NEWSLETTER

of the International Consortium “Development of High-Power Terahertz Science & Technology”

June 2019 № 12

CONTENT

EDITORIAL: HOW TO CONTRIBUTE TO THE NEWSLETTER

Dear Reader,
We are inviting contributions to the following rubrics:

- Research highlights (annotations) presenting the projects pursued by the members of the Consortium.
- Short regular papers.
- Proposals for collaborative research work.
- News from the participating institutions.
- Information about conferences, symposia, workshops, seminars.
- Programs and frameworks for an exchange of visits and mobility of researchers. Job opportunities (especially for young researchers, e.g. postdoctoral positions, specializations, internships).
- Annotations of books, conference proceedings, software and internet resources. Additions to the list of the recent scientific publications and conference reports at the website of the Consortium (http://fir.ufukui.ac.jp/Website_Consortium/publist.html).
- Information and announcements about awards and nominations.
- Short presentations of laboratories and research groups belonging to the participating institutions.

Please submit your contributions to the Newsletter as well as requests for information to:

Professor Masahiko Tani
Director of FIR UF – Facilitator of
the International Consortium
FIR UF
tani@fir.u-fukui.ac.jp

Dr. Svilen Sabchevski
Editor of the website and the Newsletter
Institute of Electronics of the Bulgarian
Academy of Sciences
IE-BAS
sabch@ie.bas.bg

Gyrotron as an advanced tool for spectroscopy applications

**M. Yu. Glyavin, G.Yu. Golubiatnikov, M.A.Koshelev,
M.Yu.Tretyakov, A.I.Tsvetkov, A.P.Fokin**

Institute of Applied Physics RAS, Nizhny Novgorod, Russia

glyavin@appl.sci-nnov.ru

Introduction

The first attempt to achieve a record-breaking spectroscopic sensitivity using the gyrotron as a source of high-power (up to 1 kW) coherent radiation to observe a signal from the spectral line of the formic acid molecule (HCOOH) at a frequency of 34 GHz was undertaken more than 40 years ago in 1974 [1]. A spectrometer with radio-acoustic detection (RAD) of absorption in a gas [2,3], in which an acoustic signal arising due to the gas heating by the radiation is recorded by a microphone, was used for this purpose. In this case, the signal from the absorption line in a gas is proportional to the power of resonant radiation. The maximum signal from the line is determined by the parameters of saturation of the spectral transition under study with radiation power, namely, the magnitude of the dipole moment of the transition and the collisional width of the absorption line. To eliminate the saturation effect, the line width of the rotational transition $J = 6_{15}–6_{16}$ of formic acid (the dipole moment of the transition is 0.1 D) was chosen in [1] to be fairly large - 70 MHz. The need to use a wide absorption line in these measurements was also determined by the fact that the gyrotron did not have a smooth and reproducible tuning of the radiation frequency, and only the maximum signal response from the line was recorded. This problem, combined with the lack of the required frequency tuning range of the radiation ($\Delta f/f \sim 10^{-4}–10^{-3}$), explains why the existing gyrotrons were not in demand in the next decades for the purposes of molecular spectroscopy, although, according to the estimates, the sensitivity achieved in the experiment was record-breaking for that time - about 10^{-11} cm^{-1} for a gyrotron power of 10^3 W. Such a sensitivity could allow solving a number of fundamental and applied problems, such as the studies of the spectra of molecules with a magnetic dipole moment (1 Bohr magneton is equivalent to approximately 0.01 D), non-polar molecules acquiring a small dipole moment due to the isotopic substitution of one of the atoms, and low-intensity forbidden transitions of both polar and non-polar molecules, the conversion of spin isomers, the analysis of high-purity gases for trace impurities, etc.

Gyrotron

The gyrotron with operation frequency 0.26 THz for spectroscopy application has been developed at IAP RAS [4]. The spectral line width of radiation with the PLL system did not exceed 1 Hz [5]. The frequency stability was determined by the frequency and time standard SRS FS740 synchronized by a GPS signal and was of the order of 10^{-13} and 10^{-11} for long-term and short-term relative stability, respectively. The range of electronic frequency tuning reached 50-60 MHz for certain parameters of the gyrotron. A broader, smooth tuning of the gyrotron frequency in the PLL mode was carried out by a precisely controlled variation in the resonator temperature (4 MHz/ºC). The total frequency tuning range of the gyrotron in the PLL mode achieved in this work was 263.1-264.0 GHz with an adjustable radiation power in the range 10-500 W. The spectral range accessible for 0.26 THz gyrotron experiments can be significantly extended by using the high harmonic generation at presence of operating mode at fundamental harmonic. This paper demonstrates that all these factors, combined with the conventionally high output power, extend the application range of a gyrotron, making it a working tool for solving the problems of high-resolution molecular spectroscopy.

The RAD spectrometer belongs to the class of spectrometers in which the result of the radiation interaction with a substance is recorded by the change in the properties of the substance. The excitation of molecules during the absorption of radiation at the frequency of the spectral transition and their relaxation as a result of collisions leads to the heating of the gas and the appearance of an acoustic signal, which increased with the radiation power. This makes it possible to increase the spectrometer sensitivity.

Experiment

A detailed description of the parameters of the gyrotron used as a source of continuous coherent radiation in the RAD spectrometer can be found in [5]. The diameter and length of the absorbing cell of the RAD spectrometer used in the experiments were 2 and 10 cm, respectively. The small length of the cell not only makes it compact and convenient to use (for example, for shielding from external magnetic fields and thermal stabilization), but also reduces the influence of the standing waves generated by the reflection of radiation from the windows of the cell. The high sensitivity of the RAD spectrometer achieved in this way makes it possible to examine the lines of both strong and weak transitions without changing the cell dimensions. This is a significant difference between the RAD method and the classical direct-absorption spectrometer, in which sensitivity is directly related to the optical path length, and transitions of different strength are studied using various cells differing in length and the number of passes. Note that the dipole moments of the transitions that are interesting for modern spectroscopy are much smaller in magnitude. For example, the asymmetric isotopologue of the carbon dioxide molecule $^{16}O^{12}C^{17}O$ has a small dipole moment and for a notable saturation of the lines of the rotational spectrum of this molecule, a power of about 1 GW is needed, so high power sources are needed.

Results

It has been shown that low-intensity molecular spectral lines can be recorded by the radio-acoustic method with an absorption-coefficient sensitivity of the order of $\sim 10^{-10}$ cm^{-1} for a line recording time from 1 to 10 min. High sensitivity was achieved due to the use of a gyrotron whose radiation power in the RAD cell did not exceed ~ 10 W in these experiments, which is several orders of magnitude higher than the radiation power of the mm/submm-wave radiation sources, which are conventional for spectroscopy, and can be increased by another several orders of magnitude.

The system of precision control and digital control of the gyrotron radiation frequency based on the PLL system used in this paper, combined with high stability of the radiation power, permits high-accuracy studies of high-resolution molecular spectra, including long-term accumulation of the absorption signal, to achieve an additional multiple increase in the sensitivity of the RAD spectrometer.

Using a RAD spectrometer and gyrotron radiation, we obtained records of the spectra of different gases (see, for example, Fig.1), analyzed the shape of the observed lines, and determined their spectroscopic parameters.

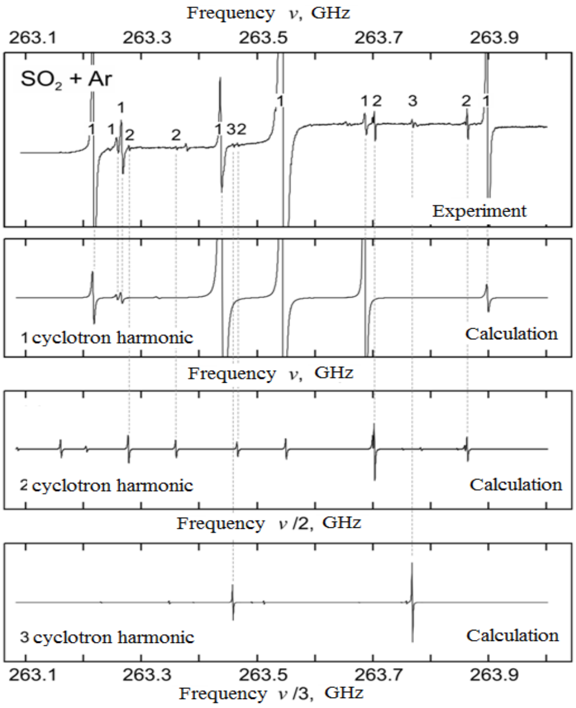


Fig 1. Survey spectrum of a SO_2 mixture with argon in the gyrotron tuning range, which was recorded using frequency modulation of the radiation with detection of the absorption signal at the fundamental harmonic of the modulation frequency. The lines are identified as absorption at the fundamental (first), second, and third harmonics of the gyrotron and are marked with corresponding numbers. Bottom panels show the calculated spectra for respective harmonics of the gyrotron radiation.

A good agreement between the measured values and the results of the study of these lines by other spectroscopic methods and tools is shown. Thus, we can talk of a RAD spectrometer with the gyrotron as a radiation source having a PLL-based frequency control and monitoring system as of a promising terahertz spectrometer for a study of the shape of the lines and determination of their quantitative characteristics. The most promising advantage of the spectrometer is the possibility to further increase its sensitivity by increasing the power of the sounding radiation and detecting weak, and therefore poorly studied, molecular lines corresponding to transitions with very small matrix elements of the dipole moment, such as transitions of paramagnetic molecules occurring due to the magnetic dipole moment. The latter is usually is equal to about one Bohr magneton, which in the interaction with radiation is equivalent to an electric dipole moment of about 0.01 D. As an example, we mention the spectra of an oxygen molecule in excited vibrational states that have never been studied in the mm/submm wavelength range due to the lack of sensitivity of the spectrometers and are not observed in the IR range due to the absence of the dipole moment derivative of this molecule. Another object of research can be the mentioned rotational spectra of isotopologues of symmetric diatomic and linear molecules, such as HD, $^{14}N^{15}N$, $^{16}O^{17}O$, $^{16}O^{12}C^{17}O$, etc., which remain almost unexplored. Studies of the quadrupole transitions of non-polar molecules, which are forbidden in the electric-dipole approximation, as well as transitions between the spin isomers of the molecules, which are still more forbidden, i.e., transitions between para and ortho states, are the most interesting for fundamental spectroscopy.

The gyrotron radiation analysis carried out in this paper clearly demonstrates a unique opportunity for using the RAD spectrometer to determine the exact frequency and power characteristics of radiation sources.

Acknowledgements. The gyrotron development supported by the Russian Scientific Foundation under the project 19-12-00141 and RAD facility development supported by Russian Scientific Foundation under the project 17-19-01602.

