Iván Cámara Mayorga Sebastianstr. 2 53115 Bonn Tel. 0228 525342/ 015157316172

Dekan des Fachbereichs 12
Prof. Dr. E. Griese
Universität Siegen
D-57068 Siegen.

Bonn, den 10 September 2009

Juniorprofessur (W1) für Sensorik und Sensordatenverarbeitung im Rahmen des DFG-Graduiertenkollegs 1564 – Imaging New Modalities –

Ihre Anzeige im „www.grk1564.uni-siegen.de“

Sehr geehrter Prof. Dr. Griese,

hiemit sende ich Ihnen meine Bewerbungsunterlagen zu der ausgeschriebenen Professur.

Das von Ihnen beschriebene Aufgabengebiet entspricht meinem Profil und Neigungen. Im THz Photonik Gebiet verfüge ich über eine mehrjährige Berufs- und Forschungserfahrung.

Als Dipl. Physiker und Dipl. Ingenieur (Nachrichtentechnik) habe ich im akademischen Bereich, in der Forschung und in der Telekommunikationsindustrie gearbeitet. Meine Promotion in Physik „Photomixers as tunable terahertz local oscillators“ habe ich mit „Summa Cum Laude“ am 18.09.08 abgeschlossen.

Mein Wissen und Können habe ich als Wissenschaftlicher Mitarbeiter seit 2002 am Max Planck Institut für Radioastronomie in Bonn unter Beweis gestellt.

Mein Know-How gepaart mit hoher Leistungsmotivation sehe ich als eine gute Ausgangsbasis für das neue Aufgabengebiet der Professur.

Die Spitzentechnologie, die ich am MPIfR entwickelt habe, ist bereits in der Lage, die anspruchvollen Anforderungen eines astronomischen Heterodynempfängers zu erfüllen. Daher bin ich mir sicher, dass andere Anwendungen dieser Technologie, wie z. B. in Zivilsicherheit, stark von davon profitieren würden.

Über eine Einladung zu einem persönlichen Gespräch würde ich mich sehr freuen.

Mit freundlichen Grüßen,

Dr. Iván Cámara Mayorga.

PS.: Sollte Sie mir zu einem persönlichen Gespräch einladen, bitte ich Sie zu berücksichtigen, dass ich mich zwischen 9.10-24.10 im Ausland befinden werde.

Anlage

Lebenslauf

Ausgewählte Publikationen/ Publikationsliste

„Research Achievements“

„Statement of Research Plan”

Referenzen

Eine Kopie meiner Zeugnisse bekommen Sie in den nächsten Tagen per Post zugeschickt.

CURRICULUM VITAE

Personal Details

Name: Iván Cámara Mayorga.
Address: Sebastianstr. 2, 53115 Bonn (Germany)
Tel.: +49 228 525342, +49 228 9212133, +49 15157316172
Birth Date: 11 November 1976.
Marital Status: Married.
Nationality: Spanish.

Education

PhD in Physics (summa cum laude – Ausgezeichnet 0.0)
2006 – 2008. University of Bonn (Germany).
Doctoral thesis "*Photomixers as tunable THz local oscillators*".
Supervisor Prof. Dr. Karl Maier.

Master Degree in Physics (Licenciado en Ciencias Físicas).
2006. National Estate Distance University (UNED). Madrid (Spain).

Master Degree in Electrical Engineering (Ingeniero de Telecomunicación)
1998 – 2000. Alfonso X El Sabio University. Madrid (Spain).

Bachelor Degree in Electrical Engineering (Ingeniero Técnico de Telecomunicaciones)
1994 – 1998. Alcalá de Henares University (Spain).

High School in IB "Carlos III" (COU)
1994. Toledo - Spain (with Honours: A-Levels in all subjects).

