Poster 2

April 30 (Tuesday) / 15:10 ~ 16:30 / Capri room

Gyrotrons

P2-1.1 / Influence of different magnetic field profiles on gyrotron

Xuewei Wang (University of Chinese Academy of Science, China), Qianzhong Xue (University of Chinese Academy of Science, China), Shan Zhang (University of Chinese Academy of Science, China)

As we all know, external magnetic field can affect the efficiency of beam mode interaction in gyrotron. This paper puts forward three kinds of magnetic field profile and compares their influence on cavity mode in a 394 GHz gyrotron.

P2-1.2 / Design of a Triode MIG for 140GHz Gyrotron Oscillator

He Zhu (University of Chinese Academy of Sciences / Chinese Academy of Sciences, China) Wei Guo (University of Chinese Academy of Sciences, China), Min Zhu (University of Chinese Academy of Sciences, China), Jirun Luo (University of Chinese Academy of Sciences / Chinese Academy of Sciences, China)

This abstract designed a triode magnetron injection gun (MIG) for the 140GHz 1MW $TE_{28,8}$-mode gyrotron oscillator. The electron beam produced by the MIG can operate at accelerating voltage 80kV and current of 40A. The guiding center of the electron beam at the cavity is 10.1mm, corresponding to 0.511 times of the radius of the cavity. The simulation result of EGUN indicate that the velocity ratio is 1.30 and the perpendicular velocity spreads is 1.86%. This triode MIG is now being manufactured and will be adopted in the 140GHz $TE_{28,8}$-mode gyrotron soon.

P2-1.3 / Cold analysis of a cavity for 170 GHz Gyrotron

Mukesh Kumar Alaria (CSIR- Central Electronics Engineering Research Institute, India), Anirban Bera (CSIR- Central Electronics Engineering Research Institute, India), AK Sinha (CSIR- Central Electronics Engineering Research Institute, India)

In this paper, design and cold analysis of interaction cavity for high power 170 GHz Gyrotron have been carried out. The cold cavity analysis for quality factor (Q) value, resonant frequency and mode profile are performed which again confirms the interaction cavity geometry for 170 GHz Gyrotron. The cold characterization of Gyrotron cavity has been carried out using non-destructive method. The interaction cavity is made of high quality oxygen free high thermal conductivity copper (OFHC). Gyrotron interaction cavity of 170 GHz has been experimentally characterized using VNA. The experimental result shows the good agreement between measured and simulated results.

P2-1.4 / Third harmonic CW gyrotron with operating frequency 1.2 THz for a DNP/NMA spectroscopy

Manuilov V.N (Nizhny Novgorod State University, Russia), T.Idehara (University of Fukui, Japan), S.Mitsudo (University of Fukui ,Japan), O.Dumbrajs (University of Fukui, Japan), Glyavin M.Yu (Institute of Applied Physics Russian Academy of Science, Russia), Tsvetkov A.I. (Institute of Applied Physics Russian Academy of Science, Russia), Bandurkin I.V. (Institute of Applied Physics Russian Academy of Science, Russia), Fedotov A.E. (Institute of Applied Physics Russian Academy of Science, Russia)

The project of a third harmonic CW gyrotron with an output frequency of 1.185 THz (wavelength about 250 μm) and an output power of 100-200 W, intended for DNP/NMR spectroscopy applications is described. The project based on the cryomagnet with a maximum magnetic field intensity of 15 T. The analysis of the modes spectrum, coupling factors and starting currents proposed $TE_{-15,6}$ or $TE_{+21.4}$ modes as most promising candidates. To improve mode selection different schemes, including multi-beam electron optics are analyzed. The specific feature of magnetron injection gun is that it allows form two beams or one beam with the same electrode profile by eliminating of the additional emitter ring on the cathode surface. The important role of velocity spread for parasitic mode suppression is shown. In the conditions of an extremely dense spectrum of modes, this makes it possible to suppress the most dangerous parasitic traveling modes at the first and second cyclotron harmonics, which are very sensitive to the velocity spread.

P2-1.5 / Design of High-Efficient Powerful CW Technological Gyrotron Complex with operating frequency 28 GHz

Manuilov V.N. (Nizhny Novgorod State University, Russia), Glyavin M.Yu. (Institute of Applied Physics Russian Academy of Science, Russia), Proyavin M.D. (Institute of Applied Physics Russian Academy of Science, Russia), Zavolsky N.A. (Institute of Applied Physics Russian Academy of Science, Russia), Sobolev D.I. (Institute of Applied Physics Russian Academy of Science, Russia), Morozkin M.V. (Institute of Applied Physics Russian Academy of Science, Russia)

The project of a first harmonic CW gyrotron with the operating frequency of 28 GHz and an output power more than 20 kW, intended for various technological applications is described. Both magnetic system and the system of the beam wave interaction are optimized in such a manner as to provide very high (close to 50%) electronic efficiency and at the same time small energy consumption of the “hot” coils. For the last purpose the magnetically shielded coils are used. It allowed both to increase the operating magnetic field up to 1.024 T and so to operate on the first cyclotron harmonic and at the same time to provide reasonable (13 kW) power consumption of the main coil. Operation on the first cyclotron harmonic ensures absence of the spurious modes within the cyclotron frequency band and so allows to increase the output power in some times in comparison with existing at the moment technological gyrotrons operating on the second cyclotron harmonic. Results of optimization of the key gyrotron subsystems such as electron gun, cavity and collector allowing to operate in CW regime are presented.

P2-1.6 / Variation of electron beam quality in a Continuously Frequency-Tunable 500GHz Gyrotron

Tao Song (University of Electronic Science and Technology of China, China), Chen Zhang (University of Electronic Science and Technology of China, China), Ning Zhang (University of Electronic Science and Technology of China, China), Wei Wang (University of Electronic Science and Technology of China, China), Diwei Liu (University of Electronic Science and Technology of China, China), Shenggang Liu (University of Electronic Science and Technology of China, China)

The variation of the electron beam quality including the velocity spread, the guiding center radius spread, and the pitch factor when the operating frequency of a 500 GHz TE_{85} mode continuously frequency-tunable gyrotron used for Dynamic Nuclear Polarization enhanced Nuclear Magnetic Resonance spectroscopy is tuned by changing the operating magnetic field B_0, has been studied. It is found that the velocity spread varies from 4.7% to 5.8% and the guiding center radius spread changes from 2.09% to 2.15%, when the operating magnetic field B_0 changes between 9.12 T and 9.20 T at an operating voltage of 12kV.

P2-1.7 / Initial Experimental Results for a High Power Frequency-Tunable sub-THz Gyrotron

Xiaotong Guan (University of Electronic Science and Technology of China, China), Wenjie Fu (University of Electronic Science and Technology of China, China), Dun Lu (University of Electronic Science and Technology of China, China), Tongbin Yang (University of Electronic Science and Technology of China, China), Yang Yan (University of Electronic Science and Technology of China, China)

Experimental results of a high power frequency tunable sub-THz gyrotron is presented in this paper. A series of high-order axial modes in a long gyrotron cavity are excited successfully by an electron beam of high voltage and high current. Initial experimental results show that a frequency tuning range of 0.79 GHz from 218.27 GHz to 219.06 GHz is obtained by only tuning the operating magnetic field. And during the frequency tuning, the output power is no less than 0.5 kW, while the maximum output power is 3.80 kW. The axial mode transition in high power gyrotron is experimental demonstrated. This results should be conductive to the future development of frequency-tunable gyrotron for some up-and coming THz applications.

P2-1.8 / Coaxial Magnetron Injection Gun for Sub-THz, Multimegawatt Gyrotron

Nitin Kumar (CSIR-Central Electronics Engineering Research Institute, India), Arti Kumari (Banasthali Vidyapeeth, India), Anirban Bera (CSIR-Central Electronics Engineering Research Institute, India)

The design of coaxial Inverse Magnetron Injection Gun (IMIG) for 240 GHz, 2 MW gyrotron isdiscussed in this article. The IMIG is designed to generate the helical electron beam of power ≥ 6 MW with an optimum pitch factor of 1.25 - 1.35. The gyrotron operates at very high order TE mode which may lead towards the severe mode competition. To suppress the possibility of mode competition, the spread in beam energy and guiding center radius should be as minimum

as possible, at least < 5 %. The geometry of IMIG is optimized rigorously and modified to suppress the beam halo effect without disturbing the beam quality. The IMIG design confirms the pitch factor, transverse velocity spread and guiding center radius of 1.30, 2.74 % and 8.68 mm, respectively.

P2-1.9 / Research Progress of a Second Harmonic Gyrotron

Zi-Chao Gao (Peking University, China), Chao-Hai Du (Peking University, China), Shi Pan (Peking University, China), Fan-Hong Li (Peking University, China), Pu-Kun Liu (Peking University, China)

A scheme of a second harmonic gyrotron operating in CW regime is presented. This tube is designed to provide output power about several tens of watts at 330 GHz. -Whispering-gallery mode is selected as the operating mode. The performance of the candidate TE_{82} and TE_{92} mode is evaluated by nonlinear code. It is confirmed that TE_{92} mode can suppress the competing modes successfully. The fabricating key components of this tube is presented.

P2-1.10 / Design of Four-Way Quasi-Optical Power Combiner for High Power Millimeter Wave

Fujia Li (University of Electronic Science and Technology of China, China), Hao Fu (University of Electronic Science and Technology of China, China), Zewei Wu (University of Electronic Science and Technology of China, China), Lingna Yue (University of Electronic Science and Technology of China, China), Xiaoyi Liao (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China)

The four-way quasi-optical power combiner consists of a pair of phase-correcting mirrors with Gaussian beam output is proposed in this paper. Applying the geometric optics approximation and the scalar diffraction theory, a numerical simulation code of the quasi-optical power combiner is developed. The proposed power combiner is validated by a commercial simulation software, and the results show that the combination efficiency of 94% at 30 GHz is obtained. The proposed quasi-optical power combiner features high power, high efficiency, high purity, and simple structure.

P2-1.11 / Multistability of Phase-Locked Modes in a System of Two Delay-Coupled Gyrotron Oscillators

Asel B. Adilova (Saratov State University, Russia), Nikita M. Ryskin (Saratov Branch of Institute of Radio Engineering and Electronics RAS, Russia)

THz range gyrotrons operating in continuous mode are of great interest for many applications, such as spectroscopy, plasma diagnostics, biomedical research, etc. These applications require high frequency stability. In addition to the existing methods of spectrum generation control, the use of various types of synchronization has recently attracted interest. In particular, mutual synchronization of two coupled gyrotrons, which is presented in this article. The mechanism of transition to synchronization at the desired frequency is considered.

P2-1.12 / Operational Characteristics of a 30kW W-band Gyrotron Developed at KERI

Varun Pathania (Korea Electrotechnology Research Institute / University of Science and Technology, Korea), Hasina Khatun (Central Electronics Engieeering Research Institute, India), Seong-Tae Han (Korea Electrotechnology Research Institute / University of Science and Technology, Korea)

We report operational characteristics of a 30kW W-band gyrotron developed at KERI through holistic integration of home-made DC power supplies and a super conductor magnet. Auxiliary power supply combined to the main power supply providing the emission current of 2A takes part of the accelerating potential of 50kV up to 18kV and increases the overall efficiency of the gyrotron system up to 48%.

P2-1.13 / Operating the KIT 170 GHz 2 MW Coaxial-Cavity Gyrotron at 204 GHz: Performance Expectations and First Cold Test of the Quasi-Optical System

Tobias Ruess (Karlsruhe Institute of Technology, Germany), Konstantinos Avramidis (Karlsruhe Institute of Technology, Germany), Gerd Gantenbein (Karlsruhe Institute of Technology, Germany), Zisis Ioannidis (Karlsruhe Institute of Technology, Germany), Stefan Illy (Karlsruhe Institute of Technology, Germany), Jianbo Jin (Karlsruhe Institute of Technology, Germany), Felix C. Lutz (Karlsruhe Institute of Technology, Germany), Ioannis Gr. Pagonakis (Karlsruhe Institute of Technology, Germany), Sebastian Ruess (Karlsruhe Institute of Technology, Germany), Tomasz Rzesnicki (Karlsruhe Institute of Technology, Germany), Manfred Thumm (Karlsruhe Institute of Technology, Germany), Dietmar Wagner (Institute for Plasma Physics, Germany), John Jelonnek (Karlsruhe Institute of Technology, Germany)

The KIT 170 GHz TE_{34},19-mode coaxial-cavity gyrotron has been studied for an upgrade towards a dual- or even triple frequency operation at 170/204/(238) GHz. For this reason, the electron magnetron injection gun (MIG), the cavity and the launcher are simulated for operation with the $TE_{40,23}$-mode and $TE_{48,26}$-mode at 204 GHz and 238 GHz, respectively. A modification of the coaxial-cavity midsection length leads to an increase of the theoretical RF output power from 1.6 MW to around 2.1 MW at 204 GHz. Further, first experimental cold tests using a mode generator setup, show a successful excitation of the $TE_{40,23}$-mode, which is the highest-order mode ever excited.

P2-1.14 / Design Studies of Mini-Channel Cavity Cooling for a 170 GHz, 2 MW Coaxial-Cavity Gyrotron

Parth Chandulal Kalaria (Karlsruhe Institute of Technology, Germany), Philipp T Brücker (Karlsruhe Institute of Technology, Germany), Sebastian Ruess (Karlsruhe Institute of Technology, Germany), Stefan Illy (Karlsruhe Institute of Technology, Germany), Konstantinos A Avramidis (Karlsruhe Institute of Technology, Germany), Gerd Gantenbein (Karlsruhe Institute of Technology, Germany), Manfred Thumm (Karlsruhe Institute of Technology, Germany), John Jelonnek (Karlsruhe Institute of Technology, Germany)

In high-power fusion gyrotrons, the maximum heat-load on the wall of the interaction section is in the order of 2 kW/cm^2, which is the major limiting technological factor for output power, efficiency and pulse-length of the tube. The ongoing gyrotron development demands a very effective cavity cooling system for stable and optimum gyrotron operation. In this work, the thermal performance of a mini-channel cavity cooling is numerically investigated using the ANSYS Fluent® code-package. The influence of the various physical and operating parameters on the cavity cooling efficiency is systematically studied for a 170 GHz, 2 MW coaxial-cavity gyrotron and an optimized heat sink design is proposed. A mock-up test set-up is also developed to experimentally validate the simulation results.