References

1. I.I. Antakov, S.P. Belov, L.I. Gershtein, V.A. Ginzburg, A.F. Krupnov, G.S. Parshin, Use of large powers of resonant radiation for enhancing the sensitivity of microwave spectrometers, *JETP Letters*, 19 (1974) 634-637.
2. A.F. Krupnov, Modern submillimeter microwave scanning spectroscopy, "Modern Aspects of Microwave Spectroscopy," *G.W. Chantry, Ed, Academic Press, London* (1979) 217-256.
3. M.Yu. Tretyakov, M.A. Koshelev, D.S. Makarov, and M.V. Tonkov, Precise Measurements of Collision Parameters of Spectral Lines with a Spectrometer with Radioacoustic Detection of Absorption in the Millimeter and Submillimeter Ranges, *Instruments and Experimental Techniques*, 51 (2008) 78-88.
4. M.Yu. Glyavin, A.V.Chirkov, G.G.Denisov et al. Experimental tests of 263 GHz gyrotron for spectroscopy applications and diagnostic of various media, *Rev. Sci. Instr.*, 86(5), 054705 (2015).
5. A.Fokin, M.Glyavin, G.Golubiatnikov, L.Lubyako, M.Morozkin, B.Movschevich, A.Tsvetkov, G.Denisov High power sub-terahertz microwave source with record frequency stability up to 1 Hz. Scientific Reports 8, 4317 (2018).

On the efficiency of gyrotrons with wide emitters

O.Dumbrajs[1], G.S.Nusinovich[2], M.D.Proyavin[3] and M.Yu.Glyavin[3]

[1] *Institute of Solid State Physics, University of Latvia,*
Kengaraga Street 8, LV-1063 Riga, Latvia

[2] *Institute for Research in Electronics and Applied Physics,*
University of Maryland, College Park, Maryland 20742-3511, USA

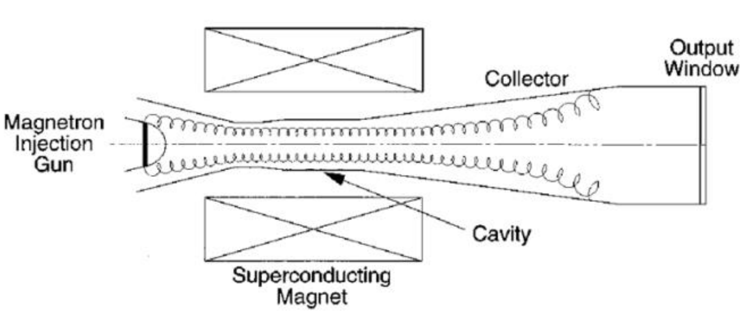
[3] *Institute of Applied Physics, Russian Academy of Sciences,*
Ul'yanov Street 46, 603950 Nizhny Novgorod, Russia

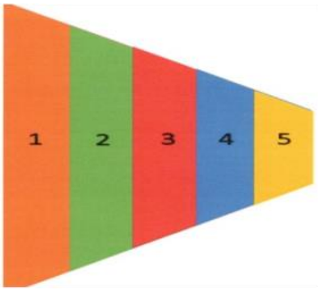
Introduction

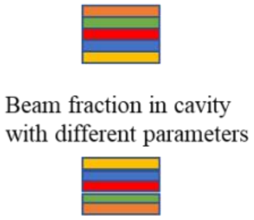
- Development of high-power, THz-range gyrotrons is important for many applications.
- The cost of cryomagnets rapidly increases with the inner bore diameter.
- So it is desirable to increase the gyrotron power, while keeping the size of the gyrotron tube, which should be inserted into the cryomagnet, fixed.
- This can be realized by using electron guns with fixed cathode radii, but wide emitters.
- Emitter widening may cause efficiency degradation.
- This degradation can be caused by increasing the beam thickness in the resonator (radial non-uniformity of the beam coupling to the resonator mode).
- The degradation can also be caused by the difference in beam alpha and spread of the electron 'slices' produced by different layers of the emitter.
- This study is focused on the last (but not least!) problem.

Content

- Method: presentation of the emitter as a set of slices and calculation of the distribution functions of electrons emitted by these slices.







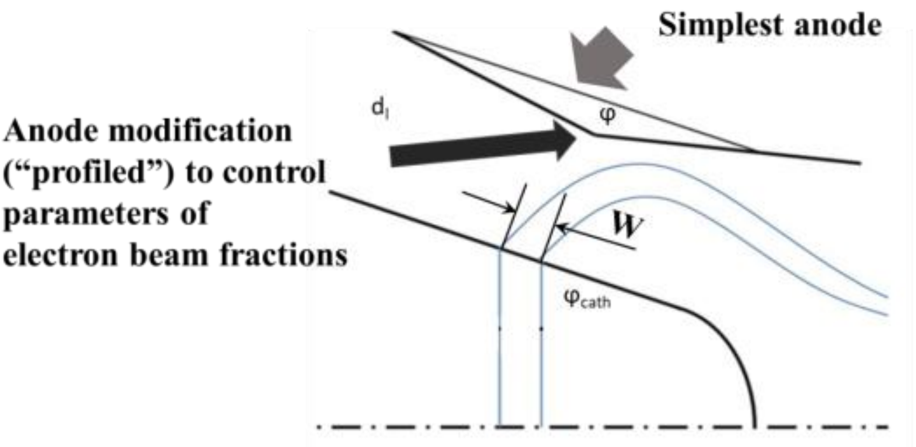
- Calculation of the efficiency of interaction of the fractions of the electron beam with the resonator field. Example: IAP RAS/GYCOM technological gyrotron with the operating frequency 28 GHz

- Comparison of characteristics of beam fractions in the 'normal' emitter with those of the 'widened' emitter (7 layers instead of 5).

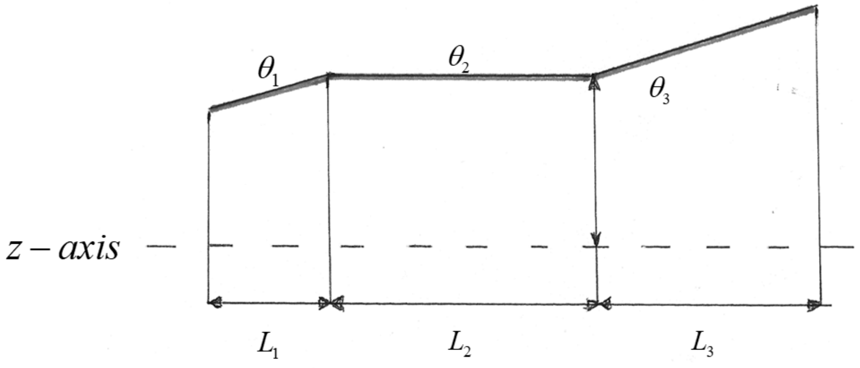
- Analysis of some possibilities of the efficiency improvement.

Method of simulations

1. Distribution functions characterizing the properties of electron fractions produced by different parts of the emitter were calculated by using the code CST Studio Suite
2. The influence of the electron velocity spread on the efficiency was calculated by the means of the time-dependent self-consistent formalism *[O. Dumbrajs, T. Saito, Y. Tatematsu, and Y. Yamaguchi, "Influence of the electron velocity spread and the beam width on the efficiency and mode competition in the high-power pulsed gyrotron for 300 GHz band collective Thomson scattering diagnostics in the large helical device", Physics of Plasmas 23, 093109 (2016)]*.
3. A triangular shape with 9 velocity components was used to describe the distribution functions.

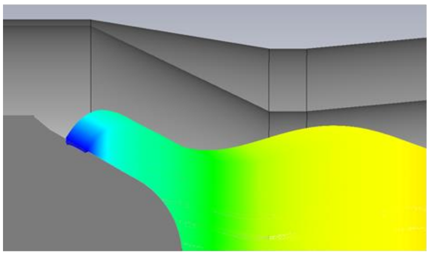


Anode modification ("profiled") to control parameters of electron beam fractions

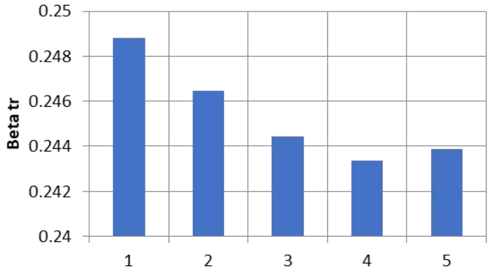


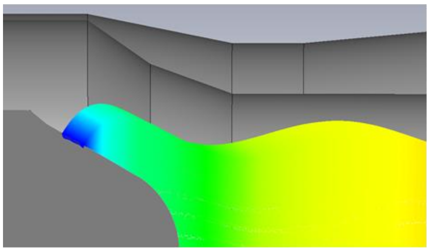
Mode $TE^{-}_{1,2}$ Geometry of the cavity: $\Theta_1=7^0$, $\Theta_2=0^0$, $\Theta_1=2^0$, $L_1=7$ mm, $L_2=65$ mm, $L_3=62$ mm, $R_{cav}=9.05$ mm.
Cold cavity approximation: F=28.175 GHz, $Q_{dif}=917$, $Q_{ohm}=10997$, $Q_{tot}=846$