Professional Experience:

Max Planck Institut für Radioastronomie (Bonn - Germany)
2002 – Present.
Research Associate (Wissenschaftlicher Mitarbeiter)

- R & D of Photonic Local Oscillators (100 GHz - 2.7 THz) for radio astronomy applications.
- R & D of Laser Systems (Solid State Ti:Sa and Semiconductor Lasers) and comb generators.
- Quasioptics & Cryogenic Design.

University Alfonso X (Madrid – Spain).
May 2001 - July 2002.
Associate Professor in Telecommunications Engineering.
Responsible for:

- Electromagnetic Theory.
- Microwave Theory.
- Communication Theory
- Communications Electronics.
- Signal & Systems Laboratory.
- Optical Communications Laboratory.

Nortel Networks. RF Planning Engineer (Madrid – Spain).
July 2000 - September 2001.
Contractor in Xfera UMTS project.

- UMTS RF Planning for the north of Madrid.
- Simulation of signal coverage.
- On field activities related to antenna site acquisition and design for civil engineering.

Alcatel Espacio. **Department of Radio frequency Engineering. (Madrid – Spain). Scholarship from January 2000 - July 2000.**
Simulation of satellite transponder circuits (Phase locked loops, oscillators) with the simulation tool application Libra.

Moscow Aviation Institute. Summer 1997. Moscow – Russia.
Scholarship
Development of a software application for the Glonass Satellite Positioning System though IAESTE (International Association for a technical experience).

Computer Science Skills

- **RF Design** and Simulation of microstrip, coplanar waveguide, coplanar strip transmission lines and antennas with IE3D (Zeland Software).
- **TCAD Semiconductor Simulation** with ATLAS (Sylvaco)
- **Electronic circuit simulation** with PSpice
- **Programming languages** Matlab, C, C++, Java, Pascal & Visual Basic.
- **Microsoft Office** and Database design with MS Access.

Languages

- **English**

Fluent.

- **German**

Fluent.

- **Russian**

Good.

- **Spanish**

Mother tongue.