P2-1.15 / Study of a 140 GHz, High Power Gyrotron at UESTC

Ying-hui Liu (University of Electronic Science and Technology of China, China), Chao-jun Lei (The Chinese People's Armed Police Force Academy, China), Xin-jian Niu (University of Electronic Science and Technology of China, China), Hui Wang (University of Electronic Science and Technology of China, China), Guo Guo (University of Electronic Science and Technology of China, China), Jian-wei Liu (University of Electronic Science and Technology of China, China), Zhang Shuangshi (The Chinese People's Armed Police Force Academy, China), Li Hongfu (University of Electronic Science and Technology of China, China)

A kind of gradually tapered cavity for a high-order mode 140 GHz, 1 MW gyrotron has been Studied to effectively suppress the parasitic modes at the University of Electronic Science and Technology of China recently. The $TE_{29,\ 8}$ mode is selected as an operating mode of the desired gyrotron. A gyrotron with optimized parameters have been designed and constructed. An output power of 1.2 MW is obtained by calculation at an accelerating beam voltage of 75 kV by simulation, a beam current of 45 A, corresponding to an overall efficiency of 35.5%.

P2-1.16 / Analysis on the Resonator in a 140 GHz Gyrotron

Kang An (Beijing Vacuum Electronics Research Institute, China) , Yichi Zhang (Beijing Vacuum Electronics Research Institute, China) , Zhiliang Li (Beijing Vacuum Electronics Research Institute, China) , Bentian Liu (Beijing Vacuum Electronics Research Institute, China)

By means of numerical calculation and CST simulation, the resonant frequency and the quality factor of the resonant of 140GHz and $TE_{22,6}$ mode gyrotron were calculated. Under the working voltage of 68kV, current of 28A and magnetic field of 5.5T, the output peak power of 430kW and under the working voltage of 69.12kV, current of 27.6A and magnetic field of 5.68T, the gyrotron can also work in the $TE_{22,6,2}$ mode with the outpower of 470kW.

P2-1.17 / Analyses of Transmission Characteristics of Electromagnetic Wave in Confocal Gyro-TWT

Yang Jie (Chinese Academy of Science / University of Chinese Academy of Sciences, China), Xu Shouxi (Chinese Academy of Science / University of Chinese Academy of Sciences, China), Wang Yong (Chinese Academy of Science / University of Chinese Academy of Sciences, China), Wang

Xiaoyan (Chinese Academy of Science / University of Chinese Academy of Sciences, China), Zhao Guohu (Chinese Academy of Science / University of Chinese Academy of Sciences, China), Zhang Lianzheng (Chinese Academy of Science, China)

Confocal gyrotron traveling wave tube (gyro-TWT) is a novel gyrotron amplifier which can operate in higher order modes and generate high power. Confocal waveguide has mode selectivity, since the diffraction losses at the edge of the mirrors are different for different waveguide mode, which has extremely decreased mode density. In this paper, the analyses of transmission characteristics of a confocal waveguide for 220 GHz gyro-TWT is presented.

P2-1.18 / Design and Experiment of TE_{62} Quasi-optical Mode Generator for a W-band Gyrotron Oscillator

Zhi-Hui Geng (Chinese Academy of Sciences, China), Rui Zhang (Chinese Academy of Sciences, China), Xiao-Wan Hou (Chinese Academy of Sciences, China), Shou-Xi Xu (Chinese Academy of Sciences, China), Xiu-Dong Yang (Chinese Academy of Sciences, China), Gao-Feng Liu (Chinese Academy of Sciences, China), Yun-Feng Liao (Chinese Academy of Sciences, China)

In this paper, a W-band rotating TE_{62} mode is obtained by means of a quasi-optical mode generator in order to test quasi-optical system of the gyrotrons. The quasi-optical generator consists of two mirrors and a coaxial cavity with a perforated outer wall. The simulation results with an electromagnetic analyses software show that the mode purity is up to 96.5%. Processing technologies for components of the mode generator are finished. The assembly device is finished on the basis of the multidimensional localization, which has been tested on the multidimensional automatic test platform.

P2-1.19 / Simulation of Three Different Magnetic Field Sweeping Systems for MW-class Gyrotron

Kai Wang (University of Chinese Academy of Sciences / Chinese Academy of Sciences, China), Qianzhong Xue (University of Chinese Academy of Sciences / Chinese Academy of Sciences, China)

In this paper, magnetic field sweeping system is coming into use to spread electron deposited areas for MW-class gyrotron. The simulation of conventional vertical field sweeping system, transverse field sweeping system and their combination are carried out. The comparison of above three sweeping systems are also presented. The optimum simulated results indicate the scattering length of spent electron and peak power density are approximately 1100mm and 121 W/cm^2, respectively.

P2-1.20 / Mode Competition and Ohmic Losses in High-power Coaxial-cavity Gyrotron

Shan Zhang (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), Qianzhong Xue (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China)

Ohmic loss density on the cavity walls and mode competition in a coaxial-cavity with a tapered inner rod of a high-power gyrotron is investigated. Ohmic losses and the mode competition can be restrained by a suitable operating mode and an appropriate design of the inner conductor.

P2-1.21 / Measurement of a broadband input coupler for a W-band gyro-TWA

Liang Zhang (University of Strathclyde, UK), Craig R. Donaldson (University of Strathclyde, UK), Adrian W. Cross (University of Strathclyde, UK), Wenlong He (Shenzhen University, China)

In this paper, the design and measurement results of the input coupling system for a W-band gyro-TWA is represented. The coupling system was designed to achieve 10% bandwidth centered at 95 GHz. In the measurement, an average transmission coefficient of -2.0 dB was measured over the designed frequency range.

P2-1.22 / Terahertz Gyro-BWO Using a High-Order Whispering-Gallery Mode

Shi Pan (Peking University, China), Chao-Hai Du (Peking University, China), Zi-Chao Gao (Peking University, China), Fan-Hong Li (Peking University, China), Hui-Qi Bian (Peking University, China), Pu-Kun Liu (Peking University, China)

Gyrotron backward-wave oscillators (gyro-BWOs) extending to the terahertz (THz) band require high-order modes to improve the power-handling capability. Here we investigate a THz high-order whispering-gallery mode (WGM) gyro-BWO equipped with a cathode-end output circuit. The segment-tapered circuit contributes to uplifting the start-oscillation currents of the near-cutoff competing mode and reclaiming the dominance of operating mode. The scheme is applicable to other high-order mode gyro-BWOs with broadband tuning.

P2-1.23 / Design of a 75GHz Low Voltage-Continuous Wave Gyrotron with Mode Converter

Dun Lu (University of Electronic Science and Technology of China, China), Wenjie Fu (University of Electronic Science and Technology of China, China), Xiaotong Guan (University of Electronic Science and Technology of China, China), Tongbin Yang (University of Electronic Science and Technology of China, China), Yang Yan (University of Electronic Science and Technology of China, China)

The gyrotron is widely studied for its ability to generate high frequency and high power microwaves. When the operating voltage is lower, the volume of the power system and the water cooling system can be smaller, which makes the gyrotron more convenient for experimental research and industrial use. Therefore, a 10kV, 1A low-voltage continuous wave gyrotron is designed, including an electro-optical system, a high-frequency resonant cavity, and a mode converter TE_{01}-TE_{11} mode. The electron gun emits a current density of 600 mA/cm^2, and the electron injection transversal and vertical velocity ratio is 1.52 velocity spread is 5% , and the output power of the design gyrotron is 1.5 kW with efficiency of 15%. Particle-in-cell simulation shows that and an operating frequency of 75.6 GHz. The mode converter adopts an axis perturbation method with a total length of 59.72 mm, a center frequency of 75.6 GHz, a single

frequency point conversion efficiency of 99.8%, and a conversion efficiency of 90% or more with a bandwidth of 2.8 GHz.

P2-1.24 / High-Gain Confocal gyro-TWAs With a Nonuniform Distributed Circuit

Yelei Yao (University of Electronic Science and Technology of China, China), Jianxun Wang (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China), and Guoxiang Shu (Shenzhen University, China)

We report the non-uniform distributed confocal travelling-wave amplifier (gyro-TWA) for high-gain operation at the first time. The circuit applies a long section with heavy circuit loss to the phase-modulation region for stability consideration, whilst utilizing a taper circuit that attached to a short wide-mirror section in the nonlinear-interaction region to maximum the output power. Nonlinear theory calculations predicted that the W-band gyro-amplifier operates at HE_{04} mode is capable of producing an output power of above 100 kW and a saturated gain of more than 60 dB within 93-97 GHz.

P2-1.25 / Thermal Analysis of Magnetron Injection Gun for 140GHz Gyrotron

Hui Wang (University of Electronic Science and Technology of China, China), D. H. Wan (University of Electronic Science and Technology of China, China), X. J. Niu (University of Electronic Science and Technology of China, China), Y. H. Liu (University of Electronic Science and Technology of China, China), G. Guo (University of Electronic Science and Technology of China, China), J. W. Liu (University of Electronic Science and Technology of China, China)

As the Gyrotron magnetron injection gun (MIG) plays a significant role in determining the efficiency and reliability of the Gyrotron, 3-dimensional thermal and structure analysis using FDTD code CST is presented. The detailed model of the MIG has been created by CST Mphysics Studio. With the detailed structure and material properties setting, temperature distribution in the MIG is calculated, and deformation analysis at critical locations in axial and radial direction have been carried out. Under the condition of the deformation, electron beam parameters of the MIG are compared with the initial design values using CST Particle Studio. It shows in the case of deformation value, which is under the condition of filament's temperature is 1000, changes of the velocity spread, the velocity ratio and the variation of guiding center radius are within the acceptable range. According to deformation error analysis, appropriate correction amount is introduced in the manufacture of the Gyrotron.

P2-1.26 / Analysis of the Effect of the Difference between Designing and Machining on Electric Characteristics in a 140GHz Gyrotron Oscillator Cavity

Chen Yang (University of Chinese Academy of Sciences / Chinese Academy of Sciences, China), Min Zhu (Chinese Academy of Sciences, China), Wei Guo (Chinese Academy of Sciences, China), Jirun Luo (University of Chinese Academy of Sciences / Chinese Academy of Sciences, China)

To compare with the difference between the designed cavity and the machined cavity, the measured size data of the three machined cavities were used to calculate cold-cavity characteristics and beam wave interaction respectively for analyzing the effect on the resonant frequency, diffractive quality factor, axial field distribution, output power and efficiency.

P2-1.27 / Extension of Frequency Tuning Band in sub-THz Gyrotrons with Strong External Reflections

Michael Glyavin (Institute of Applied Physics RAS, Russia), Naum Ginzburg (Institute of Applied Physics RAS, Russia), Roman Rozental (Institute of Applied Physics RAS, Russia), Alexander Sergeev (Institute of Applied Physics RAS, Russia), Irina Zotova (Institute of Applied Physics RAS, Russia), Alexey Fedotov (Institute of Applied Physics RAS, Russia), Seitaro Mitsudo (University of Fukui, Japan), Toshitaka Idehara (University of Fukui, Japan)

We demonstrate that extension of frequency tuning bands in sub-THz gyrotrons can be provided by using strong external reflections. Simultaneously, it allows reducing the operating currents while maintaining the kilowatt output power level. Simulations show that using a Bragg-type reflector. we can achieve 3 GHz smooth frequency tuning band in a 200 GHz gyrotron with output power up to 1 kW. Such parameters are needed for testing of quantum electrodynamics predictions through the spectroscopy of positronium.

P2-1.28 / GDS2H – V.2018: A COMPREHENSIVE COMPUTER CODE PACKAGE FOR THE DESIGN OF SECOND HARMONIC GYROTRONS

S. Yuvaraj (Indian Institute of Technology Roorkee, India), S. Adya (Indian Institute of Technology Roorkee, India), D. Mondal (Indian Institute of Technology Roorkee, India), A. S. Thakur (Indian Institute of Technology Roorkee, India), A. Agarwal (Indian Institute of Technology Roorkee, India), M. V. Kartikeyan (Indian Institute of Technology Roorkee, India), M. Thumm (Karlsruhe Institute of Technology, Germany)

Gyrotrons operating at the second harmonic of the electron cyclotron frequency have an inherent advantage of working with reduced magnetic cavity field thus making the entire system lighter with lower cost, which is a prior requirement in some specific ISM applications. In this paper, we present the latest developments of our in-house computer code package for the conceptual design of second harmonic gyrotrons (GDS2H-V.2018). The code has been validated for the design of two specific second harmonic devices, namely: (i) a 70 GHz, 500 kW gyrotron for experimental okamaks and (ii) a 263 GHz, 100 W gyrotron for DNP experiments.

P2-1.29 / Design Studies of Magnetron Injection Gun for V and W Band Gyrotrons

Surbhi Adya (Indian Institute of Technology Roorkee, India), M. V. Kartikeyan (Indian Institute of Technology Roorkee, India), Udaybir Singh (Council of Scientific and Industrial Research, India)

In this paper, design studies of electron guns supporting second harmonic operation of V and W band gyrotrons for plasma diagnostics and defence (active denial systems) applications are

presented. The in house code Gyrotron Design Suite Second Harmonic Version 2018 (GDS2H-V. 2018) is used for the initial design studies of the magnetron injection guns along with the magnetic guidance system. The particle trajectory code EGUN is used for the parametric optimization and simulation of the designed electron guns.

P2-1.30 / Design of 94GHz $TE_{22,6}$ Quasi-Optical Mode Converter for Large Power Gyrotron

Guo Guo (University of Electronic Science and Technology of China, China), Jianwei Liu (University of Electronic Science and Technology of China, China), Xinjian Niu (University of Electronic Science and Technology of China, China), Yinghui Liu (University of Electronic Science and Technology of China, China), Hui Wang (University of Electronic Science and Technology of China, China)

This paper focus on the design of a quasi-optical mode converter for large power gyrotron with the operation frequency of 94GHz and the working mode of $TE_{22,6}$. A quasi optical mode converter consists of a Denisov-type radiator and two mirrors. By analysis of the working mechanism for the Denisov radiator and the calculation theory of the mirror field, the program is performed to optimize the parameters of the radiator and mirror system. Numerical calculation results show that the edge feed electric field of the output window reaches -30dB and the power transmission efficiency is 95% with the Gauss beam content of 96%. Simulation results from FEKO verify that the radiator power transmission efficiency is 92.9% and the Gauss content is 94%.