Different types of MIG and parameters of HEB fractions

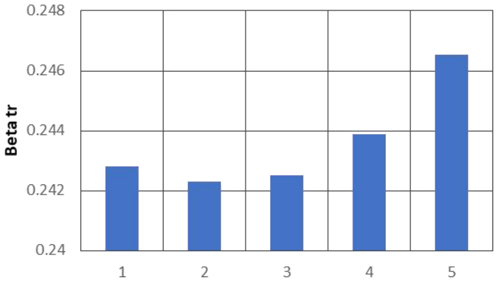


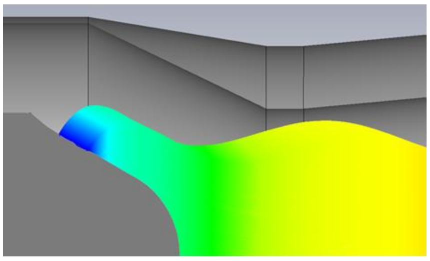
Standard
W=5 mm



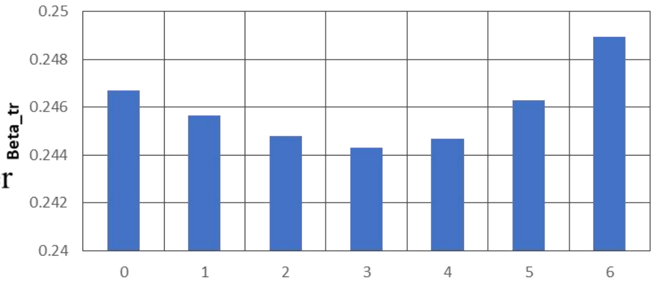


Profiled anode
W=5 mm

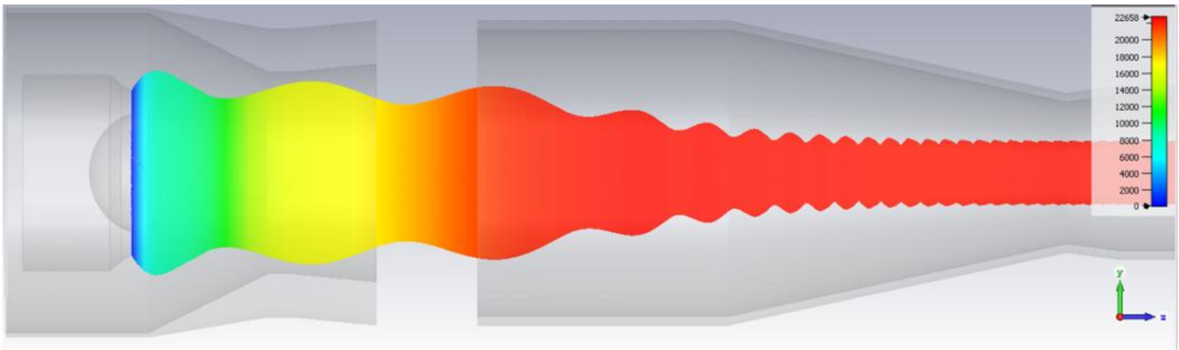




Wide emitter
W=7 mm



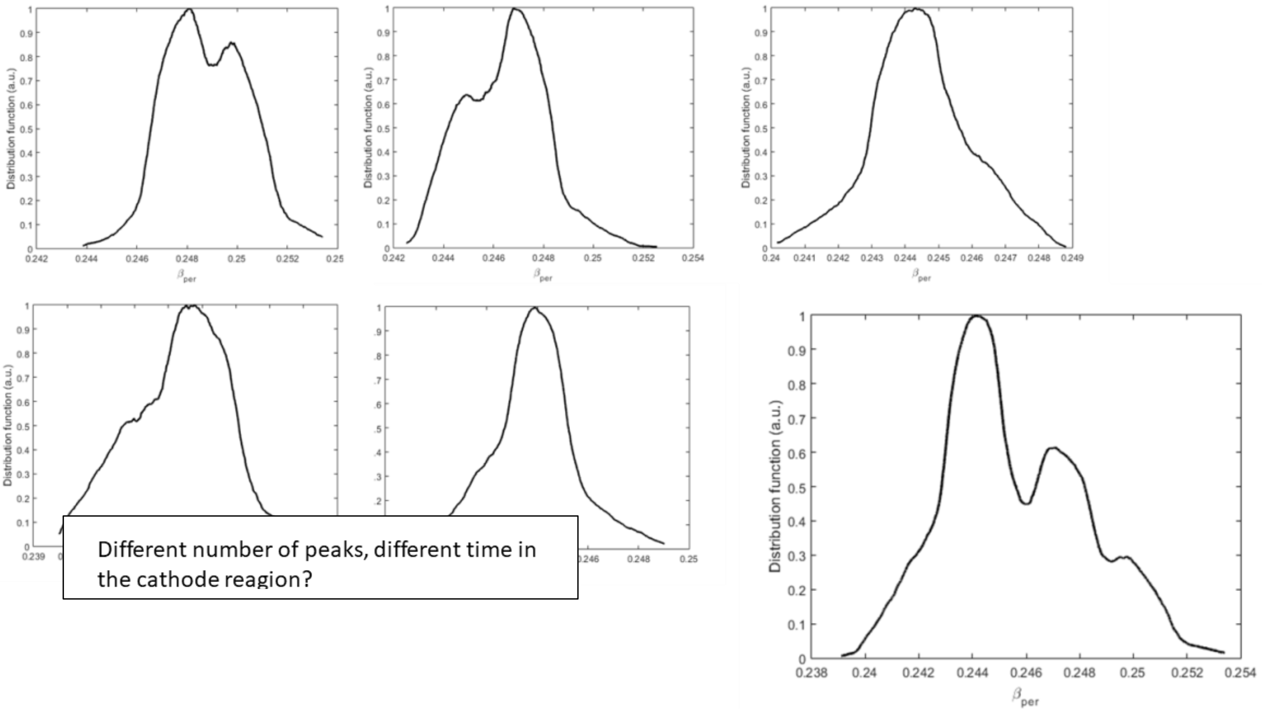
MIG with a “standard” emitter (divided in 5 layers) Distribution functions in five layers and that of a whole beam



The colors show electron energy in eV

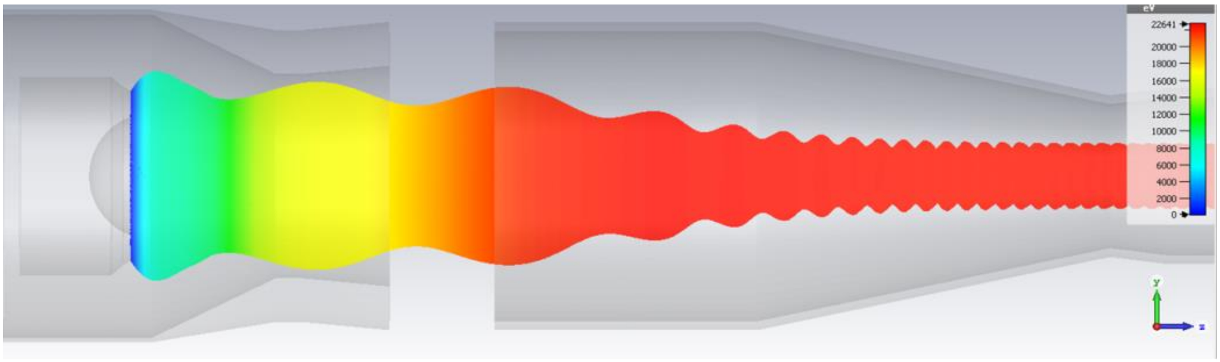
Fraction	R_{el} (mm)	β_{per}	$\Delta\beta_{per}$	α	Δ
1	3.2	0.249	0.04	1.67	0.79
2	3.156	0.248	0.036	1.64	0.8
3	3.092	0.245	0.037	1.57	0.81
4	3.049	0.244	0.033	1.55	0.82
5	2.989	0.244	0.041	1.55	0.82
all	3.1	0.246	0.057	1.6	0.81

Distribution functions of electrons for “standard” emitter (divided in 5 layers)



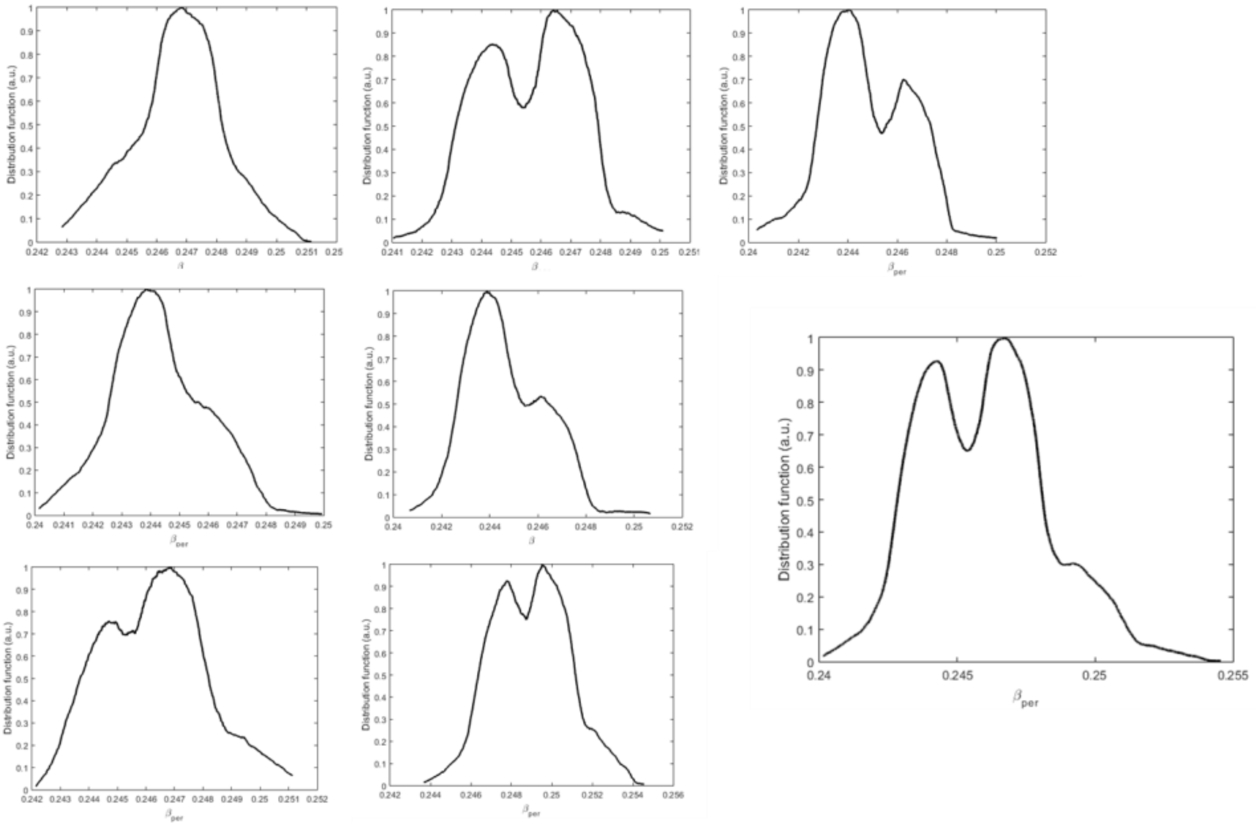
Different number of peaks, different time in the cathode reagion?