PUBLICATIONS AND CONFERENCES

1. Rosita Sowade, Ingo Breunig, **Ivan Camara Mayorga**, Jens Kiessling, Cristian Tulea,Volkmar Dierolf and Karsten Buse. Continuous-wave optical parametric terahertz source. *Nature Photonics (submitted)*
2. Luis Enrique García Muñoz, **Iván Cámara Mayorga**, High Bandwidth Tapered Slot Antenna for Terahertz Photomixing, *IEEE Transactions on Microwave Theory and Techniques Special Issue (submitted)*
3. Axel Roggenbuck, Anselm Deninger, **Iván Cámara Mayorga**, Holger Schmitz, Joachim Hemberger, Frank Lison, and Markus Grüninger, CW Terahertz Spectrometer with High-Precision Frequency Control. *Conference on Lasers and Electro-Optics (CLEO) 2009*
4. Anselm Deninger, Axel Roggenbuck, Stephanie Schindler, **Iván Cámara Mayorga**, Holger Schmitz, Joachim Hemberger, Rolf Güsten, and Markus Grüninger. Cw THz Spectrometer with High SNR and MHz Frequency Resolution. *International Conference on Infrared, Millimeter, and Terahertz Waves 2009*
5. Claus-Stefan Friedrich, Carsten Brenner, Stefan Hoffmann, Andreas Schmitz, Iván **Cámara Mayorga**, Andreas Klehr, Götz Erbert, and Martin R. Hofmann. New Two-Color Laser Concepts for THz Generation. *IEEE Journal Of Selected Topics In Quantum Electronics,* vol. 14, no. 2, March/ April (2008)
6. **Cámara Mayorga** I., Ernest Michael , Andreas Schmitz , Peter van der Wal , Rolf Guesten, Karl Maier, Alfred Dewald et al. *Terahertz Photomixing in high energy oxygen- and nitrogen-ion-implanted GaAs,* Applied Physics Letters, 91 (2007) .
7. E. A. Michael, **Cámara Mayorga** Iván, Rolf Güsten , Alfred Dewald , Rudolf Schieder, *Terahertz continuous-wave large-area traveling-wave photomixers on high-energy low-dose ion-implanted GaAs,* Applied Physics Letters, 90 (2007).
8. **Cámara Mayorga** I., P. Muñoz Pradas, M. Mikulics, A. Schmitz, C. Kasemann, P. van der Wal, K. Jakobs and R. Güsten, *Terahertz photonic mixers as local oscillators for hot electron bolometer and superconductor-insulator-superconductor astronomical receivers* , J. Appl. Phys, 100, Issue 4, pp. 043116-043116-4 (2006).
9. **Cámara Mayorga** I., P. Muñoz Pradas, M. Mikulics, A. Schmitz, C. Kasemann, P. van der Wal, K. Jakobs and R. Güsten, Superconductor- *Insulator- Superconductor (SIS) and Hot Electron Bolometer (HEB) pumping with LT-GaAs based photonic local oscillators. International Symposium on Space Terahertz Technology* (Gothenburg 2005)
10. Stone M.R., Naftaly M., Miles R.E., **Cámara Mayorga** I. , Malcoci A., Mikulics M., 2005, *Generation of continuous-wave terahertz radiation using a two-mode titanium sapphire laser containing an intracavity Fabry-Perot etalon*, J. Appl. Phys. 97, 103108 (2005)
11. M. Mikulics, M. Marso, I. **Cámara Mayorga**, R. Güsten, S. Stancek, P. Kovac, S. Wu, X. Li, M. Khafizov, R. Sobolewski, E.A. Michael, R. Schieder, M. Wolter, D. Buca, A. Förster, P. Kordos, H. Lüth
Photomixers fabricated on nitrogen-ion-implanted GaAs, Applied Physics Letters, 87 (2005), 041106
12. M. Naftaly, M.R. Stone, A. Malcoci, R.E. Miles and I. **Cámara Mayorga**. *Generation of CW Terahertz radiation using two-colour laser with Fabry-Perot etalon*. Electronic Letters, Vol. 41 no. 3, pp 128. (2005),

13. M. Marso, M. Mikulics, R. Adam, S. Wu, X. Zheng, I. **Cámara Mayorga** , F. Siebe, A. Förster, R. Güsten, P. Kordoš, and R. Sobolewski, *Ultrafast phenomena in freestanding LT-GaAs devices*, Acta Phys. Polonica A 107,109 (2005).