P2-1.31 / Wideband chaotic generation in K-band helical waveguide gyro-TWT with external reflections

Alexander Bogdashov (Institute of Applied Physics RAS, Russia), Roman Rozental (Institute of Applied Physics RAS), Alexander Sergeev (Institute of Applied Physics RAS), Naum Ginzburg (Institute of Applied Physics RAS), Sergey Samsonov (Institute of Applied Physics RAS), Irina Zotova (Institute of Applied Physics RAS)

Results of simulations of wideband chaotic generation based on a helical waveguide K-band gyro-TWT with external reflections are presented. It is shown that as the reflection coefficient increases, a spectrum width of about 2 GHz is achieved in the system. For experiments a broadband Bragg-type reflector with a non-uniform corrugation period and depth, providing the necessary reflections in the frequency range 23-25 GHz was fabricated.

P2-1.32 / Closed-form expressions for frequencies and diffraction Q factors of open gyrotron cavity

Andrey G. Rozhnev (Saratov Branch V. A. Kotelnikov Insitute of Radioengineering and Electronics Russian Academia of Science, Russia)

New closed-form expressions for calculating the frequencies and diffraction Q-factors of the axial-symmetric gyrotron cavities are obtained by the small parameter expansion method. The

results of the calculation of the gyrotron cavity are compared with the data obtained by solving the inhomogeneous string equation and using the known formulas.

P2-1.33 / Design of Diode Type Magnetron Injection Gun for 170GHz Gyrotron

Alok Mishra (CSIR-Central Electronics Engineering Research Institute, India), Anirban Bera (CSIR-Central Electronics Engineering Research Institute, India), M. V. Kartikyean (Indian Institute of Technology Roorkee, India)

This paper presents the electron gun design study of using diode-type magnetron injection guns (MIGs) for 1MW, 170GHz gyrotron operated on the $TE_{28,12}$ mode. The initial design has done through the computational analysis and the design optimization achieved with the help of EGUN beam trajectory program. Further, the feasibility of designed gun type also has discussed.

P2-1.34 / Design of Ka-Band MW-Level Low-Voltage High Current Gyroklystron

Shiyu Wang (University of Electronic Science and Technology of China, China), Li Wang (University of Electronic Science and Technology of China, China), Chao Fang (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China), Guoxiang Shu (Shenzhen University, China), Fuyong Zhang (SASTIND, China)

This paper introduces a design of a Ka-band MW level gyroklystron. The first cavity and the second cavity operate fundamental TE_{01} mode and the output cavity works at fundamental TE_{02} mode. All design based on the PIC (Particle in cell) code MAGIC. The MAGIC simulation result shows that this gyroklystron can deliver an output power of more than 1.2 MW with a gain of >35 dB at 34 GHz and bandwidth of 5 %. The achieved efficiency exceeds 34 % when driven by a 70 kV, 50 A beam when the velocity ratio is around 1.04.

P2-1.35 / The Calculation and Design of a 140GHz MW-class gyrotorn at IECAS

Min Zhu (Chinese Academy of Sciences, China), Jjirun Luo (Chinese Academy of Sciences, China), Wei Guo (Chinese Academy of Sciences, China), Chen Yang (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), Wenqi Li (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), He Zhu (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China)

A 140GHz megawatt-class Gyrotron project has been developed in IECAS (the institute of electronics, Chinese Academy of Sciences), with the purpose of providing high power microwave source for ITER program. This paper presents an overall design schematic of 140GHz, 1MW gyrotron with a gradually tapered cavity. As the $TE_{28,8}$ mode has been used successfully in the MW-class gyrotron, it is selected as the operating mode here. With some optimized parameters, an output power of 1.12MW is obtained based on the calculation with beam accelerating voltage of 80kV, beam current of 40A and an overall efficiency of 33.81%.

P2-1.36 / Thermal Analysis of Micro-Channel Cooling for a Megawat Gyrotron Traveling Wave Tube

Wei Rao (University of Electrnic Science and Techonology of China, China), Guo Liu (University of Electrnic Science and Techonology of China, China), Chao Fang (University of Electrnic Science and Techonology of China, China), Wei Jiang (University of Electrnic Science and Techonology of China, China), Jianxun Wang (University of Electrnic Science and Techonology of China, China), Li Wang (University of Electrnic Science and Techonology of China, China), Yong Luo (University of Electrnic Science and Techonology of China, China), Guoxiang Shu (Shenzhen University, China)

When a gyrotron traveling wave tube (gyro-TWT) is operating under the condition of high operating duty or continuous wave high power, the maximum heating power density may reach 10 MW/m2 within a range of dozens of square centimeters. In this paper, an optimized micro-channel cooling option for an X-band megawat-level gyro-TWT is developed and analyzed by using the simulation software ANASYS workbench. The simulation results show that the maximum temperature of the ceramic dielectric is 207 degrees when the gyro-TWT operates to saturation at 8.4 GHz.

Poster 2

April 30 (Tuesday) / 15:10 ~ 16:30 / Capri room

HPM and relativistic devices / Magnetrons

P2-2.1 / Design and Simulation of an X-Band RBWO using Non-uniform Bragg Structure

M.A. Ansari (Indian Institute of Technology, India), M. Thottappan (Indian Institute of Technology, India)

An X-band relativistic backward wave oscillator using a non-uniform Bragg structure as its slow wave structure and cut-off neck waveguide reflector is designed to increase its beam-wave interaction efficiency. The non-uniformity in Bragg introduces variable coupling impedance and velocity tapering in order to keep the synchronism between the RF wave and the electron beam. In the present work, a two-way helically corrugated single fold Bragg structure used that efficiently converts the backward propagating TM_{01} mode to forward propagating linearly polarized HE_{11} mode. The beam-wave interaction efficiency of the Bragg based RBWO is calculated as ~12%.

P2-2.2 / Design of MW-Class L-Band Magnetron with TE11 to TE10 Mode Converter

Jung-Hoon Han (The affiliated institute of Electronics and Telecommunications Research Institute, Korea), Taek-Heon Kim (The affiliated institute of Electronics and Telecommunications Research Institute, Korea), Seung-Kab Ryu (The affiliated institute of Electronics and Telecommunications Research Institute, Korea)

A magnetron is a representative signal source for vacuum electron devices. This paper describes the design of Lband magnetron for mega-watt (MW) power output. First, the radius and the length of the cathode are designed based on the required output current. The number of cavities in the anode is determined to be 12, and the length of the anode is designed to be approximately quarter wavelength. The remaining design dimensions of the anode are also presented in reasonable design way. We perform particle-in-cell (PIC) simulation using CST-particle studio (PS) tool and confirm that π-mode spokes are formed. We design and measure an antenna and a mode converter that deliver the amplified signal of the magnetron to the outside. The designed antenna is a type of the dipole, and the output mode is converted from TE11 to TE10 and deliver to the WR-650. The final output of the magnetron confirmed by simulation is 1.26 MW with 1.3 GHz oscillation. The anode output efficiency including the mode converter is about 34%. Based on the simulation and the cold test results, it is expected that the magnetron can be successfully manufactured.

P2-2.3 / Experimental Study on Axial Virtual Cathode Oscillator Operated Using 140J/170kV Pulsed Source

Se-Hoon Kim (Hanyang University, Korea), Chang-Jin Lee (Hanyang University, Korea), Kwang-Cheol Ko (Hanyang University, Korea)

An axial virtual cathode oscillator with stainless steel cathode and stainless steel anode is experimentally analyzed. A 140J/170kV Marx generator is used as an impulse generator to drive the axial virtual cathode oscillator. The gap distance between the anode and the cathode sets to 0.4 cm. The output power of the axial virtual cathode oscillator is analyzed for stainless steel cathode.

P2-2.4 / Circuit Design and Analysis of an External Coupled Magnetron at Ka Band for High Power Applications

Yong Yin (University of Electronic Science and Technology of China, China), Minsheng Song (University of Electronic Science and Technology of China, China), Tianqi Hu (University of Electronic Science and Technology of China, China), Yu Zhao (University of Electronic Science and Technology of China, China), Bin Wang (University of Electronic Science and Technology of China, China), Hailong Li (University of Electronic Science and Technology of China, China), Lin Meng (University of Electronic Science and Technology of China, China)

This paper describes the circuit of an Ka band high power magnetron with external couple structure. Main difference between the newly developed magnetron and the coaxial magnetron is that the coaxial cavity is replaced by a magnetron like circuit. To suppress the competition modes, the inner cavity operated in the π mode are connected to the external couple structure operated in the 2π mode. The dispersion relations of the external coupled magnetron are studied to verify the mode suppression properties of the newly circuit. The output circuit is also included.

P2-2.5 / The Characteristics Research on A6 Relativistic Magnetron with Diffraction Output Operating in the Negative First Harmonic of 2π/3 Mode

Chaoxiong He (University of Electronic Science and Technology of China, China), Tianming Li (University of Electronic Science and Technology of China, China), Biao Hu (University of Electronic Science and Technology of China, China), Haiyang Wang (University of Electronic Science and Technology of China , China), Keqiang Wang (University of Electronic Science and Technology of China, China), Xin Wang (University of Electronic Science and Technology of China, China), Jiayin Li (University of Electronic Science and Technology of China, China)

This paper presents that the A6 relativistic magnetron with diffraction output (MDO) operating in the negative first harmonic of 2π/3-mode can be feasible for the buildup of oscillations in the theory. Furthermore, the phase velocity of the negative first harmonic of 2π/3 mode is lower than that of the fundamental harmonic, which can be beneficial for the beam-wave interaction. A design for the MDO is presented numerically using the 3-D fully electromagnetic

and particle-in cell code CHIPIC. Compared with the fundamental harmonic of the conventional π mode, the PIC simulation demonstrates that the operation with the negative first harmonic of 2π/3 mode in the MDO can obtain higher total conversion efficiency. With a proper operating voltage and magnetic field, the results show that MDO synchronizing with the negative first harmonic of 2π/3 mode can get 61.2% total conversion efficiency, and the output power reaches 1.2 GW, respectively.

P2-2.6 / Influence of the Magnetic Field and Impedance of Pulsed Power System on the Resonance of Magnetron with Diffraction Output

Shen Shou Max Chung (Air Force Institute of Technology, National Penghu University of Science and Technology, Taiwan), Shih-Chung Tuan (Oriental Institute of Technology, Taiwan)

Particle-In-Cell (PIC) simulations were performed to study the resonance condition of A6 Magnetron with Diffraction Output (MDO) by conducting a magnetic field strength sweep and no resonance condition are found which results in lower than expectation output power. The cause of this is conjectured to be the impedance of the pulsed power system. Low pulsed power impedance results in more explosive field emission electrons, and they require higher than usual magnetic field to confine within the anode-cathode space to form resonance.

P2-2.7 / Investigation of X-Band Coaxial Magnetron using Three-dimensional Particle-In-Cell Simulation

Jeong-Hun Lee (Korea Electrotechnology Research Institute, Korea), Geun-Ju Kim (Korea Electrotechnology Research Institute, Korea), Sanghoon Kim (Korea Electrotechnology Research Institute, Korea), Yong-Seok Lee (Korea Electrotechnology Research Institute, Korea), Insoo S. Kim (Korea Electrotechnology Research Institute, Korea), Jung-Il Kim (Korea Electrotechnology Research Institute, Korea)

Medical magnetrons to operate the medical linear accelerator (LINAC) are widely used for the radiation therapy systems. The operation performances of medical LINAC generating the high energy X-ray to treat the cancers depends on the RF performances of medial magnetron. The medical 9.3 GHz coaxial magnetron is investigated by using three-dimensional particle-in-cell simulation to analyze the RF performances. The maximum output power of 1.88 MW with the efficiency of 53 % is measured at the stable π-mode resulted from the 20-electron spokes. And, the frequency bandwidth controlled by the frequency tuner shows the 1.5 MHz/μm with the bandwidth of 60 MHz.

P2-2.8 / Conceptual RF design of 3.7 GHz 20 kW CW Magnetron for LHCD system of Tokamaks

Aviraj R. Jadhav (IIT Bombay, India), Joseph John (IIT Bombay, India), Kushal Tuckley (IIT Bombay, India), Harish V. Dixit (BITS-Pilani, Inida), P. K. Sharma (Institute for plasma research, India)

This paper outlines the design steps for a 3.7 GHz 20 kW CW magnetron. Such magnetrons

may be used for current drive experiments in tokamak systems. The anode design is carried out using some empirical formulae and procedure. The design is simulated in CST Microwave Studio and the parameters are adjusted to obtain the π-mode field at the required frequency.

P2-2.9 / The Cause of Forward Leakage Current in Pulsed Magnetron with Diffraction Output

Shen Shou Max Chung (Air Force Institute of Technology / National Penghu University of Science and Technology, Taiwan), Shih-Chung Tuan (Oriental Institute of Technology, Taiwan)

Particle-In-Cell (PIC) simulations were performed to study the leakage current of the A6 Magnetron with Diffraction Output (MDO). Due to the time lag for the high voltage pulse to travel through the cathode, phase space diagrams show explosive field emission generated electrons have higher energy at the front end than the late end; the repelling force from the space charges pushes the late electrons towards to output and form the forward "leakage current", which is intrinsic in this type of device.

P2-2.10 / Electron Cloud Build-Up in a Cold Cathode Magnetron at the Front of Anode Impulse

Gennadiy Churyumov (Kharkiv National University of Radio Electronics, Ukraine / Harbin Institute of Technology, China), Wang Nannan (Harbin Institute of Technology, China), Alexander Gritsunov (Kharkiv National University of Radio Electronics, Ukraine)

A possible scenario of forming the re-entrant electron cloud in a cold cathode magnetron at the front of anode voltage impulse is considered. The role of the RF fields of the low-voltage modes is shown as well as their influence on the secondary emission mechanism of space charge accumulation at the front of the anode voltage impulse have been refined.