MIG with a “wide” emitter (divided in 7 layers) Distribution functions in seven layers and that of a whole beam

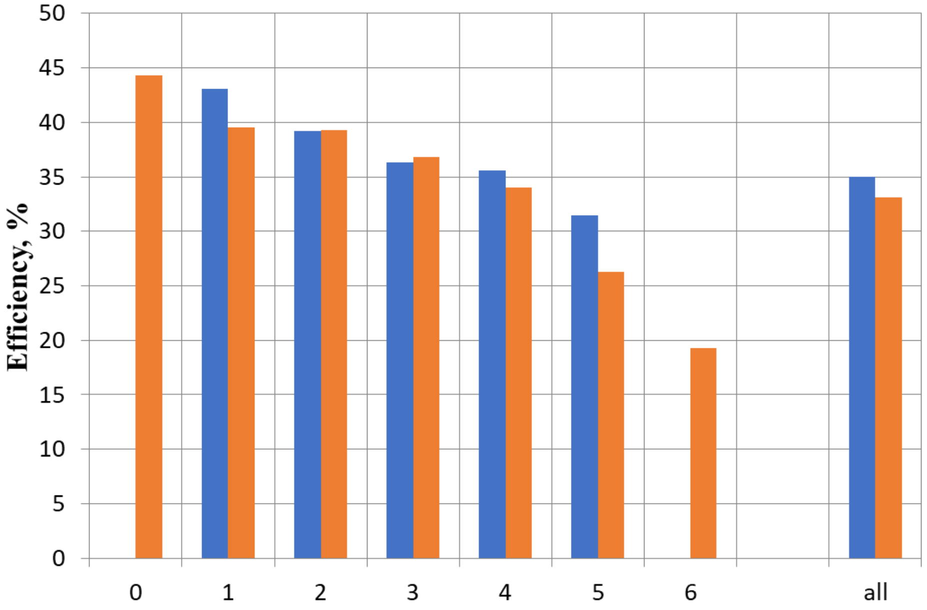


Fraction	R$_{el}$ (mm)	β_{per}	$\Delta\beta_{per}$	α	Δ
0	3.24	0.247	0.0324	1.62	0.8
1	3.167	0.2445	0.0362	1.56	0.82
2	3.139	0.245	0.0408	1.57	0.81
3	3.097	0.245	0.0408	1.57	0.81
4	3.042	0.246	0.0407	1.6	0.81
5	2.94	0.2465	0.0365	1.61	0.81
6	2.914	0.249	0.0402	1.67	0.79
all	3.082	0.2475	0.0606	1.63	0.8

Distribution function of electrons for “wide” emitter (divided in 7 layers)



Efficiency calculations for a gyrotron with a “standard” (blue) and “wide” (orange) emitter

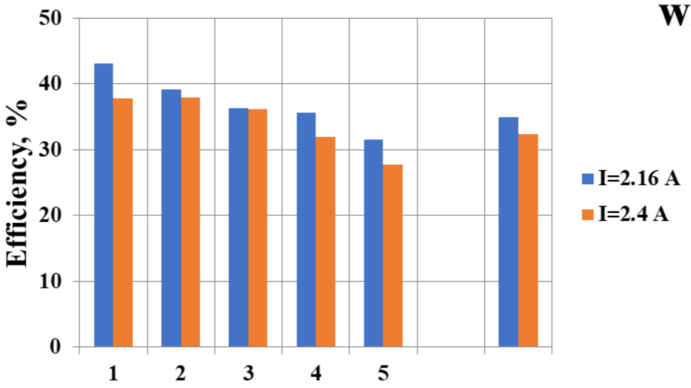


By using profiled
anode, especially
for a wide emitter,
we can control
parameters of
electron fractions.

B=1.024 T
I=2.16 A
U=20 kV

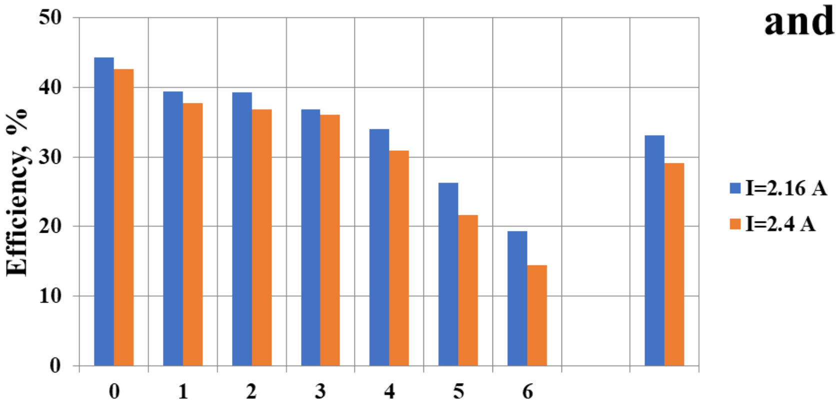
Efficiencies of fractions may depend differently on B and I.

Efficiency calculations for a gyrotron



with a “standard”

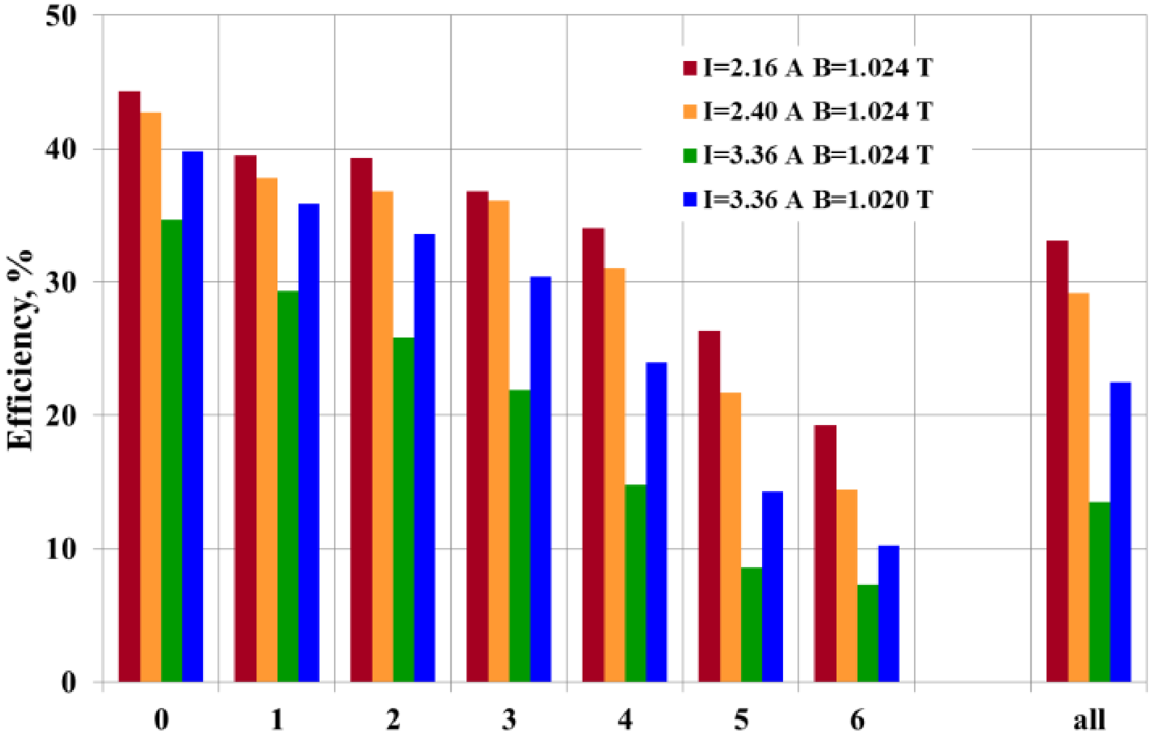
B = 1.024 T



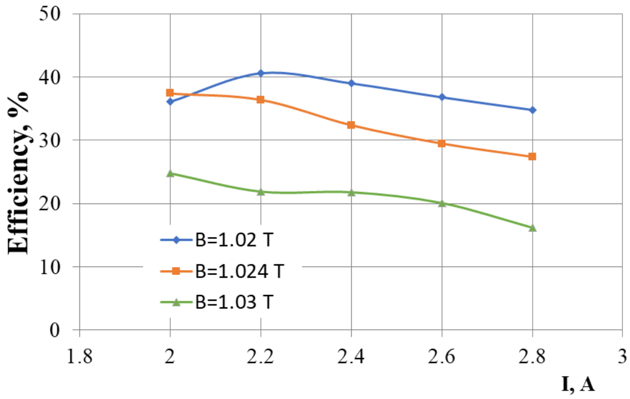
and “wide” emitter

B = 1.024 T

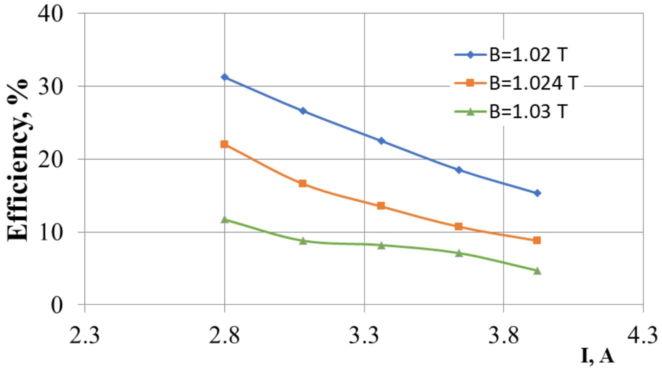
Efficiency calculations for a gyrotron with “wide” emitter



Efficiency calculations for a gyrotron



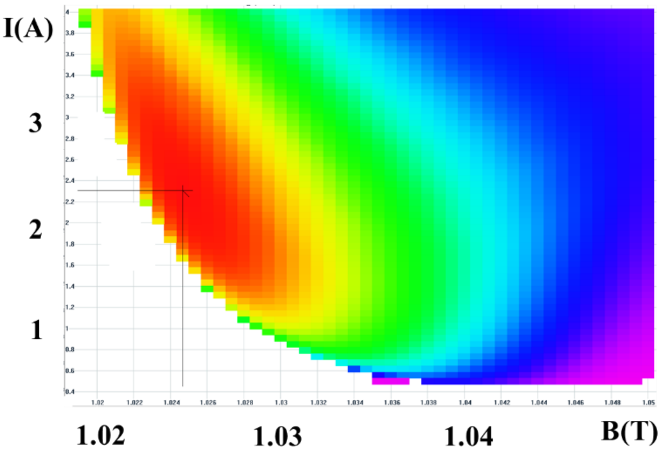
with a “standard”



and “wide” emitter

The beam current in the case of a wide emitter is higher. Therefore the optimal magnetic field is lower (the cyclotron resonance mismatch should be larger).

Color map of efficiency in I(B) diagram



The optimal point is shown for the standard emitter. In the case of a wide emitter, the current is higher, so the optimal magnetic field is lower.

Some possibilities for improvement

Although, our simulations predict a reasonable efficiency in a gyrotron with a widened emitter, it makes sense to analyze how this efficiency can be increased. There are known general methods of the synthesis of gyrotron electron guns (*Sh. E. Tsimring, “Synthesis of systems for the formation of helical electron beams, Radiophysics and Quantum Electronics, vol. 20, 1068-76, 1978*) that can be used for maximizing the electron beam pitch ratio and minimizing the velocity spread. Below, for illustration purposes, we consider a simple case: a simple electron gun with *parallel surfaces of the cathode and anode*. As follows from a simple adiabatic theory of magnetron-type electron guns (*A. L. Goldenberg and M. I. Petelin, Radiophysics and Quantum Electronics, vol. 16, 106-11,* *1973*), the orbital electron velocity at the entrance to resonator depends on the magnetic field there and the normal electric field at the cathode as

$$\beta_{\perp 0} = \frac{v_{\perp 0}}{c} = (\alpha_H)^{\frac{2}{3}}(E_{\perp c}/H_0).$$

Here $\alpha_H = H_0/H_c$ is the ratio of the magnetic field in the resonator to that on the cathode, i.e. the magnetic compression factor.

