven (50%) operated in a frequency of 2.45 GHz for 0, 15-, 30-, 45- and 60-seconds, without adding water. The dry matter digestibility of faba bean and wheat grain increased by 7.4 and 0.5% without creating negative effects on other parameters at 30 and 15 second, respectively. This may improve nutrient utilization capacity of microwave treated faba bean and wheat for better animal production.

8:20pm - 8:40pm

Microwave Soil Disinfestation for Strawberry Production

Graham Ian Brodie¹, Muhammad Jamal Khan¹, and Scott Mattner²

¹ School of Agriculture and Food, The University of Melbourne, VIC, Australia

² Victorian Strawberry Industry Certification Authority, VIC, Australia

The banning of fumigants, like methyl bromide, has prompted an investigation of microwave soil disinfection. Although chemical fumigation provided the best results, microwave soil treatment was statistically similar to soil fumigation and statistically better than steam disinfection. Microwave treatment required far less energy than steam treatment.

8:40pm - 9:00pm

Microwave atmospheric plasma processed air and argon for disinfection of lentil from BGM

Saeedeh Taheri¹, Graham Ian Brodie¹, Dorin Gupta¹, and Mohan V. Jacob²

¹ School of Agriculture and Food, The University of Melbourne, VIC, Australia.

² College of Science and Engineering, James Cook University, QLD, Australia.

Plasma processed gas was obtained by a downstream microwave plasma with air and argon followed by the treatment of lentil inoculated with BGM. There was a 41% and 32.3% reduction in the contaminated seeds after treatments for 100s-24h holding time and 10s-60 min holding time in processed air and 30%air/70%argon, respectively. A holding time in the trapped gas was necessary for the decontamination of the seeds.

WEDNESDAY, JUNE 30, 2021

All times shown are Eastern Daylight Savings Time; Exact times of presentations are subject to change.

SESSION: DIELECTRIC PROPERTIES & FOOD PROCESSING

Session Chair: Vadim Yakovlev, Worcester Polytechnic Institute

8:30am - 9:00am

Interactive Coffee Break

9:00am - 9:30am

INVITED: Prediction of Material Dielectric Permittivity by Machine Learning

Candice Ellison^{1,2}, Robert Tempke^{1,3}, Shivani Panyda⁴, and Dushyant Shekhawat¹

¹National Energy Technology Laboratory, Morgantown, WV, United States

²Leidos Research Support Team, Morgantown, WV, United States

³West Virginia University, Morgantown, WV, United States

⁴Louisiana State University, Baton Rouge, LA, United States

A convolutional neural network (CNN) was developed to predict static dielectric permittivity of materials. Using an open source material properties database, data from 3379 oxide materials were used as training data for the CNN. Based on the crystal structure, material density, and chemical formula, the CNN was successfully able to predict static permittivity with $R^2=0.9996$

9:30am - 9:50am

Microwave Dielectric Properties of Marinated Chicken Breast Meat

S. Trabelsi, USDA-ARS, USA

Dielectric properties of marinated chicken breast meat were measured between 200 MHz and 20 GHz. Results show that the marinade pick up level can be determined from measurement of the dielectric loss factor at frequencies below 1 GHz.

9:50am - 10:10am

Use of novel microwave technology as a hurdle antimicrobial intervention to decontaminate Salmonella spp. in chicken breast

Darvin Cuellar¹, Don Stull², and Alejandro Echeverry¹

¹Texas Tech University, Lubbock, USA ²MicroZap, Lubbock, USA

The samples were inoculated with 1 ml of rifampicin resistant (RR) Salmonella spp. by pouring the inoculum on the surface; the inoculated samples were assigned to a negative Control (0 Kw·s), Treatment A (142.7 Kw·s), or Treatment B (124.5 Kw·s). The microwave Treatment A was the most effective at reducing the concentration of Salmonella RR in the inoculated chicken breast by more than 1 Log CFU/50g (> 90% of inoculated microbial population).

10:10am - 11:10am

EXHIBITOR & POSTER SESSION

SESSION: NEW TECHNOLOGIES

Session Chair: Klaus Werner, pinkRF

11:10am - 11:40am

INVITED: Industrial Microwave Heating and the Industrial Internet of Things (IIoT): Exploration of Technology and Business Opportunities

M. Krieger, Cober Inc., USA

The real time data collection capabilities afforded by Industrial Internet of Things (IIoT) connected devices and sensors can provide benefits including cost savings and higher quality product. IIoT technologies will be explained, and usage scenarios in industrial microwave heating applications will be covered along with business benefits. Implementation options will also be described.

