

**2011 IEEE MTT-S International Microwave Workshop Series
on Innovative Wireless Power Transmission:
Technologies, Systems, and Applications**

IMWS-IWPT 2011

**May 12-13, 2011,
Oubaku Plaza, Uji Campus, Kyoto University, Uji, Kyoto, Japan**

Advance Program



**Sponsored by
IEEE Microwave Theory and Techniques Society**

**Supported by
Research Institute for Sustainable Humanosphere,**



IMWS-IWPT2011 Program at a Glance

May 12 (THU)

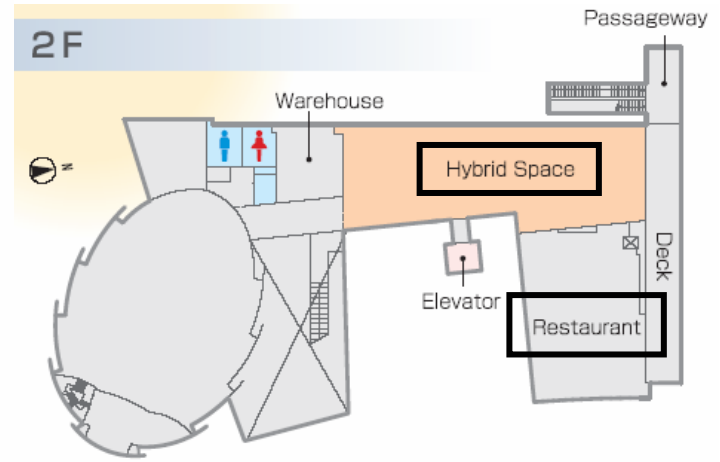
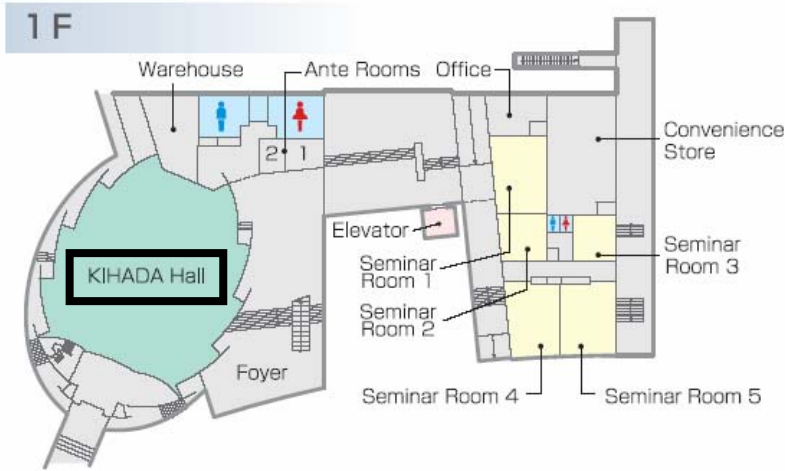
	KIHADA Hall	Hybrid Space	
9:00	Opening Remarks		
9:20	Keynote Speech 1		
10:10	Break		
10:20	Keynote Speech 2		
11:10	Keynote Speech 3		
12:00	Lunch		
13:00	Session 1: Rectennas		
14:20	Session 2: Circuit and Device		
15:40	Break		
16:00	Session 3: Long Distance WPT Applications		
17:40	Session 4: Short Distance WPT Applications		
18:40			
19:00	Banquet (Restaurant)		
21:00			

May 13 (FRI)

	KIHADA Hall	Hybrid Space
8:50	Session 5-1: Radio Management and Regulations	
9:50	Session 5-2: Biological Effects and EMC Control	
11:10	Break	
11:30	Session 6: Coupling	
13:10	Lunch	
14:20	Session 7: Improved Antenna Design Considerations for New Applications	
15:20	Session 8: Phased Array	
16:40	Break	
17:00	Session 9: Other Applications	
18:00	Session 10: Microwave Rockets as a Low-Cost Interface to Space	
19:00		Poster Session (12:40-14:20)
19:20	Closing	
19:40		