Some possibilities: simple case

1) Take into account that far from the midplane of the solenoid the magnetic field varies as $H_c(z) \propto 1/z^3$. Origin of z is in the midplane of the solenoid.
2) In order to have the same orbital velocity for electrons emitted from different points of the emitter, the difference in the magnetic field should be compensated by the difference in the electric field at the cathode.
3) Represent the electric field at the cathode as $E_c = {}^{V_{\text{mod}}}\!/_{d(z)} - E_{sc}(z)$

   V_{mod} is the mod-anode voltage (or beam voltage in diode guns); $d(z) = d_L - \delta(z)$
   d_L is the distance between the emitter and the mod-anode at $z = L$
   L is the coordinate of the left end of the emitter
   E_{sc} is the space-charge field produced by the electrons emitted by the ring located on the left from a given thin ring. At the left end of the emitter $E_{sc}(\Delta z = W) = E_0$ (W being the width of the whole emitter).
   In accordance with Goldenberg and Petelin (1973), this space charge field can be defined as

$$E_{sc}(W) \approx \frac{V_{\text{mod}}}{d}\frac{I_b}{I_\rho} \text{ , } \frac{eI_\rho}{mc^3} = \sqrt{\left(\hat{E}_c/2\right)^3 \varphi_{cath}(R_{cath}/W)} \text{ , } \hat{E}_c = (eV_{\text{mod}}/mc^2)(W/d).$$

4) Electrons will have equal orbital velocities when the distance between the cathode and anode scales with the axial coordinate as

$$\frac{\delta(z)}{d_l} = \left[\frac{9}{2}\frac{W}{L} + \frac{E_{sc,0}}{V_{\text{mod}}/d_l}\right]\frac{\Delta z}{W}$$

5) Consider a simple case of a tilted anode (originally the anode is parallel to the cathode):

$$\delta(z) = (\Delta z)\varphi,\ \varphi \ll \pi;$$

$$\varphi = \frac{9}{2}\frac{d_l}{L} + \frac{eI_b}{mc^3}\frac{1}{\sqrt{\left(\hat{E}_c/2\right)^3 \varphi_{cath}}}\frac{d_l}{R_{cath}}$$

   This relation can be used to optimize electron gun by choosing properly the gun parameters: $d_L, \phi, E_0, V_{\text{mod}}, W$, and $\varphi_{cath.}$ Such optimization, however, has not been done yet.

Some questions

Are the distribution functions with one peak the best ones???
Should we vary the gun parameters $d_L, \phi, E_0, V_{\text{mod}}, W$, and $\varphi_{cath.}$ so that this is achieved?
Maybe we should aim directly to achieving the maximum efficiency not bothering about the shape of distribution functions?

Summary

1. A new method of gyrotron efficiency characterization based on tracking the interaction of electrons emitted by different layers of the emitter is proposed.
2. It is shown that it is possible to develop gyrotrons with wide emitters capable of operating at higher currents with the efficiency close to that in the gyrotrons with standard emitters.
3. The development of relatively compact gyrotrons with wide emitters is especially beneficial in the case of sub-THz gyrotrons.

NEWS FROM THE MEMBERS OF THE INTERNATIONAL CONSORTIUM

UNIVERSITY OF FUKUI
Research Center for Development of Far-Infrared Region

Dr. Yuya Ishikawa from the Research Center for Development of Far-Infrared Region received the 6th Research Encouragement Prize of the Japan Society of Infrared Science and Technology for his research on "Development of Millimeter-wave Ultra-low Temperature ESR / NMR Measurement System using 3He-4He Dilution Refrigerator".

Source: The website of the Japan Society of Infrared Science and Technology

2nd Japan - Philippines Terahertz Research Workshop 2019 (JPTW 2019)

Kobe University, Kobe, Japan, University of the Philippines Diliman, Philippines
University of Fukui, Fukui, Japan, University of the Philippines Los Banos, Philippines
De La Salle University, Philippines

The Second Japan-Philippines Terahertz Research Workshop (JPTW 2019) was held at the Research Center for Development of Far Infrared Region at the University of Fukui (FIR UF) from 14 to 16 June 2019. It covered a wide scope of topics:

1. THz spectroscopy and sensing
2. THz components (emitter, detector, waveguides, etc.)
3. THz material science (molecules, solid state materials, liquid meta-materials, nonlinear THz response, etc.)
4. Theory and Modeling associated with THz science and technology
5. Other fields associated with THz science and technology

The workshop has been organized by the Kobe University, University of Fukui, University of Philippines Diliman, University of the Philippines Los Baños, and De La Salle University and chaired by Professor Masahiko Tani (Director of FIR UF). This event follows the previous workshop (PJTW 2017) that was held in the Science and Technology Complex of the De La Salle University from 20 24 February 2017.

Please, visit the official website of the Workshop for more details including the list of the invited speakers and the program.

Institute of Applied Physics
of the Russian Academy of Sciences

New Advancement in the Thermal Treatment of Materials using Gyrotron

Recently, the paper "Ultra-rapid microwave sintering of pure and Y_2O_3-doped $MgAl_2O_4$" of the researchers from IAP-RAS has been selected as one of the best 19 featured articles published in 2018 in the Journal of the American Ceramic Society. It presents results from experiments carried out using a gyrotron system for microwave processing of materials operating at a frequency of 24 GHz with a maximum power of 6 kW.

Source: News from the website of IAP-RAS (Published on 25 May 2019).

Please follow the link to the original paper: Bykov Y.V., Egorov S.V., Eremeev A.G., Kholoptsev V.V., Plotnikov I.V., Rybakov K.I., Sorokin A.A., Balabanov, Belyaev A.V., "Ultra‐rapid microwave sintering of pure and Y_2O_3‐doped $MgAl_2O_4$," J Am Ceram Soc., vol. 102 (2018) 559‐568. DOI:10.1111/jace.15788.

SOME FORTHCOMING EVENTS

The 44th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2019) will be held in Paris, France, from 1st to 6th September 2019.

For detailed information visit the website of the conference following the link

The 29th International Crimean Conference “Microwave and Telecommunication Technology”

29-я Международная Крымская конференция «СВЧ-техника и телекоммуникационные технологии»
8–14 сентября 2019 г., Севастополь, Россия

September 8–14, 2019, Sevastopol, Russia
29th International Crimean Conference «Microwave & Telecommunication Technology»

The 29th International Crimean Conference “Microwave and Telecommunication Technology” will be held in the city of Sevastopol, Russia from 8 to 14 September 2019.

The conference has been held in Sevastopol since 1991. For 28 years, the conference has become a well-known forum where in 2018 alone over 300 reports were presented on theoretical, experimental, industrial and technological, applied and historical aspects of microwave equipment and telecommunication technologies. The authors of these reports are 606 scientists and specialists, representing 126 universities and enterprises in 9 countries: Armenia, Belarus, Great Britain, China, the Netherlands, Russia, the USA, Ukraine and Sweden. A collection of materials was published annually, for 28 years, 9060 reports were published in the conference materials, the authors of which are scientists and specialists of about 800 universities and enterprises in 43 countries (8 CIS countries and 35 foreign countries). Conference materials are indexed and refereed by many reputable databases, including the Scopus database.

For more detailed information please visit the conference website at the following **link**.

ICMTT 2020: International Conference on Microwave and Terahertz Technology

CALL FOR PAPERS

ICMTT 2020
Jun 04-05, 2020
New York, USA

ICMTT 2020: International Conference on Microwave and Terahertz Technology aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Microwave and Terahertz Technology. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Microwave and Terahertz Technology. The conference will be held during June 4-5,2020 in New York, USA.

For more details please follow the link.

The 5th Int'l Conference on Microwave and Terahertz Technology (ICMTT-BT 2019)

The 5th Int'l Conference on Microwave and Terahertz Technology (ICMTT-BT 2019) will be held in Bangkok, Thailand during December 13-15, 2019. For more information please visit the website of the conference.

LIST OF SELECTED RECENT PUBLICATIONS

Bibliography and links to selected recent publications on topics related to the research field of the International Consortium and published after February 2019, i.e. after issuing the previous Newsletter #11. This cumulative list is in chronological order as collected from various bibliographical and alert services

A. Publications by authors from the institutions participating in the International Consortium

V.L. Bratman, Yu.K. Kalynov, O.P. Kulagin, A.N. Leontyev, P.B. Makhalov, V.N. Manuilov, I. V Osharin, A.V. Savilov, A.E. Fedotov, A.P. Fokin, A.V. Chirkov, “A Compact THz Source for Enhancing the Sensitivity of Nuclear Magnetic Resonance Spectroscopy with Dynamic Nuclear Polarization,” Bulletin of the Russian Academy of Sciences: Physics, vol. 82, n. 12 (2018) 1592–1595. Original Russian Text: V.L. Bratman, Yu.K. Kalynov, O.P. Kulagin, A.N. Leontyev, P.B. Makhalov, V.N. Manuilov, I.V. Osharin, A.V. Savilov, A.E. Fedotov, A.P. Fokin, A.V. Chirkov, 2018, published in Izvestiya Rossiiskoi Akademii Nauk, Seriya Fizicheskaya, 2018, Vol. 82, No. 12, pp. 1760–1765.DOI:10.3103/S1062873818120274.
https://link.springer.com/article/10.3103%2FS1062873818120274

I.V. Bandurkin, V.L. Bratman, Yu.K. Kalynov, Yu.S. Oparina, I.V. Osharin, N.A. Zavolsky, A.V. Savilov, “Terahertz Gyrotrons at High Cyclotron Harmonics with Irregular Electrodynamic Systems,” Bulletin of the Russian Academy of Sciences: Physics, vol. 82, n. 12 (2018) 1582–1586. Original Russian Text: I.V. Bandurkin, V.L. Bratman, Yu.K. Kalynov, Yu.S. Oparina, I.V. Osharin, N.A. Zavolsky, A.V. Savilov, 2018, published in Izvestiya Rossiiskoi Akademii Nauk, Seriya Fizicheskaya, 2018, Vol. 82, No. 12, pp. 1748–1753. DOI:10.3103/S1062873818120250.
https://link.springer.com/article/10.3103%2FS1062873818120250

S.V. Kuzikov, A.V. Savilov, “Terahertz Gyrotrons at High Cyclotron Harmonics with Irregular Electrodynamic Systems,” Bulletin of the Russian Academy of Sciences: Physics, vol. 82, n. 12 (2018) 1596–1599. Original Russian Text: S.V. Kuzikov, A.V. Savilov, 2018, published in Izvestiya Rossiiskoi Akademii Nauk, Seriya Fizicheskaya, 2018, Vol. 82, No. 12, pp. 1766–1770.DOI:10.3103/S1062873818120298.
https://link.springer.com/article/10.3103%2FS1062873818120298

I.V. Bandurkin, I.S. Kurakin, Yu.S. Oparina, A.V. Savilov, V.L. Bratman, N. Balal, Yu. Lurie, “Terahertz Undulator Radiation of Stabilized Dense Electron Beams”, Bulletin of the Russian Academy of Sciences: Physics, vol. 82, n. 12 (2018) 1587–1591. Original Russian Text: I.V. Bandurkin, I.S. Kurakin, Yu.S. Oparina, A.V.