P2-2.11 / Noise Suppression of a 2.45GHz Magnetron for Wireless Power Transfer

Dokyun Kim (Korea Electrotechnology Research Institute / University of Science and Technology, Korea), Varun Pathania (Korea Electrotechnology Research Institute / University of Science and Technology, Korea), Suyeon Park (Kwangwoon University, Korea), Jinjoo Choi (Kwangwoon University, Korea), Jong-Soo Kim (Korea Electrotechnology Research Institute, Korea), Seong-Tae Han (Korea Electrotechnology Research Institute / University of Science and Technology, Korea)

We demonstrate a way to suppress noise of a commercial 2.45GHz magnetron for wireless power transfer application. The impurity of the microwave spectrum was identified being attributed to the switching frequency of 76kHz in the power supply. With the decoupling capacitor disposed to the output of the high-voltage power supply driving the magnetron, the spectral purity of the magnetron was significantly enhanced.

P2-2.12 / Frequency and Phase Locking Experiments on a 2.45 GHz magnetro

S. Y. Park (Kwangwoon university, Korea), Y. R. Heo (Kwangwoon university, Korea), J.Y. Kang (Kwangwoon university, Korea), D. G. Kim (Korea Electrotechnology Research Institute /

University of Science and Technology, Korea), S. T. Han (Korea Electrotechnology Research Institute / University of Science and Technology, Korea), J. J. Choi (Kwangwoon university, Korea)

This paper describes a study and experimental demonstration on a magnetron operating at 2.45 GHz. We checked the characteristics of the 1 kW magnetron. There were two noise sources of magnetron at frequencies of 0.5 Hz and 75 kHz. In order to suppress these noises, we used an external injection locking method. Measurement results showed that the frequency noise suppression was down up to 30 dBc and the phase fluctuation is reduced to 4 degrees when injection input power was 7 W. Power combining experiments were performed using two identical magnetrons. An initial result showed an output power of 2 kW, corresponding to combining efficiency > 93%.

Poster 2

April 30 (Tuesday) / 15:10 ~ 16:30 / Capri room

Components

P2-3.1 / Improvement Of Hybrid-Type High-Power Gyrotron Launcher

Wenqi Li (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), Zhiqiang Zhang (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), Jirun Luo (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), Yong Li (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), Yu Fan (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China)

A numerical synthesis method for hybrid-type high-power gyrotron launchers has been tested to transform the $TE_{32,9}$ mode of the ITER EU 1-MW gyrotron operating at 170GHz with a specific set of TE modes to generate a Gaussian-like field distribution as the target function. However, we cannot perfectly transform the operating mode into the specific set of TE modes of target function due to the diffraction effect of the launcher cut. In this case, we proposed a method to generate an optimized target function to improve the process of transforming the operating mode into the target set of TE modes. Simulation results show that the higher fundamental Gaussian mode content(FGMC) of 99.1% of the RF wave beam can be achieved at the aperture of launcher using the optimized target function.

P2-3.2 / Study on Secondary Electron Multiplication Characteristics of 1.3GHz High Power Coupler Cold Window

Yao Long (Institute of Electronics / University of Chinese Academy of Sciences, China), Wang Yong (Institute of Electronics / University of Chinese Academy of Sciences, China), Zhang Rui (Institute of Electronics, China), Zhang Xue (Xiang tan University, China)

In this paper, the design of a 1.3GHz high power coupler cold window is presented for the Shanghai light source hard X-ray free electron laser system. The cold window consists of 3 parts: outer conductor, inner conductor and ceramic window. The multipactor effect is a resonant vacuum electron discharge that appears in components operating with high power electromagnetic field. When certain RF resonance condition is met, the secondary electrons grow exponentially, which leads to remarkable power losses and heating of the ceramic window, so that it becomes impossible to increase the fields by raising the incident power.

P2-3.3 / Study of Gaussian Mode Output Window for 140GHz Gyrotron

Zhiliang Li (Beijing Vacuum Electronics Research Institute, China), Bentian Liu (Beijing Vacuum Electronics Research Institute, China), Yang Zhang (Beijing Vacuum Electronics Research

Institute, China), Jinjun Feng (Beijing Vacuum Electronics Research Institute, China)

The paper describes study of a Gaussian mode output window for 140GHz gyrotron oscillator. According to the law of Fresnel, the output window is optimized and designed by using numerical calculations. Then, the design parameters are obtained. Finally, an output window was fabricated and tested. The testing results show that theoretical analysis are in good agreement with cold test, the output window can achieve bandwidth of 5GHz when VSWR below 1.3.

P2-3.4 / Study on a Novel Directional Coupler for Rapid Power Measurement of the W band Gyro-TWT

Xu Zeng (Beijing Vacuum Electronics Research Institute, China), Efeng Wang (Beijing Vacuum Electronics Research Institute, China), Jinjun Feng (Beijing Vacuum Electronics Research Institute, China)

A study of a novel directional coupler for measuring the output power of a W-band gyro-TWT has been presented. The designed directional coupler is a three ports device, in which, the multi-apertures with different diameters have been arranged in two rows. By using it, the rapid power measurement for the W-band TE01 mode gyro-TWT has been achieved. The measurement result indicates that the coupling coefficient of the directional coupler is between -50dB and -56dB with the bandwidth of 6GHz, which agrees well with the simulation result. In additional, the influence of the arrangement method of the apertures on the coupling coefficient has also been analyzed.

P2-3.5 / Optimization Design of Gyrotron Quasi-optical Mode Converter Launcher

Zhao Guohui (Chinese Academy / University of Chinese Academy of Sciences, China), Xue Qianzhong (Chinese Academy / University of Chinese Academy of Sciences, China), Wang Yong (Chinese Academy / University of Chinese Academy of Sciences, China), Wang Xuewei (Chinese Academy / University of Chinese Academy of Sciences, China), Zhang Shan (Chinese Academy / University of Chinese Academy of Sciences, China), Zhang Lianzheng (Chinese Academy, China)

An optimized design results of a launcher for 94GHz TE_{62} mode gyrotron quasi-optical mode converter are given in this paper. The launcher is designed by coupling mode theory and has two stages of perturbations. Under the condition that the original perturbation length remains unchanged, the perturbation amplitude is optimized and the variation of the perturbation amplitude along the axis is obtained. The simulation results show that the beam launched by the optimized launcher has no side lobe at the position of mirror 1 compared with that before optimization.

P2-3.6 / Design of Phase Correcting Mirror for Gyrotron Quasi-optical Mode Converter

Zhao Guohui (Chinese Academy / University of Chinese Academy of Sciences, China), Xue Qianzhong (Chinese Academy / University of Chinese Academy of Sciences, China), Wang Yong (Chinese Academy / University of Chinese Academy of Sciences, China), Wang Xuewei (Chinese

Academy / University of Chinese Academy of Sciences, China), Zhang Shan (Chinese Academy / University of Chinese Academy of Sciences, China), Zhang Lianzheng (Chinese Academy, China)

In this paper, the design of a phase correcting mirror is presented for the mirror system of 94 GHz TE_{62} mode gyrotron quasi-optical mode converter. The mirror system consists of 3 mirrors, the third mirror is phase correcting mirror. The phase correcting mirror designed based on Katsenelenbaum-Semenov Algorithm (KSA). After adding phase correcting mirror into the mirror system, the scalar and vector mode contents on the output window increased by 1.2794% and 2.5647% respectively.

P2-3.7 / Design of Water Cooling System for 170GHz, Long-Pulse Gyrotron

Yichi Zhang (Beijing Vacuum Electronics Research Institute, China), Bentian Liu (Beijing Vacuum Electronics Research Institute, China), Xu Zeng (Beijing Vacuum Electronics Research Institute, China), Yang Zhang (Beijing Vacuum Electronics Research Institute, China)

A water cooling system has been designed aiming to insure the 1MW 170GHz gyrotron stable operates under continuous wave (CW) operating condition. In this work, thermal loss power of main parts is calculated by theory analysis and software simulation. Considered to maximum allowable heat-flux, the water cooling system controls the maximum temperature below the boiling temperature and the deformations of the geometry are significantly small enough not to influence the performance heavily.

P2-3.8 / The Vacuum Window for 0.34-THz Folded Waveguide Traveling Wave Tube

Peng Hu (China Academy of Engineering Physics, China), Wenqiang Lei (China Academy of Engineering Physics, China), Yi Jiang (China Academy of Engineering Physics, China), Yinhu Huang (China Academy of Engineering Physics, China), Rui Song (China Academy of Engineering Physics, China), Hongbin Chen (China Academy of Engineering Physics, China)

The vacuum windows for a 0.34-THz folded waveguide traveling wave tube are designed and fabricated, the window structure is modified pill-box window structure and the window dielectric is sapphire piece. In the cold-test measurement, the bandwidth S_{11} parameter below -15 dB achieves 30 GHz.

P2-3.9 / Electromagnetic particle-in-cell simulations of dielectric multipactor

Wang Huihui (University of Electronic Science and Technology of China, China), Liu Laqun (University of Electronic Science and Technology of China, China), Liu Dagang (University of Electronic Science and Technology of China, China), Meng Lin (University of Electronic Science and Technology of China, China)

The multipactor of dielectric window is studied by electromagnetic Particle-In-Cell (PIC) simulations. Firstly, simulations show that the multipactor of dielectric window on the upstream side is more serious than that on the downstream side. Secondly, the multipactor of dielectric

window on the upstream side in microwaves of TEM mode is simulated in more details, and compared to our theoretical results. It is found that the multipactor is more serious than Kishek's model in the regions of weak dc electric fields and strong rf electric fields, which leads the vanish of upper boundary. Thirdly, the dielectric multipactor in microwaves of TE modes is simulated. It is found that the upper boundary reappears when the rf frequency of TE modes trends to the cutoff frequency of waveguide.

P2-3.10 / A Tri-band Serpentine Mode Converter Applied in High Power Microwave

Hao Li (University of Electronic Science and Technology of China, China), Keqiang Wang (University of Electronic Science and Technology of China, China), Chen Cai (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China), Tianming Li (University of Electronic Science and Technology of China, China), Jianing Zhao (University of Electronic Science and Technology of China, China), Chaoxiong He (University of Electronic Science and Technology of China, China), Xin Wang (University of Electronic Science and Technology of China, China)

In this paper, a tri-band serpentine mode converter applied in high power microwave is proposed. This mode converter consists of an outer coaxial waveguide and an inner embedding circular waveguide, and they have the same curvature distribution along longitudinal propagation axis. The outer coaxial mode converter operates at 8.5 GHz (X band) and 15 GHz (Ku band), the center frequency of the circular mode converter is 35 GHz (Ka band). In the mode converter, the injected coaxial TEM mode (coa.TEM) and circular TM_{01} modes (cir.TM_{01}) can be transformed simultaneously into coaxial and circular TE_{11} modes (coa.TE_{11} and cir.TE_{11}), respectively. The results validated by CST show that the maximum conversion efficiencies of the synthesized mode converter at central frequencies are all over 97.8%, and the bandwidths (conversion efficiency is over 95%) are 730 MHz, 820 MHz, and 720 MHz, respectively.

P2-3.11 / Simulation of A Ka-band Mode Converter from the Rectangular Waveguide TE_{10} Mode to the Circular Waveguide TE_{02} Mode

Wang Xiaoyan (Chinese Academy / University of Chinese Academy of Sciences, China), Gao Dongping (Chinese Academy, China), Wang Yong (Chinese Academy / University of Chinese Academy of Sciences, China), Yang Jie (Chinese Academy / University of Chinese Academy of Sciences, China), Zhang Fengzhen (Chinese Academy / University of Chinese Academy of Sciences, China), Zhang Lianzheng (Chinese Academy, China)

The structure of a mode conversion from the rectangular waveguide TE_{10} mode to the cylindrical waveguide TE_{02} mode is studied. The simulation results with Ansoft HFSS shows that the -3dB bandwith is about 2GHz and total efficiency is more than 70% from input rectangular TE_{10} mode to circular TE_{02} mode at Ka band. This mode converter made a foundation for a Gyro-amplifier operating in high-order mode.

P2-3.12 / Development of tuning diaphragm for high power continuous wave klystron

Yongqing Zhang (Chinese Academy of Sciences, China), Shengyi Yin (Chinese Academy of Sciences, China), Haibing Ding (Chinese Academy of Sciences, China), Xiangyang Gao (Chinese Academy of Sciences, China), He Jin (Chinese Academy of Sciences, China), Xiaoxin Sun (Chinese Academy of Sciences, China)

In order to meet the requirement of 150MHz frequency tuning range for continuous wave klystron, a copper/ Mn copper-nickel alloy/copper (Cu/ (Cu-Ni) /Cu) diffusion welding tuning diaphragm with a thickness of 0.3mm and the corresponding tuning mechanism were developed. During the research, the vacuum hot pressing diffusion welding of composite material, the stamping and forming of tuning diaphragm, the microstructure analysis of copper / Mn copper-nickel alloy /copper diffusion interface, and the test of turning range of tuning structure at X band are carried out. The results show that the tunable range of the composite diaphragm and the tuning structure can reach 280MHz, which is far beyond the design requirement.

P2-3.13 / Effect of Preparation Process on Surface Roughness of Parts for Welding Vacuum Envelope of Space Traveling Wave Tube

YUAN Guangjiang (Chinese Academy of Sciences, China), ZHANG Yuanmin (Chinese Academy of Sciences, China), LI Yunjin (Chinese Academy of Sciences, China), ZHAI Dehui (Chinese Academy of Sciences, China), SONG Wei (Chinese Academy of Sciences, China), WANG Xin (Chinese Academy of Sciences, China)

Surface roughness of parts is one of key parameters on bonding quality of transient liquid phase welding. In the paper, various preparation processes for parts of vacuum envelope of space traveling wave tube were employed. Differences among these preparation processes were studied. Parts of vacuum envelope were prepared by preferable processes. Perfect vacuum envelopes of space traveling wave tube were produced by transient liquid phase welding.