WEDNESDAY, JUNE 30, 2021, CONTINUED

All times shown are Eastern Daylight Savings Time; Exact times of presentations are subject to change.

11:40am - 12:00pm **Effect of Dynamic Changing Frequency on the Microwave Heating Uniformity of Food in a Solid-State System**
R. Yang, J. Chen, University of Tennessee, USA

Gellan gum samples loaded in food trays were heated in a solid-state microwave system for 6 min with dynamically shifting frequency, and the top surface thermal images were used for assessment of heating uniformity. Compared with orderly-shifting strategies, a complementary shifting strategy, based on a proposed algorithm, achieved the best performance in terms of heating uniformity.

12:00pm - 12:20pm **Computational Characterization of a Millimeter-Wave Heat Exchanger with AlN:Mo Cylindrical Susceptors**

Catherine M. Hogan¹, Brad W. Hoff², Ian M. Rittersdorf³, and Vadim V. Yakovlev¹

¹Department of Mathematical Sciences, Worcester Polytechnic Institute, Worcester, MA, USA

²Air Force Research Laboratory, Albuquerque, NM, USA

³Naval Research Laboratory, Washington, DC, USA

Computational tests of a physical prototype of a MMW heat exchanger with 5 cylindrical susceptors made of AlN:Mo composite showed highest energy efficiency for 3-4% concentration of Mo by volume. Comparison with 4-, 9-, 16-cylinder layouts suggested by the highest density packing of equal circles in a square showed that all systems provide high level of uniformity of temperature distribution.

12:20pm - 1:00pm **SOLID STATE RF ENERGY SECTION PANEL**

THURSDAY, JULY 1, 2021

SESSION: MICROWAVE CHEMISTRY & INDUSTRIAL PROCESSING II

Session Chair: Ulrich Erle, Nestle R&D

8:30am - 9:00am **Interactive Coffee Break**

12:00pm - 12:20pm **INVITED: Green gel synthesis of microwave-induced plasma-in-liquid (MPL) and its application for on-site water treatment**

S. Horikoshi, Sophia University, Dept. of Material and Life Science, Japan

This study started with a completely unexpected discovery. In the synthesis of Ag nanoparticles using MPL, it was discovered that the polymer added as a protective agent turns into a gel (jelly) due to the MPL. This synthesis method has the advantage that it can be done without using highly toxic chemical substances. It has succeeded in recovering contaminated ions in water and elucidation of the gel formation mechanism.

THURSDAY, JULY 1, 2021, CONTINUED

All times shown are Eastern Daylight Savings Time; Exact times of presentations are subject to change.

- 9:30am - 9:50am **Effect on the microstructure of the dietary fiber of bagasse and sugarcane bud using an alkaline treatment with microwave-assisted sodium hydroxide**
María Elena Sánchez-Pardo¹, D. I. Llanes Gil-López^{2,3}, J. A. Lois-Correa²
¹Instituto Politécnico Nacional, ENCB-Zacatenco, Av. Wilfrido Massieu, 07728, Ciudad de México, México.
²Instituto Politécnico Nacional, CICATA-Altamira, km 14.5 carretera Tampico–Puerto Industria Altamira, Tamps., México, 89600
³Tecnológico Nacional de México, Instituto Tecnológico de Altamira, Tampico, Tamps.
- The sample-dissipated heat produces the rupture of walls and structures such as cellulose, hemicellulose and lignin. The microwave-assisted alkaline treatment produced physical changes. Due to the lignin bonds' breakdown, the formation of accumulations in the treated fibers was also observed. It is possible to use these delignified fibers as dietary fiber in food for human consumption.*
- 9:50am - 10:10am **Waste Processing Using Microwave Assisted Pyrolysis**
Scarlett Allende¹, Raviteja Challa¹, Graham Brodie^{1,2}, Mohan V. Jacob*¹
¹Electronics Material Lab, College of Science and Engineering, James Cook University, Townsville QLD 4811 Australia
²Dookie Campus, The University of Melbourne, 940 Nalinga Rd., Dookie, 3647, Australia
- Microwave Assisted pyrolysis is used to disintegrate biomass (approximately 180g of food waste mixed with 15% susceptor) and the by-product yield was studied as a function of microwave power (kW) and susceptor used. Increase in microwave power level and increase in the susceptor produces high biogas yield.*
- 10:10am - 10:30am **Microwave Analysis of the Thermal Properties of Seed Corn**
Robert F. Schiffmann, R.F. Schiffmann Associates Inc., USA
- In order to import seed corn, commonly used as animal feed, from certain countries into the USA, the Dept of Agriculture requires the destruction of germination. It can be accomplished by heating to a de-germination temperature. A laboratory microwave procedure is designed to determine the time & temperature required to achieve this goal.*
- 10:30am - 10:50am **Multimode Microwave Assisted Comminution of a Sulfide Ore: Bench Versus Pilot Scale**
John H. Forster¹, Adam E. Olmsted², Chris A. Pickles², Darryel Boucher¹, and Erin R. Bobicki¹
¹University of Toronto, Toronto, Canada ²Queen's University, Kingston, Canada
- Samples of a sulfide ore were irradiated by low power (3.2 kW, 2450 MHz) and high power microwave (150 kW, 915 MHz) systems to assess changes in ore competency and draw conclusions on scale-up requirements. The energy input required in comminution could be reduced by over 10%, and further optimization will allow for improvement of the current results and incentivize scale-up of the technology.*
- 10:50am - 11:50am **EXHIBITOR & POSTER SESSION**