Savilov, V.L. Bratman, N. Balal, Yu. Lurie, 2018, published in Izvestiya Rossiiskoi Akademii Nauk, Seriya Fizicheskaya, 2018, Vol. 82, No. 12, pp. 1754–1759. DOI: 10.3103/S1062873818120262.
https://link.springer.com/article/10.3103%2FS1062873818120262

I.O. Girka, I.V. Pavlenko, M. Thumm, "Electromagnetic energy rotation along plasma-metal interface in cylindrical waveguides initiated by azimuthal surface waves," Physics of Plasmas, vol. 26, n. 2 (2019). DOI: 10.1063/1.5089487.
https://aip.scitation.org/doi/abs/10.1063/1.5089487

Kulygin M., "Stress Test of Nanosecond Semiconductor Cavity Switches with Subterahertz Gyrotrons," IEEE Trans. on Terahertz Science and Technology, vol. 9 (2019) 186-192. DOI:10.1109/TTHZ.2019.2891020.
https://ieeexplore.ieee.org/document/8601305

Zavolsky N.A., Zapevalov V.E., Zuev A.S., Plankin O.P., Sedov A.S., Semenov E.S., "Analysis of the Methods of Discrete and Smooth Frequenc Tuning in Gyrotrons for Spectroscopy, on the Example of a Generator Operated in the 0.20–0.27 THz Frequency Range, " Radiophysics and Quantum Electronics,vol. 61, n. 6 (2018) 436-444. DOI:10.1007/s11141-018-9905-4.
https://link.springer.com/article/10.1007%2Fs11141-018-9905-4

Likhachev A., Danik A.,Kishko S., Ponomarenko S., Martseniak O., Khutoryan E., OgawaI., Idehara T., Kuleshov A., "Compact radiation module for THz spectroscopy using 300 GHz continuous-wave clinotron," Review of Scientific Instruments, vol. 90, n. 3 (2019) 034703. DOI:10.1063/1.5064796.
https://aip.scitation.org/doi/10.1063/1.5064796

Z.C. Ioannidis, K.A. Avramidis , G. Gantenbein, S. Illy, T. Kobarg, I.Gr. Pagonakis, T.Rzesnicki, J.Jelonnek, „Development and Experimental Verification of an XY-Table for the Optimization of the Alignment of High-Power Gyrotrons," IEEE Trans. on Electron Devices, (2019). DOI: 10.1109/TED.2019.2899163.
https://ieeexplore.ieee.org/document/8663602

Lu X., Shapiro M.A., Temkin R.J., "Linear theory of instabilities generated by an electron beam in a metamaterial-loaded waveguide," Physics of Plasmas, vol. 26, n. 3 (2019) 033104. DOI:10.1063/1.5087587.
https://aip.scitation.org/doi/abs/10.1063/1.5087587

Abubakirov E.B., Denisenko A.N., Fedotov A.E., Leontyev A.N., Rozental R.M., Tarakanov V.P., "Electron-optical system for a high-current Ka-band relativistic gyrotron," Physics of Plasmas, vol. 26, n. 3 (2019)033302. DOI:10.1063/1.5085483.
https://aip.scitation.org/doi/10.1063/1.5085483

Kulygin M.L., Denisov G.G., Novikov E.A., Fokin A.P., Litovsky I.A., "Switching of Subterahertz Waves Within a Duration Range of Ten Orders of Magnitude," Radiophys Quantum Electronics, vol. 61, n. 8–9 (2019) 603-613. DOI:10.1007/s11141-019-09920-x.
https://link.springer.com/article/10.1007/s11141-019-09920-x

Z.C. Ioannidis, F. Albajar, S. Alberti, K.A. Avramidis, W. Bin, T. Bonicelli, A. Bruschi, J. Chelis, F. Fanale, G. Gantenbein, J. Genoud, J.-P. Hogge, V. Hermann, S. Illy, J. Jelonnek, J. Jin, W. Kasparek, G. P. Latsas, F. Legrand, C. Lechte, I. Gr. Pagonakis, T. Rzesnicki, F. Sánchez, C. Schlatter, M. Schmid, I. G. Tigelis, M. Thumm, M. Q. Tran, A. Zisis, A. Zein, "Recent experiments with the European 1MW, 170GHz industrial CW and short-pulse gyrotrons for ITER," Fusion Engineering and Design, (2019). DOI:10.1016/j.fusengdes.2018.12.065.
http://www.sciencedirect.com/science/article/pii/S0920379618308299

G. Gantenbein, K. Avramidis, S. Illy, Z.C. Ioannidis, J. Jin, J. Jelonnek, P. Kalaria, I.Gr. Pagonakis, S. Ruess, T. Ruess, T. Rzesnicki, M. Thumm, C. Wu, "New trends of gyrotron development at KIT: An overview on recent investigations," Fusion Engineering and Design, (2019). DOI:10.1016/j.fusengdes.2018.12.063.
http://www.sciencedirect.com/science/article/pii/S0920379618308263

Ruess T., Avramidis K.A., Gantenbein G., Ioannidis Z., Illy S., Lutz F.C., Marek A., Ruess S., Rzesnicki T., Thumm M., Wagner D., Weggen J., Jelonnek J., "Computer-Controlled Test System for the Excitation of Very High-Order Modes in Highly Oversized Waveguides," Journal of Infrared, Millimeter, and Terahertz Wave, vol. 40, n. 3 (2019) 267-268. DOI:10.1007/s10762-018-0566-3.
https://link.springer.com/article/10.1007/s10762-018-0566-3?wt_mc=alerts.TOCjournals&utm_source=toc&utm_medium=email&utm_campaign=toc_10762_40_3

I.V. Bandurkin, M.Y. Glyavin, T. Idehara, A.V. Savilov, "Double-Beam Gyrotron With Frequency Multiplication," IEEE Trans. on Electron Devices (2019). DOI: 10.1109/TED.2019.2905047.
https://ieeexplore.ieee.org/document/8675760

Saito T., Tatematsu Y., Yamaguchi Y., Fukunari M., Hirobe T., Shinbayashi R., Tanaka S. et al. "Developments for collective Thomson scattering equipment with a sub-THz gyrotron in LHD." EPJ Web of Conferences, vol. 203, 03012. EDP Sciences, 2019.
https://www.epj-conferences.org/articles/epjconf/pdf/2019/08/epjconf_ec2018_03012.pdf

Saito T., Tatematsu Y., Yamaguchi Y., Fukunari M., Hirobe T., Shinbayashi R., Tanaka S., Ohkubo K., Kubo S., Shimozuma T., Tanaka K., Nishiura M., “Developments for collective Thomson scattering equipment with a sub-THz gyrotron in LHD,” EPJ Web of Conferences 203, 03012 (2019).
https://www.epj-conferences.org/articles/epjconf/pdf/2019/08/epjconf_ec2018_03012.pdf

A. A. Likhachev, A.A. Danik, Yu.S. Kovshov, S.A. Kishko, S.S. Ponomarenko, V.N. Zheltov, E.M. Khutoryan, A.N. Kuleshov ryan, "Effect of Electron Beam Velocity Spread in a Clinotron," IEEE Trans. on Electron Devices, vol. 66, n. 3 (2019) 1540-1544. DOIO:10.1109/TED.2019.2891547.
https://ieeexplore.ieee.org/document/8624399

Picard J.F., Schaub S.C., Rosenzweig G., Stephens J.C., Shapiro M.A., Temkin R.J., "Laser-driven semiconductor switch for generating nanosecond pulses from a megawatt gyrotron," Applied Physics Letters, vol. 114, n. 16 (2019) 164102. DOI:10.1063/1.5093639.
https://aip.scitation.org/doi/10.1063/1.5093639

Tsvetkov A.I., Fokin A.P., Sedov, A.S., “First Experiments on Data Transmission Using a Sub-THz Gyrotron,” J Infrared Milli Terahz Waves (2019). DOI: 10.1007/s10762-019-00595-z.
https://link.springer.com/article/10.1007%2Fs10762-019-00595-z

Bykov, Y.V., Eremeev, A.G., Glyavin, M.Y. et al., “Millimeter-Wave Gyrotron Research System. I. Description of the Facility,” Radiophysics and Quantum Electronics (2019). DOI:10.1007/s11141-019-09933-6.
https://link.springer.com/article/10.1007/s11141-019-09933-6

M. Thumm, G.G. Denisov, K.Sakamoto, M.-Q. Tran,"High-power gyrotrons for electron cyclotron heating and current drive," Nuclear Fusion (2019). DOI:10.1088/1741-4326/ab2005.
http://iopscience.iop.org/10.1088/1741-4326/ab2005

Kalynov Yu.K., Manuilov V.N., Fiks A.Sh., Zavolskiy N.A., "Powerful continuous-wave sub-terahertz electron maser operating at the 3rd cyclotron harmonic," Applied Physics Letters, vol. 114, n. 21 (2019)213502. DOI:10.1063/1.5094875.
https://aip.scitation.org/doi/10.1063/1.5094875

P. Wang, H. Xiao, L. Li, O. Dumbrajs, "Functional Analysis Method for Nonlinear Theory of Gyrotrons," IEEE Trans. on Plasma Science, (2019). DOI:10.1109/TPS.2019.2917040.
https://ieeexplore.ieee.org/document/8732591

Bykov Y.V., Egorov S., Eremeev A.G., et al., ”Millimeter-Wave Gyrotron System for Research and Application Development. Part 2. High-Temperature Processes in Polycrystalline Dielectric Materials,” Radiophys Quantum Electronics (2019). DOI:10.1007/s11141-019-09936-3.
https://link.springer.com/article/10.1007/s11141-019-09936-3