P2-3.14 / A Broadband low-lessW-band Pill-box Window

Tongbin Yang (University of Electronic Science and Technology of China, China), Wenjie Fu (University of Electronic Science and Technology of China, China), Xiaotong Guan (University of Electronic Science and Technology of China, China), Dun Lu (University of Electronic Science and Technology of China, China), Yang Yan (University of Electronic Science and Technology of China, China)

To develop wide-band low-loss window for W-band vacuum electronic devices, an asymmetric pill-box window is investigated in this paper. The presented pillow-box window is composed of standard waveguide, circular waveguide, and sapphire dielectric window. According to the equivalent circuit theory, initial parameters for the asymmetric pill-box window is designed. 3-D electromagnetic computer code CST is used to verify and optimize the design. By carefully controlling the errors in machining, assembly, and brazing process, a prototype sample is manufactured and test. The test results show that the S_{21} is > -1dB between the frequency

range of 76-110 GHz. The leak rate of the window system is 1.2E-10 Pa·m^3/sec.

P2-3.15 / A broadband three-way power divider based on E-Y structure

Zhe Wang (University of Electronic Science and Technology of China, China), Youlei Pu (University of Electronic Science and Technology of China, China), Wei Shao (University of Electronic Science and Technology of China, China), Xin Wang (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China)

In this paper, a broadband three-way power divider based on E-Y structure is presented. It can realize odd-ways power divider with compact structure, low loss, and low VSWR. In addition, the amplitude and phase are good balance. The simulated results of the power divider has shown that the return loss is greater than 30 dB, the amplitude difference of output ports is less than 0.1 dB from 26 to 40 GHz (the whole Ka-band).

P2-3.16 / A Broadband Ridge Gap Waveguide to Micro-strip Transition Using Probe Current Coupling

Songtao Peng (University of Electronic Science and Technology of China, China), Youlei Pu (University of Electronic Science and Technology of China, China), Wei Shao (University of Electronic Science and Technology of China, China), Xin Wang (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China)

Based on the current coupling theory, a broadband, low-loss micro-strip to ridge gap waveguide transition is presented in this paper. The impedance matching between ridge gap waveguide and 50 Ω micro-strip line is realized by the ridge probe. Compared with the traditional step impedance transformation, the probe transition can greatly expand the operating band and reduce the sensitivity to assembly tolerance. The optimized back-to-back ridge gap waveguide to micro-strip transition shows that the relative bandwidth of 100 % for S_{11} < -20 dB can be obtained. The insertion loss is better than 0.1 dB in the designed frequency bands for the whole structure.

P2-3.17 / A Novel TE_{01} Input Coupler for a W-band Gyrotron Traveling-Wave Tube

Chao Fang (University of Electronic Science and Technology of China, China), Guo Liu (University of Electronic Science and Technology of China, China), Wei Rao (University of Electronic Science and Technology of China, China), Yue Wang (University of Electronic Science and Technology of China), Shiyu Wang (University of Electronic Science and Technology of China, China), Jiangxun Wang (University of Electronic Science and Technology of China, China), Wei Jiang (University of Electronic Science and Technology of China, China), Li Wang (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China), Guoxiang Shu (Shenzhen University, China)

A novel input coupler, 4 coaxial sector waveguides excited via a rectangular TE_{10}, was simulated and verified by millimeter wave measurement. Simulations predicts that the average transmission was -2dB with a 3dB bandwidth of 15GHz (90-105GHz) and port reflection was less than -10dB. Excellent performance was observed, which was in good agreement with the simulation results. This input coupler has many available applications such as gyro-devices, high power transmission line, microwave and antenna system.

P2-3.18 / Coaxial Multipactor Susceptibility at GHz Frequencies

Nicholas M. Jordan (University of Michigan, USA), Flynn B. Darby (University of Michigan, USA), Stephen V. Langellotti (University of Michigan, USA), Y. Y. Lau (University of Michigan, USA), Ronald M. Gilgenbach (University of Michigan, USA)

Uncertainty in multipactor prediction currently leads to unanticipated device failures in many medium and high-power systems. Space-based systems, such as communication satellites, are strongly impacted by this uncertainty, due to their tight engineering requirements and susceptibility to signal degradation. The high-frequency coaxial regime, in particular, is not well characterized. We report here on experimental and computational results obtained in coaxial geometry for this frequency-space.

P2-3.19 / A Broadband Reflective Polarization Converter Based on the Metallic Grating

Yu Zhang (University of Electronic Science and Technology of China, China), Zewei Wu (University of Electronic Science and Technology of China, China), Wei Shao (University of Electronic Science and Technology of China, China), Xin Wang (University of Electronic Science and Technology of China, China), Hao Li (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China)

In this paper, a novel structure of reflective circular polarizer for millimeter wave band is proposed, which can convert the linear polarization to the circular polarization in a wide band. The proposed reflection-type circular polarizer is a metallic grating consisting of mushroom-shaped elements. The grating profile and period are optimized to provide great converting performance. The simulation results show that the 1.2 dB axial ratio bandwidth is about 5.6 GHz. The designed grating circular polarizer features simple structure and wide bandwidth, which can be used for broadband transmission systems in the millimeter wave range.

P2-3.20 / Compact Waveguide Coupler with Broadband and High Coupling Flatness

Miao Sun (University Of Electronic Science And Technology Of China, China), Yong Xu (University Of Electronic Science And Technology Of China, China), Tinghui Peng (University Of Electronic Science And Technology Of China, China), Ya Mao (University Of Electronic Science And Technology Of China, China), Weijie Wang (University Of Electronic Science And Technology Of China, China), Yong Luo (University Of Electronic Science And Technology Of China, China)

A compact rectangular waveguide coupler with high coupling flatness is proposed and measured in this paper. The coupler mainly consists of a main waveguide, a secondary waveguide and the coupling aperture array. Two rows and two columns of four square coupling holes combing two slots between each column holes is composed the coupling aperture array. It realizes broadband, high coupling flatness and compact size by adopting the proposed aperture array, especially for coupling flatness. For verification purpose, a Ka-band prototype has been designed, manufactured and measured. The total length of the coupler is only 56.7 mm and the experimental results by Vector network analyzer show that coupling degree varies −29.8 dB to −30.3 dB over the full waveguide bandwidth.

P2-3.21 / The dielectric constant measurement using a TE_{01} mode in W-band

Hong Eun Choi (Ulsan National Institute of Science and Technology, Korea), Wonjin Choi (Ulsan National Institute of Science and Technology, Korea), Mun Seok Choe (Ulsan National Institute of Science and Technology, Korea), Evgenya Simakov (Los Alamos National Laboratory, USA), Bruce Carlsten (Los Alamos National Laboratory, USA), Muhammed Zuboraj (Los Alamos National Laboratory, USA), Eun Mi Choi (Ulsan National Institute of Science and Technology, Korea)

The dielectric constant varies with frequency so that the known dielectric constant at low-frequency is no longer valid at high-frequency regions. When the frequency increases, experimental imperfection such as air gap between a sample and a resonator cannot be ignored anymore in the dielectric constant measurement by means of the resonator method. In contrast to the existing resonator method using a fundamental TE_{10} mode in a rectangular waveguide, we propose to use a TE_{01} mode in a circular waveguide which is less affected by the air gap between the surface of the waveguide and the dielectric material.

P2-3.22 / Electromagnetic and thermal analysis of high-order mode RF window

Xinde Sheng (Chinese Academy of Science / University of Chinese Academy of Sciences, China), Jirun Luo (Chinese Academy of Science / University of Chinese Academy of Sciences, China), Min Zhu (Chinese Academy of Science, China), Wei Guo (Chinese Academy of Science, China), Yu Fan (Chinese Academy of Science, China)

Electromagnetic and thermal analysis of high-order mode RF window was carried out using CST MPHY software, including transmission, reflection, insertion loss, and the temperature distribution on the disk of the window. A double-disk beryllia window, whose bandwidth of -25dB reflection was 2.16GHz and maximum temperature difference on the ceramic disk surface was 43K, was designed to applied to a 140GHz, $TE_{28,8}$ -mode operation gyrotron oscillator.

P2-3.23 / Design of a Q-band Circular Waveguide TE_{01} Mode Converter

Tinghui Peng (University of Electronic Science and Technology of China, China), Yong Xu (University of Electronic Science and Technology of China, China), Miao Sun (University of Electronic Science and Technology of China, China), Ya Mao (University of Electronic Science

and Technology of China, China), Weijie Wang (University of Electronic Science and Technology of China, China), Yong Luo (University of Electronic Science and Technology of China, China)

In this paper, a Q-band rectangular waveguide TE_{10} mode to circular waveguide TE_{01} mode converter is designed and analyzed. The topology of the proposed mode converter is constituted by an $TE^{\square}_{10}$ to $TE^{\square}_{20}$ mode converter with twist waveguide, $TE^{\square}_{20}$ to TE^{+}_{22} mode converter with cross-waveguide and the transformation from TE^{+}_{22} to TE°_{01} mode. The three segments of the proposed mode converter can be designed separately, and the linearly gradient structure is adopted in each segment for easy processing. Simulation results reveal that the insertion loss of the proposed TE_{01} mode converter is better than -0.06 dB and the return loss is below -20 dB at Q-band. It realizes high conversion efficiency (>98.6%) in a relative bandwidth of 36.6%.

P2-3.24 / 3D Printing Integrated Fabrication of CathodeHeater Assembly

Xin Sun (Beijing Vacuum Electronics Research Institute, China), Wensheng Shao (Beijing Vacuum Electronics Research Institute, China), Huaichao Yang (Advanced Technology & Materials Co. ,Ltd, China)

This paper reports on a new type of cathode-heater assembly and uses the selective laser melting (SLM) technology in 3D printing to achieve an integrated fabrication process. A thermal resistance of about 0.4 Ω.is reached after the excess heater sub-support columns are fused with a high energy laser. After applying a heating power of 21.6 W, the heater generated by the SLM reached a temperature of 1250 ˚C.

P2-3.25 / Design of the 94 GHz, TE_{62} Mode Generator Using Quasi-Optical Techniques

Shuang Chen (University of Electronic Science and Technology of China, China), Jinhao Li (University of Electronic Science and Technology of China, China), Yinghui Liu (University of Electronic Science and Technology of China, China), Jianwei Liu (University of Electronic Science and Technology of China, China), Xinjian Niu (University of Electronic Science and Technology of China, China), Hui Wang (University of Electronic Science and Technology of China, China), Guo Guo (University of Electronic Science and Technology of China, China), Lina Wang (University of Electronic Science and Technology of China, China), Tao Song (University of Electronic Science and Technology of China, China)

This paper details the core of the high-order TE_{62} mode generator components -- the coaxial resonant cavity. In order to obtain high purity TE_{62} mode and improve the isolation among the modes, we use a cavity with an improved coaxial structure. The slowly variable section open coaxial cavity structure can make the TE_{62} mode well separated from its nearby modes. In this paper, the influence of the inner and outer radii of the coaxial cavity on the resonant frequency is presented. The TE_{62} mode purity of the cavity was calculated by the MATLAB program to be 95.3% and the result of the HFSS simulation after the optimization design of the W-band high purity TE_{62} mode cavity is given, which is in close agreement with the ideal field distribution.

P2-3.26 / Progress of high power and long-pulse dual-frequency ECH system in KSTAR

Sunggug Kim (National Fusion Research Institute, Korea), Sonjong Wang (National Fusion Research Institute, Korea), Jongwon Han (National Fusion Research Institute, Korea), Mi Joung (National Fusion Research Institute, Korea), Jong-gu Kwak (National Fusion Research Institute, Korea)

ECH (Electron Cyclotron Heating) system for KSTAR (Korea Superconducting Tokamak Advanced Research) is composed of two dual-frequency gyrotrons, each generating 950kW of RF power at 140 GHz and 800kW of RF power at 105 GHz. EC system will be installed up to 6 gyrotrons. RF power generated by gyrotron is transmitted to antenna system. The distance of transmission line (TL) from output window of the gyrotron to the launcher is about 70m or more. TL system is composed of 63.5mm corrugated waveguides and several miter bends. The antenna for the EC system consists of two single ports and two dual ports. In this paper, we will describe the EC system currently installed in KSTAR and explain its future plans.

P2-3.27 / Interaction Impedance Measuring Method in Sine Waveguide

Qi Wu (University of Electronic Science and Technology of China, China), Jin Xu (University of Electronic Science and Technology of China, China), Shuanzhu Fang (University of Electronic Science and Technology of China, China), Pengcheng Yin (University of Electronic Science and Technology of China, China), Xuebing Jiang (University of Electronic Science and Technology of China, China), Xia Lei (University of Electronic Science and Technology of China, China), H.R.Yin (University of Electronic Science and Technology of China, China), L.N.Yue (University of Electronic Science and Technology of China, China), G.Q.Zhao (University of Electronic Science and Technology of China, China), W.X.Wang (University of Electronic Science and Technology of China, China), Yanyu Wei (University of Electronic Science and Technology of China, China)

The sine waveguide has been proved to be a promising structure with excellent transmission characteristics. In this work, a formula measuring the interaction impedance for sine waveguide is given based on the non-resonant perturbation theory. The measuring results of diversion characteristic and interaction impedance are compared with the simulation results for a sine waveguide slow-wave structure operating in W-band and the differences between the two results are less than 3.5% and 11.2%.

P2-3.28 / Evanescent Mode Resonance in Metasurface Antenna On Metal Surface

Jagannath Malik (Ulsan National Institute of Science and Technology, Korea), Sai Kiran Oruganti (Ulsan National Institute of Science and Technology, Korea), Woojin Park (Ulsan National Institute of Science and Technology, Korea), Bonyoung Lee (Ulsan National Institute of Science and Technology, Korea), Seoktae Seo (Ulsan National Institute of Science and Technology, Korea), Nak-Young Ko (Ulsan National Institute of Science and Technology, Korea), Dipra Paul Paul (Ulsan National Institute of Science and Technology, Korea), Hak-Sun Kim (Ulsan National Institute of Science and Technology, Korea), Franklin Bien (Ulsan National Institute of Science

and Technology, Korea)

We present a metasurface antenna comprising periodic arrangement of interconnected rectangular unit cells. The proposed antenna is designed to utilize evanescent mode resonance. The resonance is achieved by utilizing strong cavity mode oscillation, when the antenna is placed over a metallic surface. However, when the antenna is freely suspended in the air, in its natural state, the resonance is absent. At an optimized feed point, the antenna can be excited directly with a 50 ohm impedance line.

