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.