CONFERENCE ROOMS

Oubaku Plaza



宇治キャンパス Uji Campus

宇治キャンパス内の組織の略称
Abbreviation of Uji Campus Organization

生存研 RISH 生存圏研究所
Research Institute for Sustainable Humanosphere

1. Main Gate (Closed)
2. Uji Campus Main Bldg. (HM, HS)
Administration Office of Uji Campus
3. Uji Research Bldg. (HW)
4. Wood Composite Hall (HH)
5. Deterioration Organisms Laboratory
Woodworking Shop
6. Xylarium
7. Solar Power Station/Satellite Laboratory
8. Microwave Energy Transmission Laboratory
9. Electromagnetic Wave Laboratory



Technical Program

Thursday, 12 May, 2011

Plenary Session

KIHADA Hall 9:00 - 12:00

Thursday, 12 May, 2011

9:00-9:20

Opening Remarks: Prof. Naoki Shinohara, *Kyoto University, Japan*

Chair: Yohei Ishikawa, *Murata Corporation, Japan*

9:20-10:10

IWPT-PL-1 (Keynote Speech 1) **Wireless Power Transmission Technologies for Solar Power Satellite**
Susumu Sasaki, Koji Tanaka, and Advanced Mission Research Group, *JAXA, Japan*

10:20-11:10

IWPT-PL-2 (Keynote Speech 2) **Resonant Magnetic Field Technology for High Power and Enhanced Efficiency Wireless Power Transfer**
Prof. Joungho Kim, *KAIST, Korea*

11:10-12:00

IWPT-PL-3 (Keynote Speech 3) **Cytogenetic Studies in Mammalian Somatic Cells Exposed to Electromagnetic Fields: A Meta-Analysis**
Vijayalaxmi and Thomas J. Prihoda, *University of Texas Health Science Center, USA*

Session 1: Rectenna

KIHADA Hall 13:00 - 14:20

Thursday, 12 May, 2011

Chairs: Kenji Itoh, *Kanazawa Institute of Technology, Japan*
Shigeji Nogi, *Okayama University, Japan*

IWPT1-1 (Invited) **Innovative Antenna Systems for Efficient Microwave Power Collection**
Giorgio Franceschetti, Andrea Massa, and Paolo Rocca, *University of Trento, Italy*

IWPT1-2 **Efficiency and harmonics generation in microwave to DC conversion circuits of half-wave and full-wave rectifier types**
Shohei Imai, Shoichi Tamaru, Kazuhiro Fujimori, Minoru Sanagi, and Shigeji Nogi, *Okayama University, Japan*

IWPT1-3 **5.8GHz High Sensitivity Rectenna Array**
¹Kazuhiro Nishida, ¹Yuhei Taniguchi, ¹Kenji Kawakami, ¹Yukihiro Homma, ¹Hiroyuki Mizutani, ¹Moriyasu Miyazaki, ¹Hiroshi Ikematsu, and ²Naoki Shinohara, ¹*Mitsubishi Electric Corporation, Japan*, ²*Kyoto University, Japan*

IWPT1-4 **An Improved Detector Topology for a Rectenna**
Steve Eden Fila Mbombolo and Chan Wang Park, *Université du Québec à Rimouski, Canada*

Session 2: Circuit and Device
KIHADA Hall 14:20 - 15:40
Thursday, 12 May, 2011

Chair: Yasuo Ohno, *Tokushima University, Japan*

IWPT2-1 **Distributed Class-F/Inverse Class-F Circuit Considering up to Arbitrary Harmonics with Parasitics Compensation**

Ryo Ishikawa and Kazuhiko Honjo, *The University of Electro-Communications, Japan*

IWPT2-2 **Power Transmission through Insulating Plate Using Open-Ring Resonator Coupling and GaN Schottky Diode**