P2-3.29 / Thermal-Hydraulic Design and Analysis for High Power Dielectric Load Gyro-TWT

Wei Jiang (University of Electronic Science and Technology of China, China), Mengjun Wang (University of Electronic Science and Technology of China, China), Jianxun Wang (University of Electronic Science and Technology of China, China), Guo Liu (University of Electronic Science and Technology of China, China), Yaping Shen (University of Electronic Science and Technology of China, China), Guoxiang Shu (Shenzhen University, China)

The RF circuit is an important component in a gyro-travelling wave tube (Gyro-TWT) and its thermal performance influences the overall capability of the tube. Three different cooling structures for high power dielectric load Gyro-TWT are investigated. The simulation results are indicated that the capability is enhanced by employing the helical groove structure, and the coolant vaporization is suppressed. The Gyro-TWT based on helical groove is fabricated. The hot test for capability validation is on the way.

P2-3.30 / Effect of Thermal Deformation on Thermal Contact Resistance Between Helix and Support Rods in Helix TWT

Jinyan Wang (Southeast University, China), Jin Zhang (Southeast University, China), Xiaohan Sun (Southeast University, China)

In this paper, we analyze the effect of thermal deformation on the thermal contact resistance between the helix and support rods in the helix TWT. We simulate and discuss the stress distribution along the contact surface between the helix and the support rods with the helix deformation, and obtain the distribution of the thermal contact resistance along the slow-wave structure according to the relationship between the stress and the thermal contact resistance. The results provide a credible basis for establishing a more reasonable and accurate thermal analysis model for the helix TWT.

P2-3.31 / Design of High Power Vacuum Feedthrough for Multipactor Effect Suppression

Kwangho Jang (National Fusion Research Institute, Korea), Kenji Saito (National Institute for Fusion Science, Japan), Sonjong Wang (National Fusion Research Institute, Korea), Hyunho Wi (National Fusion Research Institute, Korea), Jonggu Kwak (National Fusion Research Institute, Korea)

A helicon current drive system need the high power vacuum feed-through (VFT) for the of upgraded KSTAR helicon current drive system. However, multipactor effect shows a problem of RF reflection in VFT vacuum region. So the proposed structure was to place a low electric field in the ceramic using a standing wave. The designed VFT shows the E_z value close to zero and the electric field absolute value of about 1.7kV/cm when transmitting 1MW in ceramic. It showed the high Q value of transmission characteristics at 476MHz.

P2-3.32 / Influence of Rectangular Aperture Aspect Ratio on Sheet Beam Generation

Nikita Gurjar (CSIR-Central Electronics Engineering Research Institute, India), M. Afaque Hossain (CSIR-Central Electronics Engineering Research Institute, India), R.K. Sharma ((CSIR-Central Electronics Engineering Research Institute, India), Niraj Kumar (CSIR-Central Electronics Engineering Research Institute, India)

A Pseudospark discharge based miniaturized sheet electron beam gun has been simulated using COMSOL Multiphysics software. The simulation has been performed to propose the dependency of the aspect ratio of rectangular aperture of hollow cathode on the onset of hollow cathode phase (HCP) as well as the HCP duration. Larger duration of the HCP is a desirable output as it increases the duration of energetic electron beam which leads to an effective beam-wave interaction. Therefore a comparative simulation study of varying aspect ratio with the change in HCP duration has been presented in the paper. A method has been proposed here showing the dependency of the aspect ratio of the rectangular aperture of sheet beam source on the HCP duration. The rectangular aperture aspect ratio has been varied from 5:1 to 12:1 for different applied gap voltage between 20kV to 25kV.

P2-3.33 / Time dependent output characteristics of horn antennas

Jinh-Shyang Yen (National Taipei University of Technology, Taiwan), Xuan-De Huang (National Taipei University, Taiwan), Chia-Wei Lin (National Taipei University, Taiwan), Kaviya Aranganadin (Hanyang University, Korea), Chii-Ruey Lin (Minghsin University of Science and Technology, Taiwan), Ming-Chieh Lin (Hanyang University, Korea), Hua-Yi Hsu (National Taipei University of Technology, Taiwan),

In this work, a three-dimensional conformal finite-difference time-domain simulation is employed to study the time dependent output properties of horn antennas for high power microwave (HPM) applications. As a benchmark, fundamental modes in standard rectangular and circular horn antennas are studied and compared with those simulated in frequency domain using HFSS. For steady state operation, the output characteristics shows similar behaviors in both frequency and time domainswhile in transient regime the time dependent characteristics demonstrates very interesting phenomena which might be better considered for a short pulse HPM operation. The final goal is to study the output characteristics of higher order modes for a specific application. Preliminary results obtained including near field and far field patterns and corresponding antenna parameters will be presented.

P2-3.34 / Estimating Internal Temperature of Slow Wave Structure Based on RBF Neural Network and Designing Test Model

Xingqun Zhao (Southeast University, China), Xiaoting Ying (Southeast University, China), Xiaohan Sun (Southeast University, China)

At present, there are many researches on the TWT (traveling wave tube) thermal properties. However, the investigations on the measurement of the temperature field inside the TWT are rarely involved. Based on RBF neural network model and ANSYS thermal simulation data of slow wave structure, a method for estimating the inner temperature of TWT is proposed in this paper, and the results with very small error are obtained by simulation data. At the end of this paper, a simplified model of slow wave structure is designed, which will be used to obtain real temperature data in the later stage to verify the reliability of the internal temperature estimation method.

P2-3.35 / Design and Experiment of Input Coupling Section for Coupled-Cavity Traveling Wave tube

Wei Guo (Chinese Academy of Sciences, China), Min Zhu (Chinese Academy of Sciences, China), Jirun Luo (Chinese Academy of Sciences, China)

In this paper, the design, experiment and improvement of an input coupling section for X-band coupled-cavity TWT are discussed. The idea, experiment and improvement are introduced. This input coupling section has been put into use. Considering the measured data, easy processing characteristics and experimental results, we think that the input coupling section achieves good results.

P2-3.36 / Study of a Promising Electrodynamic Photonic Crystal-like Structure inside a Rectangular Waveguide

Andrey Starodubov (Institute of Radio Engineering and Electronics RAS, Russia), Viktor Galushka (Saratov State University, Russia), Semen Kurkin (University of Saratov, Russia), Artem Badarin (University of Saratov, Russia/ Yuri Gagarin State Technical University of Saratov, Russia), Anton Pavlov (Saratov State University, Russia), Yurii Kalinin (Saratov State University, Russia), Alexey Koronovskii (Saratov State University, Russia)

Here we report on experimental and numerical investigations of an electrodynamic structure assembled according to photonic crystals' principles placed inside a X-band rectangular waveguide which is promising for microwave electronics. The features of dispersion characteristics of photonic crystals can be used for efficient excitation of high-order (and, hence, high-frequency) electromagnetic modes. In this work, the electrodynamic structure is a2D array of thin metal pins. Transmission and reflection of proposed system were measured experimentally and evaluated numerically. The experimental results are in good agreement with the numerical ones.

P2-3.37 / Design and simulation of L-band microwave waveguide circulator with increased efficiency and broad bandwidth

Kaviya Aranganadin (Hanyang University, Korea), Hua-Yi Hsu (National Taipei University of Technology, Taiwan), Ming-Chieh Lin (Hanyang University, Korea)

The industrial L-band WR975 circulators operating at a frequency range from 900 to 930 MHz have been designed and simulated. Commercially, an L-band circulator at 896 ± 10 MHz is available. However, for a wider bandwidth (~ 30 MHz) application, we would need two units operated in dual frequencies between 896 MHz and 915 MHz to cover the frequency range required. Through a Finite Element Method (FEM) simulation study, it was found that by reducing the height of the waveguide circulator in half a broader bandwidth can be obtained and this also leads to a reduction of overall fabrication cost. This paper discusses a detailed design and modeling of the L-broadband circulator operating at 915 MHz with a bandwidth of 43.5 MHz (892MZ to 935.5 MHz), an insertion loss of 0.25 dB for the entire bandwidth, and 0.22 dB at frequency of 915 MHz. For the entire bandwidth, the transmission efficiency is over 94.3% and it is more than 95% from 900 to 930 MHz of operating region which reduces power reflections for improving the performance and reliability of magnetrons. In addition, different ferrite materials are studied for optimizing this L-band waveguide circulator.

Poster 2

April 30 (Tuesday) / 15:10 ~ 16:30 / Capri room

Systems / Power supply / Applications

P2-4.1 / A novel interleaved structure high-voltage transformer and its application in TWTA

Depeng Bai (China Academy of Space Technology, China), Xiaoming Ji (Nanjing University, China), Xinbo Ruan (Nanjing University, China), Bin HE (China Academy of Space Technology, China), Weibo HUANG (China Academy of Space Technology, China), Bin ZHOU (China Academy of Space Technology, China)

This paper proposes a planar high voltage interleaved transformer design method. The transformer is suitable to be used in power supply for TWT. Since the parasitic parameters of the transformer are adopted as resonant elements, the cross regulation problem is alleviated. Moreover, the iteration of FEA simulation and circuits design will greatly reduce the cost of design. The method is verified by a 600W multiple output power supply for TWTA, and the performance of the prototype shows this method is effective.

P2-4.2 / Design and Measurement of Induction Voltage Adder with Amorphous Metal Magnetic Cores

Jong-Won Yang (Agency for Defense Development, Korea), Woosang Lee (Agency for Defense Development, Korea), Han-Yong Ryu (Agency for Defense Development, Korea), Heo Hoon (Pohang Accelerator Laboratory, Korea), Young Joon Yoon (Yonsei University, Korea)

We designed and fabricated IVA (Induction Voltage Adder) with 2 unit cells. Two identical unit cells were connected in series. The unit cell consisted of 4 magnetic cores. The magnetic core was fabricated to have a toroidal shape using amorphous metal. The added double output voltage of input was measured in the load. We presented the features of design of IVA pulse generator and its experimental results.

P2-4.3 / Analysis of High Frequency Flyback Converters For High-voltage Low-power Applications

Bin Zhao (Chinese Academy of Sciences, China), Gang Wang (Chinese Academy of Sciences, China), Dong Lei Wang (Chinese Academy of Sciences, China)

This paper proposes a new working mode of the high frequency Flyback converter for the high-voltage low power applications, such as atomic clock, ion analysers, high voltage ignition system, vacuum electronic devices etc. With the proposed working mode, the main switch of the Flyback converter can achieve Zero Voltage Switching (ZVS) without extra auxiliary switch. Due to the advantage of ZVS, the Flyback converter can operate under high frequency and high

efficiency conditions. As a result, the volume of the passive components can be reduced and the power density of the converter can be improved. The proposed working mode of high-frequency Flyback converter is validated by simulations and experiments.

P2-4.4 / Analysis and Design of the Resonant Current of the LCLC Resonant Converters with Consideration of Zero-Voltage Switching and Zero-current Switching

Bin Zhao (Chinese Academy of Sciences, China), Gang Wang (Chinese Academy of Sciences, China), Dong Lei Wang (Chinese Academy of Sciences, China)

The LCLC resonant converters are widely used in the Electronic Power Conditioner (EPC) in a Travelling wave Tube Amplifier (TWTA) due to the advantage of Zero Voltage-Switching (ZVS) and Zero-Current-Switching (ZCS). However, in the physical circuit, problems such as non-Zero Current-Switching and reverse resonant current appear and the efficiency decreases. Based on the working principles of the LCLC resonant converters, this paper presents the method to remove the reverse resonant current and the non-zero switching. Furthermore, an empirical data is given to guide the design of the converter. Finally, the analysis is validated by the simulations and experimental results.

P2-4.5 / Thermal Analysis of The Slow Wave Structure (SWS) Assembly of The Travelling Wave Tube

Chirag Mistry (CSIR-CEERI, India), Sanjay Kumar Ghosh (CSIR-CEERI, India)

Thermal management of helix slow-wave structure (SWS) in a traveling-wave tube (TWT) has great influence on its performance namely, average power handling capability, TWT efficiency, S-parameters, etc. The main source of thermal load of helix SWS is the intercepted power loss, which is assumed to be uniform over the TWT and as a measure of helix interception current during DC or RF testing. However, practically intercepted power loss would be different in different sections of TWT. Typically, it is higher in output section than input section due to growth of signal. In this paper, thermal analysis of helix SWS has been presented for three different cases namely, uniform heating, non-uniform heating and localized heating respectively and corresponding temperature distribution in different section of the SWS have been estimated using ANSYS.

P2-4.6 / Automatic Magnetic Field Measurement System for Traveling Wave Tube based on Virtual Instrument

Jie Zhang (University of Electronic Science and Technology of China, China), Dapeng Gong (University of Electronic Science and Technology of China, China), Tao Huang (University of Electronic Science and Technology of China, China), Bin Li (University of Electronic Science and Technology of China, China)

This paper introduces an automatic magnetic field distribution measurement system for traveling wave tube magnetic ring based on virtual instrument, which is mainly used to measure

the axial magnetic field strength of TWT magnetic bunching system. The hardware system consists of optical table, non-magnetic chuck, motor controller, electronically controlled translation platform, high-precision Gauss meter, etc. In the LabWindows/CVI virtual instrument programming environment, modular development and debugging of measurement software are carried out, and finally the distributed measurement of the axial magnetic field of the traveling wave tube is achieved.

P2-4.7 / Development of a 3.3 kJ system and a 300 kJ system for Triggered Vacuum Switch

Wung-Hoa Park (Pohnag Accelerator Laboratory, Korea), Hyung Seop Kong (Pohnag Accelerator Laboratory, Korea), Suk Ho Ahn (Pohnag Accelerator Laboratory, Korea), Byung-Joon Lee (Pohnag Accelerator Laboratory, South Korea)

We have developed a 3.3 kJ system and a 300 kJ system to fabricate a sealed-off triggered vacuum switch (TVS). The goal of fabricated sealed-off TVS was a hold-off voltage of 20 kV, a maximum peak current of 150 kA, a maximum charge of 60 C, and a pulse width of 2 ms. In order to achieve the goal, we have progressed a fundamental research to understand the characteristics of the sealed-off TVS. The fabrication of the sealed-off TVS has processed based on the fundamental research. The performance estimation has conducted for the fabricated product. The 3.3 kJ system has been developed to employ the fundamental research and the fabrication process. Whereas, the 300 kJ system has been optimized to estimate the performance for the fabricated sealed-off TVS. The basic structure of the 3.3 kJ system and the 300 kJ system are same. They are consisted of a charging part and a discharging part. The 3.3 kJ system has used a charging capacitor bank of 16.52 μF and a discharging parallel-plate inductor of 1 μH. The 300 kJ system has employed a charging capacitor bank of 1.256 mF and a discharging bus-bar inductor of 10 μH. The estimated performance of the fabricated sealed-off TVS has achieved a hold-off voltage of 20 kV, a maximum peak current of 152 kA, a maximum charge of 90 C, and a pulse width of 2 ms.