14. I. **Cámara Mayorga**, M. Mikulics, A.Schmitz, P.van der Wal, R.Güsten, M.Marso, P.Kordos, H. Lüth. *An Optimization of Terahertz Local Oscillators based on LT-GaAs Technology*. Proc. SPIE, Volume: 5498, pp. 537 (SPIE, Glasgow 2004).
15. Mikulics, M., **Cámara Mayorga**, I., Marso, M., v.d.Hart, A., Fox, A., Förster, A., Güsten, R., Lüth, H., and Kordoš, P.: *Generation of THz radiation by photomixing in low-temperature-grown MBE GaAs*. In: ASDAM 2004, pp. 231-234, Piscataway: IEEE 2004
16. Mikulics, M., Wolter, M.J., Marso, M., **Cámara Mayorga**, I., Stanček, S., Wu, S., Buca, D., Sobolewski, R., Kováč, P., Guesten, R., Lüth, H., and Kordoš, P.: *Nitrogen implanted GaAs for ultrafast photodetectors and photomixers*. In: ASDAM 2004, pp. 53-56, Piscataway: IEEE 2004.
17. Adam, R., Mikulics, M., Wu,S., Zheng,X., Marso, M., **Cámara Mayorga**, I., Siebe, F., Güsten,R., Förster,A., Kordoš,P., and Sobolewski,R.: *Fabrication and performance of hybrid photoconductive devices based on freestanding LT-GaAs*, Proc. SPIE Vol.5352, pp. 321, 2004.
18. M. Marso, M. Mikulics, R. Adama, S. Wu, X. Zheng,I. **Camara Mayorga**, F. Siebe, A. Forster, R. Gusten, P. Kordos and R. Sobolewski, *Ultrafast Phenomena in Freestanding LT-GaAs Devices*. Proceedings of the 12th International Symposium UFPS, Vilnius, Lithuania 2004
19. A.Stöhr, A.Malcoci, A.Sauerwald, I. **Cámara Mayorga**, R.Güsten, D.Jäger, *Ultra-Wide-Band Traveling-Wave Photodetectors Photonic Local Oscillators*. Journal Of Lightwave Technology, Vol. 21, No. 12, December 2003.
20. Güsten, R.; **Camara**, I.; Hartogh, P.; Hübers, H.-W.; Graf, U.; Jacobs, K.; Kasemann, C.; Röser, H.-P.; Schieder, R.; Schnieder, G.; Siebertz, O.; Stutzki, J.; Villanueva, G.; Wagner, A.; van derWal, P.; Wunsch, A.; *GREAT: The German Receiver for Astronomy at Terahertz Frequencies*. Proc. SPIE, 56-61 (2003)
21. I. **Cámara Mayorga**, M. Mikulics, M. Marso, P. Kordoš, A. Malcoci, A. Stoer, D. Jaeger and R.Güsten: *THz Photonic Local Oscillators*. Workshop: New Perspectives for Post-Herschel far infrared astronomy from space. 1-4 September 2003 Madrid, Spain

---

Reviewer of several publications in:

- Journal of Applied Physics
- Applied Physics Letters
- IEEE/OSA Journal of Lightwave Technology

Overview

The reported research achievements are a solid basis from which I would like to trace a line of continuity. I have elaborated a list of current problems to be addressed and the strategy to solve them. In addition, I plan to broaden the application spectrum of terahertz to other exciting uses apart from the current LO application.

Current problems and goals

1. Material research and device fabrication

    a. Definition of the problem: The use GaAs as a photoconductive material for 800 nm wavelengths prevents the use of standard telecommunication components, which are significantly less expensive and easier to adjust. In addition, telecommunication wavelengths (1.3 and 1.55 µm) benefit from lower attenuation losses in fiber optics. Up to date promising results have been obtained with ion-implanted InGaAs photomixers, nevertheless their high dark current limit the maximum THz power to several nW at 1 THz.

    Goal: to extend material research to materials compatible with telecommunication wavelengths. The ohmic contacts of InGaAs photomixers will be replaced by Schottky or tunnelling contacts in order to reduce their high dark current.

    b. Definition of the problem: the stoichiometry of LT GaAs or ion-implanted GaAs is restored by thermal annealing. When operating photomixers at high photocurrents, the Joule and laser heating lead to a progressive annealing of the photomixing material –thereby eliminating the electron traps. This aging process depends abruptly on the substrate temperature.

    Goal: to improve the devices lifetime by a better thermal management. This can be achieved by processing layers of high thermal conductivity within the photoactive volume.

    c. Definition of the problem: Photomixing technology gets extremely inefficiently to generate radiation beyond 3 THz.

    Goal: to generate radiation by non-linear optics methods (see future directions)

2. Systems

    a. Definition of the problem: the material dispersion of the $MgO:LiNbO_3$ phase modulator used as a comb generator limits its bandwidth below 3 THz.

    Goal: to improve the bandwidth of the comb by negative dispersion materials which compensate for the $MgO:LiNbO_3$ dispersion.

    b. Definition of the problem: The ultimate power generated by a single photomixer is limited to several microwatts. This power is still insufficient for some applications.

    Goal: to further improve the radiated power by developing arrays of photomixers. The phase control of the terahertz radiation of the radiating photomixer elements (via i.e. Spatial Light Modulators) would enable beam-steering. This technology would find a direct application for terahertz cameras or synthetic aperture radars (SAR) when using the photomixer array as a homodyne receiver.