Kenji Harauchi¹, Yuichi Iwasaki¹, Mami Abe¹, Jin-Ping Ao¹, Naoki Shinohara², Hiroshi Tonomura³ and Yasuo Ohno¹, ¹*The University of Tokushima, Japan*, ²*Kyoto University, Japan*, ³*UD Trucks Corporation, Japan*

IWPT2-3 **Control of Turn-on Voltage in GaN Schottky Barrier Diode Using Zr/Al/Mo/Au Metal Stack**

H. Tokuda¹, F. Watanabe¹, A. Syahiman¹, M. Kuzuhara¹, and T. Fujiwara², ¹*University of Fukui, Japan*
²*Sho Engineering Corp., Japan*

IWPT2-4 **Internally-matched GaN HEMT High Efficiency Power Amplifier for SPS**

Yoshinori Tsuyama¹, Koji Yamanaka¹, Koji Namura¹, Shin Chaki¹, and Naoki Shinohara², ¹*Mitsubishi Electric Corporation, Japan*, ²*Kyoto University, Japan*

Session 3: Long Distance WPT Applications

KIHADA Hall 16:00 - 17:40
Thursday, 12 May, 2011

Chair: Yoshiyuki Fujino, *NICT, Japan*

IWPT3-1 **Outline and Progress of the Japanese Microwave Energy Transmission Program for SSPS**

Yoshiharu Fuse¹, Takashi Saito¹, Shoichiro Mihara¹, Koichi Ijichi¹, Koji Namura², Yukihiro Honma², Takuro Sasaki², Yuichiro Ozawa³, Eiichiro Fujiwara³, and Teruo Fujiwara³, ¹*Institute for Unmanned Space Experiment Free Flyer, Japan*, ²*Mitsubishi Electric Co., Japan*, ³*IHI Aerospace Co., Ltd., Japan*

IWPT3-2 **Wireless Power Transmission using Modulated Microwave**

Mai Ishiba, Jun Ishida, Kimiya Komurasaki, and Yoshihiro Arakawa, *The University of Tokyo, Japan*

IWPT3-3 **Novel Wireless Impulsive Power Transmission to Enhance the Conversion Efficiency for Low Input Power**

Chun-Chih Lo, Yu-Lin Yang, Chi-Lin Tsai, Chieh-Sen Lee, and Chin-Lung Yang, *National Cheng Kung University, Taiwan, R.O.C.*

IWPT3-4 **New Phased Array and Rectenna Array Systems for Microwave Power Transmission Research**

Yukihiro Homma¹, Takuro Sasaki¹, Koji Namura¹, Fuminori Sameshima¹, Tsuyoshi Ishikawa¹, Hiroki Sumino¹, and Naoki Shinohara², ¹*Mitsubishi Electric Corporation, Japan*, ²*Kyoto University, Japan*

IWPT3-5 **Study on a Microwave Power Transmitting System for Mars Observation Airplane**

Akihito Nagahama¹, Tomohiko Mitani¹, Naoki Shinohara¹, Naoki Tsuji², Keita Fukuda², Yoshitaka Kanari², and Koichi Yonemoto², ¹*Kyoto University, Japan*, ²*Kyushu Institute of Technology, Japan*

Session 4: Short Distance WPT Applications

KIHADA Hall 17:40 - 18:40

Thursday, 12 May, 2011

Chairs: Hai-Young Lee, *Korea*
Tomohiro Seki, *NTT, Japan*

IWPT4-1 **Wireless Power Transmission System by Tightly Coupled Microstrip Line Overlay Resonators**
Hiroyuki Arai and Naoki Yoneyama, *Yokohama National University, Japan*

IWPT4-2 **High Efficiency Midrange Wireless Power Transfer System**
Jaime Garnica¹, Joaquin Cassanova², and Jenshan Lin¹, ¹*University of Florida, U.S.A.*, ²*Conservation and Production Research Laboratory, USDA, U.S.A.*