P2-4.8 / The Effect of Multipactor on the Quality of a Signal

Patrick Y.Wong (University of Michigan / Michigan State University, USA), Y. Y. Lau (University of Michigan, USA), Peng Zhang (Michigan State University, USA), Nicholas Jordan (University of Michigan, USA), Ronald Gilgenbach (University of Michigan, USA), John Verboncoeur (Michigan State University, USA)

Recently, there is significant interest in multipactor discharge because of its threat to satellite communications. In this paper, an analytical model is presented which assesses the distortion of a signal by multipactor. Complex, multi-tone signals will also be investigated. The I-Q plot is resented to show the effects of multipactor.

P2-4.9 / ESS Klystron Production Test Stand

Marcel P.J. Gaudreau P.E. (Diversified Technologies, Inc., USA), Ian Roth (Diversified Technologies, Inc., USA), Noah Silverman (Diversified Technologies, Inc., USA), Michael Kempkes

(Diversified Technologies, Inc., USA), Rebecca Simpson (Diversified Technologies, Inc., USA)

Diversified Technologies, Inc. (DTI) has delivered a new long-pulse modulator klystron test stand to Communication and Power Industries (CPI) in Palo Alto, CA for full power testing of production VKP-8292A klystrons for the European Spallation Source (ESS). The output is flat to less than 0.5% over 3.3 ms. This test stand was built using hardware and designs from an earlier SBIR effort for the Department of Energy, with modifications to support ESS requirements and klystron testing operation. Earlier versions of this design are in use at IPN Orsay and CEA Saclay in France to test RF components for ESS.

P2-4.10 / UNIST-EBIT vacuum and confinement system (with simulations)

Sung Nam Park (UNIST, Korea), Kyung-Hun Yoo (UNIST, Korea), Moses Chung (UNIST, Korea)

Intense Beam and Accelerator Laboratory(IBAL) at Ulsan National Institute of Science and Technology(UNIST) is building a miniaturized Electron Beam Ion Trap(mini-EBIT) for the spectroscopy of the highly charged ions(HCIs). The compact, easily portable table-top mini-EBIT, which has the vacuum level of 10^{-10} mbar confines the electron impact ionized atoms in both longitudinal and radial directions using the electric and magnetic fields respectively. The mini-EBIT with an on-axis electron gun which generates up to 8 keV energy-tunable electron beam, and a 0.86 T room-temp permanent magnets, allows us to do the X-ray spectroscopy of the HCIs in a cost effective and low maintenance way. In this work, we present the overall vacuum structure of the EBIT with the simulations for the electron and ion confinements using the COMSOL and SIMION.

P2-4.11 / Magnetron power modulator for driving a microtron THz FEL

Taesik Yoon (Korea Atomic Energy Research Institute / Chungnam National Univercity, Korea), B. A. Gudkov (Korea Atomic Energy Research Institute, Korea), Sangyoon Bae (Korea Atomic Energy Research Institute / Chungnam National Univercity, Korea), Sergey Miginsky (Korea Atomic Energy Research Institute, Korea), Young Uk Jeong (Korea Atomic Energy Research Institute, Korea), Kyu-ha Jang (Korea Atomic Energy Research Institute, Korea), Kitae Lee (Korea Atomic Energy Research Institute, Korea), Min Yong Jeon (Chungnam National University, Korea)

Korea Atomic Energy Research Institute (KAERI) has developed a new modulator using IGBT. The bipolar pulse generator provides preliminary dynamic magnetization of the transformer core. also, bipolar pulse generator makes possible computer control of the starting current of the magnetron. Computer operation with the bipolar pulse generator can produce 34% current change. Corrector for pulse waveform correction has been described. With the corrector we reduced magnetron frequency deviation down to 40kHz. Modulator output parameters: 10Hz 51kV 100A 6us.

P2-4.12 / A Vacuum Arc Diagnosis Method for the High Voltage Power Supply of Vacuum Tubes

Ramin Ayoubi (Sharif University of Technology, Iran), Mostafa Rahmanian (Sharif University of

Technology, Iran), Shahriyar Kaboli (Sharif University of Technology, Iran)

Vacuum tubes are widely used for various applications. These vacuum tubes are supplied by high voltage power supplies. The amount of delivered energy from the high voltage power supply to the vacuum tube is an important issue during the vacuum arc in the tube. The protection mechanism consists of a shunt crowbar which diverts the fault current from the tube to itself as a parallel path. Detection of the vacuum arc is crucial and only one sensor is usually employed to detect the vacuum arc. This characteristic intensifies the interference susceptibility of the vacuum arc diagnosis system in a noisy environment. As a result of the noise, the arc detection system can report false alarms. False alarms are very likely to damage to both the vacuum tube and the high voltage power supply. A low-pass filter is an usual preventive measure of reducing the noise effect.
Decreasing the bandwidth of the filter leads to the reduction of noise effects, while the delay of the filter diminishes the speed of the vacuum arc detection system. The more interval of arc detection increases, the more energy is delivered to the tube, and the more damage the tube suffers during the arc fault. Accordingly, a fast and noise-robust vacuum arc detection scheme is crucial to protect the tube. In this paper, a fast vacuum arc diagnosis system is proposed based on neural networks. The proposed scheme consists of two sensors those their data are combined by neural networks to diagnose the vacuum arc and to reject false alarms in a noisy environment. In order to adjust the neural networks weights, Levenberg-Marquardt algorithm is used. Simulations tests are carried out to evaluate the proposed scheme.

P2-4.13 / Experience from KSTAR ECRH Commissioning

Young-soon Bae (National Fusion Research Institute, Korea)

This paper presents technical and operational issues that have been experienced during the commissioning of electron cyclotron resonance heating (ECRH) system for Korean Superconducting Tokamak Advanced Research (KSTAR). Most of the technical issues occurred from the commissioning of high-power and long-pulse capable gyrotron which is an most important component determining reliability and stability of ECRH system.

P2-4.14 / Low Level RF Control of Cyclotron for Neutron Capture Therapy System

Sun-Hong Min (Korea Institute of Radiological and Medical Sciences, Korea), In Su Jung (Korea Institute of Radiological and Medical Sciences, Korea), Chawon Park (Korea Institute of Radiological and Medical Sciences, Korea), Ilsung Cho (Korea Institute of Radiological and Medical Sciences, Korea), Won Taek Hwang (Korea Institute of Radiological and Medical Sciences, Korea), Bong Hwan Hong (Korea Institute of Radiological and Medical Sciences, Korea)

A versatile digital Low-Level Radio Frequency (LLRF) system has been designed for the various energy cyclotrons being developed by Korea Institute of Radiological and Medical Sciences (KIRAMS). In this study, the contents of LLRF of 8MeV~30MeV cyclotron, which is a typical circular accelerator for neutron capture therapy, are discussed. Here we present blue print to construct an effective LLRF control system of the cyclotron.

P2-4.15 / Heat Dissipation Analysis of M.2 NVMe Solid-State Drive in Vacuum

Eung Chang Lee (Korea Advanced Institute of Science and Technology, Korea), Jinsung Rho (Korea Advanced Institute of Science and Technology, Korea), Bong Jae Lee (Korea Advanced Institute of Science and Technology, Korea), Heeyoub Kang (Samsung Electronics, Korea)

The use of solid-state drive (SSD) in storage devices has been rapidly growing due to the development of memory technology for high performance and high integration. Further-more, the SSD is used in satellites, and the verification of the SSD operation is necessary in high vacuum condition without convection. Due to a small form factor and high performance in the vacuum, M.2 non-volatile memory express (NVMe) SSD is more susceptible to thermal failure. Recently, Samsung Elec- tronics SSD has applied a metal heat spreader to facilitate the heat dissipation on the top surface of the controller package. For designing such a thermal solution in the SSD, thermal analysis of the SSD during the operation must be preceded. However, the M.2 NVMe SSD has multiple heat sources, such as the controller, the NAND flash memory packages and the dynamic random-access memory (DRAM), making it difficult to analyze a heat dissipation mechanism of the M.2 NVMe SSD. In this research, we employ thermocouples and a temperature sensor in the controller to obtain temperature of the M.2 NVMe SSD in various operating conditions. For heat transfer analysis, we develop the thermal simulation model of the M.2 SSD and the model was validated by comparing to temperature measurement results at various conditions. We analyzed the heat dissipation mechanism of the M.2 NVMe SSD in the high vacuum and atmospheric environment

P2-4.16 / Beam Charge Monitor for quantitatively measuring electron bunch of very Low-charge pulse and Ultra-short pulse

H. Choi (PAL-XFEL, Korea), H. Heo (PAL-XFEL, Korea), H.-S. Kang (PAL-XFEL, Korea), Herve Bayle (Bergoz Instrumentation, France), H. Bayle, F. Stulle (Bergoz Instrumentation, France), Touzain Etienne (Bergoz Instrumentation, France)

The X-ray free-electron laser (XFEL) system of the Pohang accelerator laboratory (PAL) makes short electron beams with very low quantities of electric charge. It is difficult to measure bunch charge with very low-charge pulses and ultra-short pulses using an ordinary integrating current transformer (ICT). When there is a klystron modulator or a pulse power supply generating electromagnetic noise and ground noise in the surrounding area, it becomes especially difficult to measure the quantity of electric charge. In this paper we report on charge measurements performed at PAL-XFEL using a Turbo-ICT from Bergoz Instrumentation, which was developed to overcome various kinds of noise occurring in the surrounding areas.

P2-4.17 / Research of broadband digital predistortion with low sampling frequency

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Song (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China)

In order to solve the problem of high sampling rate in the feedback loop of broadband digital predistortion, a digital predistortion method based on probability distribution of the signal was proposed, which can provide good predistortion effect with far lower sampling rate in feedback loop.

P2-4.18 / Research of electronic optical system with power of 3kW and beam diameter of 0.1mm

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As the most cutting-edge and most potential technology in the whole 3D printing system, metal parts 3D printing technology is an important development direction of advanced manufacturing technology. One of the most important ways to achieve 3D printing of metal parts is by bombarding metal powder with electrons to melt it. Electron beam melting technology is an important part of metal 3D printing. Through CST software simulation, this paper aims to design an electronic optical system with voltage of 60kV, current of 0.05A, power of 3kW and transmission distance of more than 500mm for 3D printing of metal parts. The system can also be used to study terahertz waves.

P2-4.19 / Multi-Stage Slotted Waveguide Array Antenna for High Power Applications

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An antenna for high power microwave (HPM) radiation should be required for HPM immunity test. In this paper, the design of longitudinal slotted waveguide array antenna for narrowband HPM is described. This antenna is connected to HPM source through WR-284 waveguide. To avoid electrical breakdown in the aperture for air condition, we first perform an electric field analysis on three baseline slots by using CST-Microwave studio. The overall slot array is composed of 16×16 radiating slots and is divided into 8×4 sub-arrays. The sub-array is connected to the multi-stage divider, which is designed so that the applied MW-class HPM signal decreases below the breakdown level at sub-array input. We improved the septum divider and analyzed its characteristics according to the corner radius. The simulation results for overall antenna shows that it has 21.8 dB return loss, 32.06dBi antenna gain. The maximum E-field value at overall antenna is 2.67MV/m for applied HPM signal. The fabricated prototype antenna and measured data for HPM radiation is presented.

P2-4.20 / Operation of Compact X-Band Linear Acelerator System Mounted on the Gantry for Radiation Therapy

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Linear accelerators (LINAC) that generate high energy X-rays have been widely used for radiotherapy. With the combination of advanced imaging modalities, an image-guided radiation therapy (IGRT) has greatly improved the quality of radiotherapy by acquiring instant knowledge of changes in tumor volume, radiation dose distribution, and effective tumoricidal doses during treatment. In this study, we developed a compact 9.3 GHz X-band LINAC system and installed on the gantry for potential applications in IGRT. We confirmed X-ray generation using radio frequency transmission tests and measured the X-ray dose rates while the gantry was rotating, which demonstrates stable and reliable operation of the developed system. The field size of an X-ray beam was 10.31 cm × 10.31 cm at the solid water phantom (depth 0 cm) of the film, and the standard deviation of the X-ray dose was 0.016 while rotating. Therefore, we describe the design and test results of the X-band LINAC system mounted on the O-arm gantry. We expect the use of our design for the fusion system that integrates a diagnostic imaging instrument with a radiation therapeutic device.

P2-4.21 / The photoresponse of ZnO nanowire cold cathode flat panel detector using ZnS photoconductor

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A large area flat panel detector using ZnO nanowire cold cathode and ZnS photoconductor was fabricated. The effect of film thickness of ZnS photoconductor on the photoresponse of the device was studied. It found that the maximum current gain increased initially and decreased gradually as the ZnS films thickness increased. A maximum gain of 6.49×10^4 was obtained at the thickness of 3.75 μm at an applied voltage of 730V. The results were explained using an equivalent circuit model, which considered EBIPC mechanism. Our results show that the cold cathode flat panel photodetector has great potential in indirect-conversion X-ray imaging.

P2-4.22 / The Application of Electron Beam Welding on Vacuum Electron Devices

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Electron beam welding is widely used in the field of Vacuum Electron Devices (VED). Oxygen free copper (OFC) was welded by electron beam welding with appropriate process parameters for the application of VED. The effects of welding speed and current parameter on welding depth have been studied in the experiment. Microstructure properties of OFC welding were compared with base material. The results show that the welding joint has no apparent surface defects. The welding joint has good performance, and weld penetration has increased with increasing the welding current.