Glyavin M.Y., Fedotov A.E., Zotova I.V. et al., “Experimental Demonstration of the Possibility to Expand the Band of Smooth Tuning of Frequency Generation in Short-Cavity Gyrotrons,” Radiophys Quantum Electronics, (2019).DOI:10.1007/s11141-019-09937-2.
https://link.springer.com/article/10.1007/s11141-019-09937-2

Ginzburg N.S., Yurovskii L.A., Zotova I.V., Sergeev AS., ” Frequency Conversion of High-Power Gyrotron Radiation under Conditions of Raman Backscattering on an Auxiliary Electron Beam,” Tech. Phys. Lett., vol. 45, n. 2 (2019) 134–137. DOI:10.1134/S1063785019020202.
https://link.springer.com/article/10.1134%2FS1063785019020202

B. Publications by other authors worldwide

Hou Shenyong, Yu Shen, Li Hongfu, “Numerical research on a 4 MW 170 GHz coaxial gyrotron with a double electron beam,” Physics of Plasmas, (2019). DOI:1063/1.5053637.
https://aip.scitation.org/doi/10.1063/1.5053637

Y. Xu et al., "Design and Experiment of a High Average Power Ku-Band TE01 Mode Gyro-TWT," IEEE Trans. Electron Devices, vol. 66, n. 3 (2019) 1559-1566. DOI:10.1109/TED.2019.2894537.
https://ieeexplore.ieee.org/document/8637026

X. Liao et al., "Design of a TE_{01}-Mode Waveguide Bend Based on an Elliptical Waveguide Structure," IEEE Trans. on Microwave Theory and Techniques,(2019). DOI:10.1109/TMTT.2019.2892737.
https://ieeexplore.ieee.org/abstract/document/8642538

Kumar A.N., Singh U., Gahlaut V., Bera A., "Inverse Magnetron Injection Gun for Megawatt Power, Sub-THz Gyrotron," IEEE Trans. on Plasma Science, vol. 47, n. 2 (2019) 1262-1268. DOI:10.1109/TPS.2019.2890876.
https://ieeexplore.ieee.org/document/8621616

Okada M., Kariya T., Imai T., Minami R., Numakura T., Ebashi Y., Motoyoshi F., Nakashima Y., “Performance Test of Double-Disk Type Output Window of 28/35 GHz Dual-Frequency Gyrotron for CW Operation,” Plasma and Fusion Research, vol. 14(2019) 2405043 (2019). DOI: 10.1585/pfr.14.2405043.
http://www.jspf.or.jp/PFR/PFR_articles/pfr2019/pfr2019_14-2405043.html

T. Kariya, R. Minami, T.,Imai, M. Okada, F. Motoyoshi, T. Numakura, Y. Nakashima, H. Idei, T. Onchi, K. Hanada, Shimozuma, Y. Yoshimura, Hiromi T., S. Kubo, Y. Oda, R. Ikeda, K. Sakamoto, M. Ono, K. Nagasaki,T. Eguchi, Y. Mitsunaka, “Development of high power gyrotrons for advanced fusion devices ,” Nuclear Fusion, (2019). DOI: 10.1088/1741-4326/ab0e2c.
https://iopscience.iop.org/article/10.1088/1741-4326/ab0e2c

U. Siravo, S. Alberti, J. Dubray, D. Fasel, A. Perez, ”Electrical integration of two 1MW/2s dual-frequency gyrotrons into the EC-system of the TCV tokamak,” Fusion Engineering and Design, (2019). DOI:10.1016/j.fusengdes.2019.02.117.
(http://www.sciencedirect.com/science/article/pii/S0920379619302996

MacLachlan A.J., Robertson C.W., Konoplev I.V., Cross A.W., Phelps A.D.R., Ronald K., “Resonant Excitation of Volume and Surface Fields on Complex Electrodynamic Surfaces,” Phys. Rev. Applied, vol. 11, n. 3 (2019) 034034. DOI: 10.1103/PhysRevApplied.11.034034.

https://link.aps.org/doi/10.1103/PhysRevApplied.11.034034

D. Fasel, S. Alberti, J. Dubray, T. Goodman, J.-P. Hogge, D. Minelli, U. Siravo, A. Perez, F. Albajar, G. Carannante, P. Sanchez, F. Sartori, M. Cavinato, L. De Frutos, “Enhanced operation of the EU EC test facility,” Fusion Engineering and Design, (2019). DOI:10.1016/j.fusengdes.2019.03.072.
http://www.sciencedirect.com/science/article/pii/S092037961930393X

Li R., Ruan C., Fahad A.K., Zhang Ch., Li Sh., "Broadband and high-power terahertz radiation source based on extended interaction klystron," Scientific Reports, vol. 9. n. 1(2019) 4584. DOI:10.1038/s41598-019-41087-3.
https://www.nature.com/articles/s41598-019-41087-3

A. Moro, S. Alberti, A. Bruschi, S. Garavaglia, T. Goodman, J.-P. Hogge, J. Jin, L. Porte, F. Ramseyer, M. Silva, M. Toussaint, “Design and implementation of quasi-optical components for the upgrade of the TCV EC-system, Fusion Engineering and Design,” (2019).DOI:10.1016/j.fusengdes.2019.01.157.
http://www.sciencedirect.com/science/article/pii/S0920379619301176

Adilova A.B., Preobrazhenskaya N.V., Ryskin N M., “On the Theory of Synchronization of a Two-Mode Electron Maser with a Hard Excitation,” Izv. Saratov Univ. (N. S.), Ser. Physics, 2019, vol. 19, iss. 1, pp. 19–27 (in Russian). DOI:10.18500/1817-3020-2019-19-1-19-27.

He W., Xie J., Phelps A., Cross A., Yin H., et al., “Compact High Power Millimetre Wave Sources driven by Pseudospark-sourced Electron Beams”, IET Microwaves, Antennas & Propagation, (2019). DOI: 10.1049/iet-map.2018.6190.
https://digital-library.theiet.org/content/journals/10.1049/iet-map.2018.6190

Ansari M.A., Thottappan M. “Design and Performance Analyses of High-Efficiency X-Band Relativistic Backward-Wave Oscillator Using an Improved Resonant Reflector Under Low Guiding Magnetic Field,”IEEE Trans. Plasma Science, 1–8. DOI:10.1109/tps.2019.2904041.
https://ieeexplore.ieee.org/document/8672481

S. Pan, C. Du, H. Bian, Z. Gao, F. Li, P. Liu, "Terahertz Broadband Whispering-Gallery Mode Gyrotron Backward-Wave Oscillator," IEEE Transactions on Electron Devices (2019). DOI:10.1109/TED.2019.2903897.
https://ieeexplore.ieee.org/abstract/document/8672811

Du Ch.-H., Gao Z.-Ch., Li F.-H., Bian H.-Q., Liu P.K., Pan S., "Investigation of high-order mode excitation in a terahertz second-harmonic gyro-BWO," Physics of Plasmas, vol. 26, n. 3 (2019) 033114. DOI:10.1063/1.5089598.
https://aip.scitation.org/doi/abs/10.1063/1.5089598

Zhang D., et al, "Design and preliminary experiment of radial sheet beam terahertz source based on radial pseudospark discharge," Plasma Sci. Technol., vol. 21 (2019) 044003. DOI:10.1088/2058-6272/aafbc3.
https://iopscience.iop.org/article/10.1088/2058-6272/aafbc3

Nakamura T., Kariya T., Minami R., Okada M., Hojo T., Motoyoshi F., Imai T., “Code Development for Calculating Electron Beams in the Cavities of the Future High-Power Gyrotrons,” Plasma and Fusion Research, vol. 14 (2019) 2405052. DOI:10.1585/pfr.14.2405052.
http://www.jspf.or.jp/PFR/PDF2019/pfr2019_14-2405052

Guo G., Niu X., Liu Y., Wang H., Liu J., Wei Y., “Modeling, simulation, and fabrication of electron optic system for application on 105 GHz high-power gyrotron,” Int J Numer Model. (2019) e2593. DOI:10.1002/jnm.2593.
https://onlinelibrary.wiley.com/doi/abs/10.1002/jnm.2593

Braj K. Shukla, Jatin Patel, Hardik Mistry, Harshida Patel, Dharmesh Purohit, K.G. Parmar, Rajan Babu, Joydeep Ghosh, Rakesh Tanna, Kumarpalsinh Jadeja, Kaushal Patel, Moti Makwana, C.N. Gupta, Mahesh Kushwah,

“Commissioning of Electron Cyclotron Resonance Heating (ECRH) system on tokamak Aditya-U,” Fusion Engineering and Design, (2019) 2019. DOI:10.1016/j.fusengdes.2019.03.108.
http://www.sciencedirect.com/science/article/pii/S0920379619304417

Bin W., Bruschi A. D'Arcangelo O., Fanale F., et al, "Integration of a secondary line for non-scattering plasma signals and gyrotron's spectrum monitoring," Journal of Instrumentation, vol. 14, n. 3 (2019) C03003. DOI:10.1088/1748-0221/14/03/C03003.
https://iopscience.iop.org/article/10.1088/1748-0221/14/03/C03003

Liu Y., Lei C., Niu X., Wang H., Guo G., Zhang S. Li H., "Study and design of cavity and MIG of a high-power, 140 GHz gyrotron at UESTC," Physics of Plasmas, vol. 26, n. 3 (2019) 033106. DOI:10.1063/1.5088005.
https://aip.scitation.org/doi/10.1063/1.5088005

Yeh Y.S., Zheng C., Li L., Chiang P., Chen Y., Huang B., Lo C., "Axial modes in terahertz high-harmonic large-orbit gyrotrons," Modern Physics Letters B, (2019)1940008 DOI:10.1142/S0217984919400086.
https://www.worldscientific.com/doi/pdf/10.1142/S0217984919400086

Gong H., YuanC., Zhao X., Zhang Q., "A novel TM01-TE01 high-power microwave mode converter," AIP Advances, vol. 9, n. 4 (2019)045114. DOI:10.1063/1.5091534.
https://aip.scitation.org/doi/full/10.1063/1.5091534

Maksimenko A.V., Shcherbinin V.I., Tkachenko, “Coupled-Mode Theory of an Irregular Waveguide with Impedance Walls,” V.I. J Infrared Milli Terahz Waves (2019). DOI:10.1007/s10762-019-00589-x.
https://link.springer.com/article/10.1007%2Fs10762-019-00589-x

Takahashi M., Ohnishi N., "Gas propellant dependency of plasma structure and thrust performance of microwave rocket," Journal of Applied Physics, vol. 125, n. 16 (2019)163303. DOI:10.1063/1.5053086.
https://aip.scitation.org/doi/abs/10.1063/1.5053086

G. Zhao et al., "Design of Quasi-Optical Mode Converter for 170-GHz TE32,9-Mode High-Power Gyrotron," IEEE Trans. on Plasma Science (2019). DOI:10.1109/TPS.2019.2908503.
https://ieeexplore.ieee.org/abstract/document/8689076

D. Liu et al., "Detailed Investigations on a Multisection Cavity for a Continuously Frequency-Tunable Gyrotron," IEEE Trans. on Electron Devices, (2019). DOI:10.1109/TED.2019.2909067.