IWPT4-3 **Power Transfer for a Running Automobile**
Masahiro Hanazawa¹ and Takashi Ohira², ¹*Toyota Central R & D Labs., Inc., Japan*, ²*Toyohashi University of Technology, Japan*

Friday, 13 May, 2011

Session 5-1: Radio Management and Regulations

KIHADA Hall 8:50 - 9:50

Friday, 13 May, 2011

Chairs: Toshio Nojima, *Hokkaido University, Japan*
Junji Miyakoshi, *Kyoto University, Japan*

IWPT5-1-1 **Frequency Allocations of Solar Power Satellite and International Activities**

Kozo Hashimoto^{1,2}, ¹*The Paleological Association of Japan, Inc., Japan*, ²*Kyoto University, Japan*

IWPT5-1-2 **Issues and Initiatives for Practical Use of Wireless Power Transmission Technologies in Japan**

Hiroki Shoki, *Toshiba Corporation*

IWPT5-1-3 **Activities of Energy Harvesting Consortium in Japan**

Keiji Takeuchi, *NTT Data Institute of Management Consulting, Inc., Japan*

Session 5-2: Biological Effects and EMC Control

KIHADA Hall 9:50 - 11:10

Friday, 13 May, 2011

Chairs: Toshio Nojima, *Hokkaido University, Japan*
Junji Miyakoshi, *Kyoto University, Japan*

IWPT5-2-1 (Invited) **Possible EMC Regulations for Wireless Power Transmission Equipment**

Yukio Yamanaka and Akira Sugiura, *National Institute of Information and Communications Technology, Japan*

IWPT5-2-2 (Invited) **Practical method to evaluate electromagnetic interference in active implantable medical devices**

Takeshi Toyoshima, *Medtronic Japan Co., Ltd., Japan*

IWPT5-2-3 **Microarray Analysis of Human-derived Glial Cells Exposed to 2.45 GHz Microwave**

Tomonori Sakurai¹, Eijiro Narita¹, Yukihisa Suzuki², Masao Taki², and Junji Miyakoshi¹, ¹*Kyoto University, Japan*, ²*Tokyo Metropolitan University, Japan*

IWPT5-2-4 **Active Implantable Medical Device EMI Assessments for Electromagnetic Emitters Operating at various RF Bands**

Takashi Hikage¹, Yoshifumi Kawamura¹, Toshio Nojima¹, Ben Koike², Hiroshi Fujimoto³, and Takeshi Toyoshima³, ¹*Hokkaido University, Japan*, ²*Japan Automatic Identification Systems Association, Japan*, ³*Medtronic Japan Co., Ltd., Japan*

Session 6: Coupling

KIHADA Hall 11:30 - 13:10

Friday, 13 May, 2011

Chairs: Jenshan Lin, *University of Florida, USA*
Ikuo Awai, *Ryukoku University, Japan*

IWPT6-1 (Invited) **Classification and Characterization of Wireless Power Transfer Systems of Resonance Method Based on Equivalent Circuit Derived from Even and Odd Mode Reactance Functions**

Naoki Inagaki¹ and Satoshi Hori², ¹*Nagoya Institute of Technology, Japan*, ²*Kojima Press Industry Co., Ltd., Japan*

- IWPT6-2 **Broadband and Strong Coupling Metamaterial-Based Cavity Resonator Using Artificial Magnetic Surfaces**
Chong-Yi Liou, Chi-Jung Kuo, Jen-Chun Yeh, Yu-Zhi Chueh and Shau-Gang Mao, *National Taipei University of Technology, Taiwan, R.O.C.*
- IWPT6-3 **Design and Experiment of Multi-stage Resonator-coupled WPT System**
Ikuo Awai, Takuya Komori and Toshio Ishizaki, *Ryukoku University, Japan*
- IWPT6-4 **Efficiency of magnetic resonance WPT with two off-axis self-resonators**
Jin-Wook Kim, Hyeon-Chang Son, and Young-Jin Park, *University of Science & Technology (UST), Korea, Korea Electrotechnology Research Institute (KERI), Korea*
- IWPT6-5 **Wireless Power Transfer System with a Simple Receiver Coil**
Takashi Miyamoto, Shinji Komiyama, Hiroyuki Mita and Kenichi Fujimaki, *Sony Corporation, Japan*