THURSDAY, JULY 1, 2021, CONTINUED

All times shown are Eastern Daylight Savings Time; Exact times of presentations are subject to change.

SESSION: SPECIAL PRESENTATIONS

Session Chair: Bob Schiffmann, R.F. Schiffmann Associates Inc.

11:50am - 12:20pm **Industrial Microwave Processing Activities in China**
John Yang, Shandong Jiawei Trading Co., Ltd., China

12:20pm - 12:45pm **Microwave Child Resistant Oven Door**
Randy Cooper, Association of Home Appliance Manufacturers (AHAM), USA

The presenter will walk through the timeline and development process on how the industry developed the requirements. The proposal was published in 2019 with a 2023 effectivity date.

12:45pm - 1:00pm **CLOSING CEREMONY & AWARDS**

POSTER PRESENTATIONS

Alkaline treatment with microwave-assisted of sugar cane for increasing nutraceutical properties

María Elena Sánchez-Pardo¹, D. I. Llanes Gil-López^{2,3}, J. A. Lois-Correa²

¹Instituto Politécnico Nacional, ENCB-Zacatenco, Av. Wilfrido Massieu, 07728, Ciudad de México, México.

²Instituto Politécnico Nacional, CICATA-Altamira, km 14.5 carretera Tampico–Puerto Industria Altamira, Tamps., México, 89600

³Tecnológico Nacional de México, Instituto Tecnológico de Altamira, Tampico, Tamps.

Sugarcane bagasse contributes a source of dietary fiber, antioxidants such as polyphenol and policosanol. The alkaline treatment with microwave-assisted flour was evaluated by confocal laser scanning microscopy; starch granules and cellulose were observed. An 8% increase in antioxidants was achieved in the formulation with corn flour-SCB; this mix provides dietary fiber and antioxidants.

Additionally, many oral presentations will be offered as Posters as well. Those will be updated here in a future version of the Schedule of Events.

	MEMBER FEE	NON-MEMBER FEE
Professional: Full Symposium Registration Fee	\$150.00	\$250.00
Professional: One Day Registration Fee	\$100.00	\$150.00
Student: Full Symposium Registration Fee	\$75.00	\$100.00
Student: One Day Registration Fee	\$50.00	\$75.00
Virtual Exhibitor (Includes one full registration to the event)	\$250.00	\$500.00
Short Course (Optional Add-on)	\$150	\$250

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Special thanks to the IMPI 55 Technical Program Committee for their dedication to this Symposium:

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Bob Schiffmann, R.F. Schiffmann Associates Inc., USA

Juming Tang, Washington State University, USA

SAVE THE DATES

IMPI Fall Seminar

October 19-21, 2021

Protein Innovation Center, Elk Grove Village, IL, USA

Hybrid Event with in-person and virtual attendance options

Hosted by the Middleby Corporation

The 56th Annual Microwave Power Symposium (IMPI 56)

June 14-16, 2022

The DeSoto Hotel, Savannah, Georgia, USA