Fu W., Guan X.,Yan Y., "Harmonic terahertz gyrotron with a double confocal quasi-optical cavity," Physics of Plasmas, vol. 26, n. 4 (2019) 043109. DOI:10.1063/1.5090471.
https://aip.scitation.org/doi/abs/10.1063/1.5090471

X. Guan, W. Fu, D. Lu, Y. Yan, T. Yang and X. Yuan, "Experiment of a High-Power Sub-THz Gyrotron Operating in High-Order Axial Modes," IEEE Trans. on Electron Devices (2019). DOI: 10.1109/TED.2019.2910127.
https://ieeexplore.ieee.org/abstract/document/8699104

R. Yan, D. Wang, H. Li, M. Mu, Y. Lian, Y. Luo, "Design of Collectors for High Average/Continuous-Wave Power Gyro-Devices," IEEE Trans. on Electron Devices, vol. 66, no. 3 (2019) 1512-1518. DOI: 10.1109/TED.2018.2889722.
https://ieeexplore.ieee.org/document/8613878

Mukesh Kumar Alaria, N Singh, Utpal Singh, A Bera, AK Sinha, “Development of 170 GHz, 0.1 MW short pulse gyrotron,” Fusion Engineering and Design, vol. 144 (2019) 87-92. DOI:10.1016/j.fusengdes.2019.04.073.
http://www.sciencedirect.com/science/article/pii/S0920379619306076

K. Nagasaki, S. Watanabe, K. Sakamoto, A. Isayama, H. Okada, T. Minami, S. Kado, S. Kobayashi, S. Yamamoto, S. Ohshima, S. Konoshima, T. Mizuuchi, Y. Nakamura, A. Ishizawa, S. Kubo, H. Igami, G. Weir, N. Marushchenko, "Measurement of stray millimeter-wave radiation from a 70-GHz ECH/ECCD system in Heliotron J," Fusion Engineering and Design, vol. 144 (2010) 40-45. DOI:10.1016/j.fusengdes.2019.04.051.
http://www.sciencedirect.com/science/article/pii/S092037961930585X

G.L. Ravera, S. Ceccuzzi, G. Dattoli, E. Di Palma, A. Doria, G.P. Gallerano, E. Giovenale, F. Mirizzi, G. Schettini, I. Spassovsky, A.A. Tuccillo, "Optimization of TE11/TE04 mode converters for the cold test of a 250 GHz CARM source," Fusion Engineering and Design, (2019). DOI:10.1016/j.fusengdes.2019.01.069.
http://www.sciencedirect.com/science/article/pii/S0920379619300766

D. Liu et al, "Detailed Investigations on a Multisection Cavity for a Continuously Frequency-Tunable Gyrotron," IEEE Transactions on Electron Devices, vol. 66, n. 6 (2019) 2746-2751. DOI: 10.1109/TED.2019.2909067.
https://ieeexplore.ieee.org/document/8691579

H. Li, J. Wang, Y. Yao and Y. Luo, "Development of High-Efficiency Gyro-TWT With a Nonuniform Dielectric-Loaded Circuit," IEEE Trans. on Electron Devices, vol. 66, n. 6 (2019) 2764-2770. DOI: 10.1109/TED.2019.2912761.
https://ieeexplore.ieee.org/abstract/document/8708948

Oda Y., Ikeda R., Kajiwara K., Kobayashi, et al, "Development of 1st ITER Gyrotron in QST. Nuclear Fusion (2019). DOI:10.1088/1741-4326/ab22c2.
https://iopscience.iop.org/article/10.1088/1741-4326/ab22c2

N. Kumar, U. Singh, A. Bera, "Triode Type Coaxial Inverse Magnetron Injection Gun for 2-MW, 240-GHz Gyrotron," IEEE Trans. on Electron Devices, (2019). DOI: 10.1109/TED.2019.2914472.
https://ieeexplore.ieee.org/document/8721266

Andrey V. Starodubov, Alexey A. Serdobintsev, Anton M. Pavlov, Victor V. Galushka, Ilya V. Sinev, Andrey G. Rozhnev, Roman A. Torgashov, Gennadiy V. Torgashov, and Nikita M. Ryskin "Experimental and numerical study of electromagnetic parameters of planar slow-wave structures for millimeter-wave vacuum electronic devices", Proc. SPIE 11066, Saratov Fall Meeting 2018: Laser Physics, Photonic Technologies, and Molecular Modeling, 1106618 (3 June 2019). DOIi: 10.1117/12.2524646.
https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11066/2524646

Numarura T., Kariya T., Minami R., Okada M., Hojo T., Motoyoshi F., Imai T., "Code Development for Calculating Electron Beams in the Cavities of the Future High-Power Gyrotrons,"Plasma and Fusion Research, vol. 14 (2019) 2405052. DOI:10.1585/pfr.14.2405052.
https://www.jstage.jst.go.jp/article/pfr/14/0/14_2405052/_article/-char/ja/

K. Hogan et al., "Novel Gyrotron Beam Annealing Method for Mg-Implanted Bulk GaN," 2019 IEEE International Reliability Physics Symposium (IRPS), Monterey, CA, USA, 2019, pp. 1-6. DOI:10.1109/IRPS.2019.8720600.
https://ieeexplore.ieee.org/abstract/document/8720600

Lu Z., et al.,"High power folded waveguide traveling wave tube based on variable-width technology," Physics of Plasmas, vol. 26, n. 5 (2019) 053106. DOI:10.1063/1.5088385.
https://aip.scitation.org/doi/abs/10.1063/1.5088385

N. Shi et al., "Study of 220 GHz Dual-Beam Overmoded Photonic Crystal-Loaded Folded Waveguide TWT," in IEEE Transactions on Plasma Science, vol. 47, n. 6 (2019) 2971-2978. DOI:10.1109/TPS.2019.2914164.
https://ieeexplore.ieee.org/document/8718018

W. Rao et al, "Design of a High-Gain X -Band Megawatt Gyrotron Traveling-Wave Tube," in *IEEE Transactions on Plasma Science*, vol. 47, n. 6 (2019) 2818-2822. DOI: 10.1109/TPS.2019.2915554.
https://ieeexplore.ieee.org/abstract/document/8720179

Y. Pu et al., "PID Modeling and Experiment of the Hot Test of Gyrotron Traveling Wave Tubes," IEEE Transactions on Plasma Science, vol. 47, n. 6 (2019) 2812-2817. DOI: 10.1109/TPS.2019.2915843.
https://ieeexplore.ieee.org/abstract/document/8721688

Chen K., Xu Q., Xion, N., Xu W. ‐ J., Zhang K. ‐ C., “Research on beam-wave interaction of EIK in THz band,” Int J Numer Model. (2019).DOI:10.1002/jnm.2619.
https://onlinelibrary.wiley.com/doi/abs/10.1002/jnm.2619

Bernard G.M., Michaelis V.K., "Instrumentation for High-field Dynamic Nuclear Polarization NMR Spectroscopy," eMagRes, Vol 8 (2019) 77–86. DOI 10.1002/9780470034590.emrstm1560.
https://onlinelibrary.wiley.com/doi/abs/10.1002/9780470034590.emrstm1560

C Patents

Apparatus and methods for processing ultra-wideband electromagnetic waves
Inventors: Farhad Barzegar, Irwin Gerszberg, Giovanni Vannucci, Peter Wolniansky, Paul Shala Henry
US Patent: US10205482B1
Date of publication: 2019-02-12
https://patents.google.com/patent/US10205482B1/en

Methods and apparatus for adjusting a phase of electromagnetic waves
Inventors: Paul Shala Henry, Giovanni Vannucci, Thomas M. Willis, III, Shikik Johnson, Robert Bennett, Farhad Barzegar, Irwin Gerszberg, Donald J. Barnickel
US Patent: US10205212B2
Date of publication: 2019-02-12
https://patents.google.com/patent/US10205212B2/en

Guided-wave transmission device with non-fundamental mode propagation and methods for use therewith
Inventors: Henry, Paul Shala (Holmdel, NJ, US), Bennett, Robert (Southold, NY, US), Gerszberg, Irwin (Kendall Park, NJ, US), Barzegar, Farhad (Branchburg, NJ, US), Barnickel, Donald J. (Flemington, NJ, US), Willis III, Thomas M. (Tinton Falls, NJ, US)
United States Patent: 10200126
Publication Date: 2019-02-05
http://www.freepatentsonline.com/10200126.html

Electron gun adjustment in vacuum
Inventor: Chris Ferrari , San Jose , CA (US)
US Patent: US 2019 / 0057830 A1
Publication date: 2019-02-21
http://www.freepatentsonline.com/y2019/0057830.html

Electron gun thermal dissipation in vacuum
Inventors: Chris Ferrari, San Jose, CA (US), Thomas M . Bemis, Arlington, MA (US)
Publication date: 2019-02-21
https://patents.justia.com/patent/20190057829

Microwave tempering of glass substrates
Inventors: Wei XU, Cheswick, PA (US), Yu JIAO, Blawnox, PA (US); David A., ALLERTON, Pittsburgh, PA (US), Dennis J. O ' SHAUGHNESSY, Allison Park, PA (US), Chao Y.U., Horseheads, NY (US).

Publication date: 2019-05-23
https://patentimages.storage.googleapis.com/b7/bf/27/54fa687f160ea6/US20190152832A1.pdf

NEW BOOKS

Volodymyr Girka, Igor Girka, Manfred Thumm, “Surface Electron Cyclotron Waves in Plasmas” (Springer, 2019). DOI:10.1007/978-3-030-17115-5. ISBN 978-3-030-17114-8. eBook ISBN 978-3-030-17115-5.
https://www.springer.com/us/book/9783030171148

Thomas Elsaesser, Klaus Reimann and Michael Woerner, “Concepts and Applications of Nonlinear Terahertz Spectroscopy,” (IOP, 2019). Online ISBN:978-1-64327-216-0, Print ISBN:978-1-64327-213-9.
https://iopscience.iop.org/book/978-1-64327-216-0

Richard R. Freeman, James A. King, and Gregory P. Lafyatis, “Electromagnetic Radiation,” (Oxford University Press, 2019), 640 Pages, 116 illustrations. Print ISBN-13:9780198726500. DOI:10.1093/oso/9780198726500.001.0001.
https://www.oxfordscholarship.com/view/10.1093/oso/9780198726500.001.0001/oso-9780198726500