P2-4.23 / Design and tuning of a C-band 6 MeV linear accelerating structure

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A C-band 6 MeV standing wave biperiodic on-axis coupled linear accelerating structure has been designed both for industrial and medical applications. The total length of the accelerating structure is less than 22 cm, which is powered by 3 MW klystrons. The pulsed beam current is 100 mA. The simulations of the geometry and beam dynamics study of the accelerating structure are performed by CST. A set of cavities based on design have been machined and tuned.

P2-4.24 / Design study of the electron beamline, and the beam optimization for the AWAKE RUN 2 experiment at CERN

S. Y. Kim (UNIST, Korea), M. Dayyani Kelisani (IPM, Iran), S. Doebert (CERN, Switzerland), M. Chung (UNIST, Korea)

Demonstration of the electron acceleration through the proton beam-driven plasma wakefield has been successfully done by the AWAKE RUN 1 experiment. Moreover, next AWAKE experiment is scheduled. Main goal of the AWAKE RUN 2 experiment is to achieve the capturing efficiency and the energy gain over 90%, and 10 GeV. In order to accomplish the goal, beam size, and its length have to be less than 50 um, and 100 fs rms, respectively. Since the conventional beamline cannot meet the AWAKE RUN 2 requirements, we are focusing on designing new type of the electron beamline. In this paper, we present simulation results of the beam size, and the bunch length along the new beamline.

P2-4.25 / A Study of Pulse Control of Millimeter-wave Gyrotron using High Density Plasma

Mun Seok Choe (UNIST, Korea), Ashwini Sawant (UNIST, Korea), Ingeun Lee (UNIST, Korea), Taegyu Han (UNIST, Korea), Wonjin Choi (UNIST, Korea), EunMi Choi (UNIST, Korea)

We study the fast time control of high-power millimeter-wave by means of plasma. We designedplasma chamber as helical type inductively coupled plasma to generate high density plasma in large volume. Weestimate that high-power millimeter-wave can be absorbed and reflected to plasma depending on plasma density which may be usefulto control millimeter-wave pulse switching externally.

P2-4.26 / Tuning Results of The Pulse Energy Doubler

KwangHoon Kim (Pohang Accelerator Laboratory, Korea), Soung-Soo Park (Pohang Accelerator Laboratory, Korea), Sang-Hee Kim (Pohang Accelerator Laboratory, Korea), Yong-Jung Park (Pohang Accelerator Laboratory, Korea), Juho Hong (Pohang Accelerator Laboratory, Korea), Chang-Ki Min (Pohang Accelerator Laboratory, Korea), Heung-Soo Lee (Pohang Accelerator Laboratory, Korea), Heung-Sik Kang (Pohang Accelerator Laboratory, Korea)

The PAL-XFEL has a 716m hard X-ray linac and a soft X-ray linac. There are 51 modulators, 178 accelerators structures, and the pulse energy doublers in the linac. The construction was completed at the end of 2015. After RF-conditioned for one year in 2016, The machines provide to the user service in 30Hz, 4μs on hard x-ray. The pulse energy doubler is one of the important devices that increases the peak output power of the 2.856 GHz high frequency generated by the Klystron. The device receives a 4μs length for high frequency power from the klystron and reduces the length of the pulse output to 1μs. However, the maximum peak output power can be increased four times. The total of 42 pulsed energy doublers are installed in the PAL XFEL RF system. It consists of two resonators and one 3dB coupler. The amount of heat generated depends on the operation repetition frequency. There are two ways to prevent it. Change the water temperature of the cavity cooling system or adjust the volume of each resonator. We installed a system that can remotely adjust the resonator volume by connecting a motor to each resonator. This paper reports the results of tuning at 30Hz. We also experimented a few to prepare for 60Hz operation. It reports the results of adjusting the resonance frequency by changing the volume and the cavity cooling temperature using a remote cavity tuning system.

P2-4.27 / Prototype of Field Emission Cathodoluminescent Lamp for General Lighting with a Built-in AC-DC Converter

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The prototype of cathodoluminescent bulb for general lighting with field emission cathode on

the basis of carbon fiber is manufactured. The bulb comprises a high-voltage built-in AC-DC converter of the electric line voltage and a standard E27 cap.

P2-4.28 / Mitigation of the diocotron instability in a hollow electron beam using rotating magnetic fields

CheongBin Cheon (Pusan National University, Korea), Young Hyun Jo (Pusan National University, Korea), Hae June Lee (Pusan National University, Korea)

A two-dimensional cylindrical particle-in-cell (PIC) simulation is utilized to understand the tendency of the diocotron instability in a hollow electron beam and to mitigate it. We have conducted a parametric study with the variation of the number density of electrons, the cathode voltage, the system size, and the amplitude and the frequency of periodic dipole magnets. Two orthogonal arrays of periodic dipole magnets make rotating magnetic fields which perturb the shear flow of the electron beam by the ExB drift motion. Finally, the conditions for the mitigation of the diocotron instability are investigated. This study is based on our previous study on the control of the diocotron instability of a hollow electron beam with periodic dipole magnets.

P2-4.29 / Design and modeling of a microwave plasma enhanced chemical vapor deposition system

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A Chemical Vapor Deposition (CVD) is a chemical process often used in semiconductor industry to produce high quality, high performance, solid material and thin films. In order to produce desired deposit using CVD, a wafer or a substrate is exposed to one or more violated precursors which react and/or decompose on the substrate surface and this also produces some volatile by-products which are then removed by gas flow through the reaction chamber. If the chemical reaction in CVD is initiated by microwave plasma then it is called Microwave Plasma Enhanced Chemical Vapor Deposition (MPECVD). A crucial issue for a roll-to-roll thin film cell production system is the deposition rate of the microcrystalline layer and this can be tackled using MPECVD. This technique has gained popularity in diamond and graphene fabrication. This paper discusses about the designing of an MPECVD chamber operated at 2.45 GHz of frequency using Finite Element Method (FEM) simulation. The design consists of a coaxial waveguide and a cylindrical chamber at the center connected using 4 slots in each direction. The placement of slot affects the resonant mode in the chamber. Hence the slot placements in the middle and the bottom positions of the plasma chamber produce the TE_{111} and TM_{011} mode inside the plasma chamber at 2.45 GHz, respectively. Detailed analysis will be presented using FEM simulations.

P2-4.30 / Emittance Exchange Based Bunch Compression at Argonne Wakefield Accelerator Facility

Jimin Seok (UNIST, Korea), Gwanghui Ha (Argonne National Laboratory, USA), John Gorham Power (Argonne National Laboratory, USA), Manoel Conde (Argonne National Laboratory, USA), Moses Chung (UNIST, Korea)

An emittance exchange (EEX) beamline can manipulate longitudinal phase space via control of the transverse one at the entrance to the beamline. This EEX beamline can compress a bunch length to a sub-fs level when a specific transverse focusing is applied to the small beam at the entrance of the beamline. The Argonne Wakefield Accelerator Facility (AWA) plans to generate the sub-fs bunch for applications to wakefield accelerators. A preliminary experiment has been performed using the existing EEX beamline at AWA. In this poster, results of the experiment and feasibility of sub-fs bunch compression with a modified EEX beamline are presented.

P2-4.31 / Influence of Ionization Processes on Virtual Cathode Formation

Artem Badarin (Saratov State University, Russia), Semen Kurkin (Saratov State University, Russia), Alexey Koronovskii (Saratov State University, Russia), Alexander Hramov (Saratov State University, Russia)

The paper presents the results of the study of the influence of plasma effects on the processes occurring in high-power electronic systems. The results are obtained using electromagnetic PIC code for a promising class of high-power microwave devices – relativistic vircators (generators and amplifiers with a virtual cathode). A detailed study of the behavior of critical current of a relativistic electron beam with a change of the control parameters of the system (concentration of residual gases, external magnetic field parameters, energy of electron beam and shape of current pulse) is carried out. The results obtained within the framework of the research are intended to broaden the fundamental concepts about the dynamics of intense electron beams in a plasma.

P2-4.32 / Fabrication of high resolution electron source for microscope application

Ha Rim Lee (Kyunghee university, Korea), Kyu Chang Park (Kyunghee university, Korea)

A reliable source of electrons to observe an object is one of the most important part of a microscope. The technology has been developed rapidly with the goal of complete computer control. This state is the most advanced state for field emission sources. However, the next generation of field emitters is still under development.
We evaluated whether our carbon nanotube (CNT) emitters were suitable for electron microscope such as, angular current density, virtual source size and brightness. Various emitters were measured, and it was found that electrical and structural properties affect the brightness.

P2-4.33 / Comparison of the effect of rotating electric fields and rotating magnetic fields on the diocotron instability using particle-in-cell simulations

Young Hyun Jo (Pusan National University, Korea), Hae June Lee (Pusan National University, Korea)

Recently, a beam collimator system using a hollow electron beam to enclose a circulating beam has been proposed for the high energy vacuum. In this system, the hollow electron beam should remain stable during propagation, obviously. However, the diocotron instability, which is one of the nonneutral plasma instabilities induced by shear in the flow velocity of surface waves, makes the deformation of the beam. Therefore, it is important to control the hollow electron beam at first. Previously, we investigated the stabilizing effect of periodic dipole magnets on the diocotron instability using a two-dimensional particle-in-cell simulation. In the simulation, the beam cross section of the hollow electron beam was investigated under periodic dipole magnets in addition to the axial magnetic field. In addition to the previous work, we study the effect of rotating-wall electric fields on the diocotron instability, which also makes perturbations on the ExB drift, and compared the results of rotating magnetic fields.

P2-4.34 / Development of the Gas-Cell-based Plasma Source for Laser-Wakefield Electron Acceleration

Jinju Kim (GIST, Korea), Vanessa L. J. Phung (GIST, Korea), Munsu Jin (GIST, Korea), Min-Seok Kim (Pohang Accelerator Laboratory, Korea), Hyyong Suk (GIST, Korea)

In laser-plasma accelerator research, a density tailored gas-cell/plasma source is intensively studied. We use a high-Z and low-Z gas together in the capillary gas-cell for laser-wakefield acceleration to control the gas and plasma density distribution. In this paper, some details of the research are presented.

P2-4.35 / Ultrashort bunch duration measurement using S-band RF deflector in UED system at KAERI

Sunjeong Park (Korea University, Korea), Hyun Woo Kim (Korea Atomic Energy Research Institute, Korea), In Hyung Baek (Korea Atomic Energy Research Institute, Korea), Key Young Oang (Korea Atomic Energy Research Institute, Korea), Kyu-Ha Jang (Korea Atomic Energy Research Institute, Korea), Eun-San Kim (Korea University, Korea), Seong Hee Park (Korea University, Korea), Young Uk Jeong (Korea Atomic Energy Research Institute, Korea)

As demanding the ultrashort bunches for the pump & probe experiments to investigate ultrafast phenomena occurring at atomic size level, the diagnostic tools should be developed to measure. by measuring the electron diffraction pattern directly. We have developed an S-band RF deflecting cavity working on TM_{120} mode to measure the femto-second bunch duration of electron beam in UED (Ultrafast Electron Diffraction) system at KAERI. In this conference, we will present on design, fabrication and experimental performance of the deflecting cavity. The estimated temporal resolution of RF deflector, operating with the deflecting voltage of 1.5 MV

and the drift length of 1.7 m, is 50 fs. The electron beam with 3 MeV and 1.88 pC, electron bunch duration has 67 fs in rms, which is well agreed with the simulation results.

P2-4.36 / A CMOS-compatible ionic/electronic hybrid transistor based on 2D α-MoO_3

Chuansen Yang (Beijing Orient Institute of Measurement and Test, China), Yaowen Lu (Beijing Orient Institute of Measurement and Test, China), Dashan Shang (Institute of Microelectronics of the Chines Academy of Sciences, China)

In contrast with 2D transition metal dichalcogenides, less attention was paid to 2D transition metal oxides for generally wider bandgap and low carrier concentration in stoichiometric states. Nevertheless, the layered structure of 2D transition metal oxides facilities the mechanical exfoliation and the injection of different donor ions (e.g. protons, alkali metal ions) into free spaces, which gives large density states within the bandgap. And, the dynamic process of the injected ions, which can be modulated by external voltage, closely resembles the transmission of the chemical signals in biological synapses and provides a chance to design ionic/electronic hybrid three-terminal devices based on 2D transition metal oxides to mimick artificial synapses. In this work, we fabricated a CMOS-compatible three-terminal device based on 2D α-MoO_3 nanoflakes (as channel material), and a solid electrolyte containing mobile Li^+ (as gating dielectric). The dynamic of channel conductance and its relaxation behaviors under continual and pulsed gating voltage was investigated. We demonstrated the gating-controlled electrochemical Li^+-doping is feasible to modulate the conductance of α-MoO_3 in a non-volatile and volatile way. Furthermore, the simulation of transition from short-term plasticity to long-term plasticity by the relaxation of channel conductance was implemented.

P2-4.37 / A calibration apparatus for pressure leak with the lower limit of 2×10^{-10} Pam^3/s

Yaowen Lu (Beijing Orient Institute of Measurement and Test, China), Chuansen Yang (Beijing Orient Institute of Measurement and Test, China), Duan Wu (Metrology Lab of AECC South Industry Co.,Ltd., China), Yuan Yuan (Metrology Lab of AECC South Industry Co.,Ltd., China), Detian Li (Lanzhou Institute of Physics, China)

A calibration apparatus with the lower limit of calibration of 2×10^{-10} Pam^3/s is developed to solve the calibration problem of leak with tiny leak rate. The concentration of the indicator gas in the gas mixture in the accumulating chamber was increased by using accumulation method. The standard gas mixtures were obtained by direct measurement and inflation pressure attenuation method, respectively. The 'fractionation' effect in the gas mixture was eliminated and the partial pressure of the leak indicator gas in the mass analysis chamber was increased by using dynamic injection of molecular flow method and pumping orifice with constant flow conductance. Using the quadrupole mass spectrometer (QMS) as a comparator, the leak rate of a pressure leak can be calibrated by measuring the partial pressure of the leak indicator gas in the accumulation gas through the leak and that in the standard gas mixture in the mass analysis chamber. The impact of temperature on the measurement results is reduced by using high precise two-stage semiconductor water bath method to limit the temperature within 296±0.02K. The experimental results show that the calibration of the apparatus is in the range

from 7×10^{-6} Pam^3/s to 2×10^{-10} Pam^3/s with the combined standard uncertainty between 2.0% and 7.5%.