Session 7: Improved Antenna Design Considerations for New Applications

KIHADA Hall 14:20 - 15:20

Friday, 13 May, 2011

Chair: Koichi Ogawa, *The University of Toyama, Japan*

- IWPT7-1 (Invited) **Electromagnetic Field Focusing for Short-Range Wireless Power Transmission**
Ada S. Y. Poon, *Stanford University, USA*
- IWPT7-2 **A Feasibility Study of Wireless Power Transmission System by using Two Independent Coupled Electric Fields**
Koichi Tsunekawa, *Chubu University, Japan*
- IWPT7-3 **Design of Receiving Antenna for Microwave Power Transmission to Capsular Endoscope**
Toshihiro Kumagai, Kazuyuki Saito, Masaharu Takahashi, and Koichi Ito, *Chiba University, Japan*

Session 8: Phased Array

KIHADA Hall 15:20 - 16:40

Friday, 13 May, 2011

Chairs: Andrea Massa, *University of Trento, Italy*
Masanobu Yajima, *JAXA, Japan*

- IWPT8-1 (Invited) **Innovative Array Designs for Wireless Power Transmission**
Paolo Rocca, Giacomo Oliveri, and Andrea Massa, *University of Trento, Italy*
- IWPT8-2 **Study on Optimization of Microwave Power Beam of Phased Array Antenna for SPS**
Takaki Ishikawa and Naoki Shinohara, *Kyoto University, Japan*
- IWPT8-3 **Development of Phased Array for High Accurate Microwave Power Transmission**
Tomohiro Takahashi¹, Tomohiro Mizuno¹, Manabu Sawa¹, Takuro Sasaki¹, Toru Takahashi¹, and Naoki Shinohara², ¹*Mitsubishi Electric Corporation, Japan*, ²*Kyoto University, Japan*
- IWPT8-4 **An FPGA Implementation of Complex Valued Independent Component Analysis for Real-Time Interference Canceler**
Hidehisa Shiomi, Shunsuke Fujio and Yasuyuki Okamura, *Osaka University, Japan*

Session 9: Other Applications
KIHADA Hall 17:00 - 18:00
Friday, 13 May, 2011

Chair: Kazuo Satoh, *Toyota Central R&D Laboratory, Inc., Japan*

- IWPT9-1 **HEMS with Resonant-type Wireless Power Transmission**
Takashi Yoshikawa and Ikuo Awai, *Ryukoku University, Japan*
- IWPT9-2 **Development of Highly Efficient Transducer for Wireless Power Transmission System by Ultrasonic**
Yusuke Shigeta, Yuki Hori, Kazuhiro Fujimori, Kenji Tsuruta, and Shigeji Nogi, *Okayama University, Japan*
- IWPT9-3 **Efficiency Improvement of the Impulsive Wireless Power Transmission through Biomedical Tissues by Varying the Duty Cycle**
Yu-Lin Yang, Chin-Lung Yang, Chi-Lin Tsai, and Chieh-Sen Lee, *National Cheng Kung University, Taiwan, R.O.C.*

Session 10: Microwave Rockets as a Low-Cost Interface to Space
KIHADA Hall 18:00 - 19:00
Friday, 13 May, 2011

Chair: Kimiya Komurasaki, *The University of Tokyo, Japan*

- IWPT10-1 **An Experimental Study on High Power Millimeter Wave Beam Transmission for Microwave Beaming Propulsion**
Yasuhisa Oda¹, Toshikazu Yamaguchi², Kimiya Komurasaki², Ken Kajiwara¹, Koji Takahashi¹, and Keishi Sakamoto¹, ¹*Japan Atomic Energy Agency, Japan*, ²*The University of Tokyo, Japan*
- IWPT10-2 **Development of Microwave Rocket as a Space Mass Transportation System**
Reiji Komatsu¹, Masafumi Fukunari¹, Toshikazu Yamaguchi¹, Kimiya Komurasaki¹, Yoshihiro Arakawa¹, Yasuhisa Oda², Keishi Sakamoto², Ikko Funaki³, Hiroshi Katsurayama⁴, ¹*The University of Tokyo, Japan*, ²*Japan Atomic Energy Agency, Japan*, ³*Japan Aerospace Exploration Agency, Japan*, ⁴*Yamaguchi University, Japan*
- IWPT10-3 **Interaction between Shock Wave and Plasma Region Ionized by Millimeter Wave Beam and Its Application to Pulse Detonation System as a Microwave Rocket**
Toshikazu Yamaguchi¹, Reiji Komatsu¹, Kimiya Komurasaki¹, Yasuhisa Oda², Ken Kajiwara², Koji Takahashi², and Keishi Sakamoto², ¹*The University of Tokyo, Japan*, ²*Japan Atomic Energy Agency, Japan*

Poster Session
Hybrid Space (2nd Floor) 12:40 - 14:20
Friday, 13 May, 2011

- IWPT-P-1 **System Consideration of Solar Power Satellite using Functional Models**
Koji Tanaka¹, Tatsuhito Fujita¹, Satoshi Yamaguchi², Shintaro Hamada³, Kengo Miyashiro³, and Susumu Sasaki¹, ¹*Japan Aerospace Exploration Agency, Japan*, ²*Tokyo Institute of Technology, Japan*, ³*Tokyo University of Science, Japan*
- IWPT-P-2 **Analysis on Transmission Efficiency of Wireless Energy Transmission Resonator Based on Magnetic Resonance**
Jaewon Choi, Jun-Kyung Cho, and Chulhun Seo, *Soongsil University, Korea*

- IWPT-P-3 **One-Dimensional Proximity Power Transmission Using Ribbon-Like Waveguide and Bar-Type High-Q Resonant Receiver Coupler**
Akihito Noda and Hiroyuki Shinoda, *The University of Tokyo, Japan*
- IWPT-P-4 **Acoustic Lens using Sonic Crystal for Energy-Transmission Applications**
Yusuke Kanno, Yuuki Kasai, Kenji Tsuruta, Kazuhiro Fujimori, Hideki Fukano, and Shigeji Nogi, *Okayama University, Japan*
- IWPT-P-5 **Measurement of resonator parameters for wireless power transmission system**
Tetsuya Ishida, Ikuo Awai, and Issei Sugiyama, *Ryukoku University, Japan*
- IWPT-P-6 **Effects of Exposure to A High-Frequency Electromagnetic Field at 2.45 GHz on Neurite Outgrowth in PC12VG Cells**
Eijiro Narita¹, Tomonori Sakurai¹ Yukihisa Suzuki², Masao Taki², and Junji Miyakoshi¹, ¹*Kyoto University, Japan*, ²*Tokyo Metropolitan University, Japan*
- IWPT-P-7 **A Numerical Study of Power Loss Factors in Resonant Magnetic Coupling**
Satoshi Shimokawa, Hiroyasu Kawano, Kiyoto Matsui, Akiyoshi Uchida and Masakazu Taguchi, *Fujitsu Laboratories Limited, Japan*
- IWPT-P-8 **Arbitrarily-shaped-beam microstrip reflectarray based on phase-retrieval method**
A. Kobayashi, H. Deguchi, M. Tsuji, and S. Kurihara, *Doshisha University, Japan*
- IWPT-P-9 **Development of High Accuracy Phase Control Method for Space Solar Power System**
Takanori Narita¹, Tomohisa Kimura¹, Kenichi Anma¹, Nobuhiko Fukuda¹, and Naoki Shinohara², ¹*Mitsubishi Heavy Industries, Japan*, ²*Kyoto University, Japan*
- IWPT-P-10 **Development Status of Beam Steering Control Subsystem for Microwave Power Transmission Ground Experiment**
Takehiro Miyakawa¹, Masanobu Yajima¹, Yasuyuki Fukumuro¹, Susumu Sasaki¹, Takuro Sasaki², Yukihiko Homma², and Koji Namura², ¹*Japan Aerospace Exploration Agency (JAXA), Japan*, ²*Mitsubishi Electric Corporation, Japan*
- IWPT-P-11 **Array Calibration Techniques for DOA Estimation with Arbitrary Array Using Root-MUSIC Algorithm**
Yoshiki Takahashi, Hiroyuki Yamada and Yoshio Yamaguchi, *Niigata University, Japan*
- IWPT-P-12 **Equivalent Circuit of Induction Fed Magnetic Resonant WPT System**
Hiroshi Hirayama, Yuki Okuyama, Nobuyoshi Kikuma, and Kunio Sakakibara, *Nagoya Institute of Technology, Japan*
- IWPT-P-13 **A Novel Concept for 2-Dimensional Free-Access Wireless Power Transfer System Using Asymmetric Coupling Resonators with Different Sizes**
Toshio Ishizaki, Daisuke Fukada and Ikuo Awai, *Ryukoku University, Japan*
- IWPT-P-14 **Optimal Designs for Wireless Resonant Energy Link with Symmetrical Coil Pair**
Hisayoshi Sugiyama, *Osaka City University, Japan*
- IWPT-P-15 **Development of Class-F Load Rectennas**
Ken Hatano¹, Naoki Shinohara¹, Tomoniko Mitani¹, Kenjiro Nishikawa², Tomohiro Seki², and Ken Hiraga², ¹*Kyoto University, Japan*, ²*NTT Corporation, Japan*
- IWPT-P-16 **Fundamentals of the Bridge RF Rectifier with an impedance transformer**
Tsunehiro Saen¹, Kenji Itoh¹, Shin-ichi Betsudan¹, Shigeru Makino¹, Tetsuo Hirota¹, Keisukei Noguchi¹, and Mitsuhiro Shimozawa², ¹*Kanazawa Institute of Technology, Japan*, ²*Mitsubishi Electric Corporation, Japan*

- IWPT-P-17 **Metamaterial Microwave Transmission-Line on Si-Wafer Utilizing a Semiconductor Integration Technology for WPT Modules**
Daichi Hirahara, Hirofumi Noji, Masakazu Hori, Makoto Mita and Shigeo Kawasaki, *Japan Aerospace Exploration Agency (JAXA), Japan*
- IWPT-P-18 **Phase Control System of SSPS -Automatic Correction of Phase Variations Generated at Power Amplifier-**
Yuichiro Ozawa¹, Takahiro Hirano¹, Eiichiro Fujiwara¹, and Teruo Fujiwara¹, and Naoki Shinohara²,
¹*IHI AEROSPACE Co., Ltd., Japan*, ²*Kyoto University, Japan*
- IWPT-P-19 **High Power and High Efficiency GaN-HEMT for Microwave Communication Applications**
Kazutaka Inoue¹, Norihiko Ui² and Seigo Sano¹, ¹*Sumitomo Electric Industries Ltd., Japan*, ²*Sumitomo Electric Device Innovations, Inc., Japan*
- IWPT-P-20 **Developing GaN HEMTs for High Efficiency**
Kazutaka Takagi, Keiichi Matsushita, Kazutoshi Masuda, Shinichiro Nakanishi, Tomohide Soejima, Hiroyuki Sakurai, Ken Onodera, Jeoungchill Shim, Hisao Kawasaki, Yoshiharu Takada, Mayumi Hirose and Kunio Tsuda, *Toshiba Corporation, Japan*