Research plans

1. Continuous-wave (cw) terahertz spectroscopy

It is my intention to extract the full potential of photomixer technology, which up to date I developed focused on radio astronomical uses. In particular, the unprecedented broadband properties (DC - several THz) of this technology together with the relative frequency stabilization of the driving lasers open exciting applications in the field of ultra-high resolution (<3kHz), wideband cw THz spectrometers. In this field, record breaking results have been achieved by industrial partners using cw THz spectrometers based on our photomixers.

The current research activities in the University of Siegen for homeland-security could be complemented by the installation of a photomixer based cw THz spectrometer for explosive detection. In comparison to the current pulsed system, the cw system would offer an increase of several orders of magnitude in the spectral resolution and sensitivity.

The groups of Prof. S. Schlemmer (University of Cologne, I. Physikalisches Institut) and Prof. M. Grüninger (University of Cologne, II. Physikalisches Institut) have already worked with THz spectrometers based on our photomixers for spectroscopy of gases (D_20) and and solids (lactose). These groups are very interested in the further development of this technology. The collaboration with these groups will be further maintained and intensified. A joint project in order to apply for funding would be possible.

The application of THz spectroscopy for food science is a relatively unexploited field. I consider that the potential of this technology for quality control in food industry is enormous. Therefore I plan to establish collaboration with Dr. Oliete from Centro Regional de Selección y Reproducción Animal (C.E.R.S.Y.R.A.), Valdepeñas (Spain). The aim of the joint research is to determine by THz spectroscopic methods the quality and authenticity of Manchego Cheese and/or milk.

2. Electro-optic generation of cw terahertz radiation

The non-linear optics approach for THz generation is a field with great perspectives. I plan to employ difference frequency generation in non-linear optical quasi-phase-matched waveguides illuminated by two laser modes. Since the optical waves are guided, first, a long interaction length can be achieved and second, a high optical intensity is available for efficient second-order $\chi^{(2)}$ non-linear processes to occur. Currently, exciting results have been obtained in a collaboration with the non-linear optics group of Prof. Buse in the University of Bonn: by the use of an optical parametric oscillator (OPO), 2.2 µW @ 1.4 THz cw have been obtained [Nature Photonics submitted].

3. Radio Astronomy

In the framework of collaboration with Max Planck Institute for Radio Astronomy, the use of photomixing technology as a local oscillator could be further developed. The aim would be to continue the development of photonic LO systems for the APEX telescope up to 1 THz and for the Stratospheric Observatory for Infrared Astronomy (SOFIA) at 2.7 THz.

Overview

Hereby, I describe the research activities of the THz Photonics group at the Max Planck Institute for Radio Astronomy (MPIfR). Since 2002 I work as a Research Associate (Wissenschaftlicher Mitarbeiter) and am responsible for this group, which is subordinated in the Sub-millimeter Technology Department. Our primary goal is the development of tunable, small linewidth (< 100 KHz) cw terahertz sources to deliver a local oscillator (LO) signal with sufficient power to pump radio astronomical heterodyne receivers. The approach followed to achieve this objective is to generate a THz beat signal by photomixing two NIR lasers in an ultra-fast semiconductor material. In order to develop a technology capable of fulfilling the demanding requirements imposed by a radio astronomical receiver system, a comprehensive and interdisciplinary research has beencarried out. The main milestones are listed below.

Major Research Achievements

1. Material research

Non-stoichiometric gallium arsenide is well-known to show ultra-fast carrier trapping properties due to the presence of arsenic antisites As_{Ga} and arsenic precipitates. This material is usually fabricated by molecular-beam-epitaxy (MBE) growth at low temperatures (250-350 °C) and a subsequent anneal. The resulting material is known as low-temperature-grown GaAs (LT-GaAs) and is an extended photoconductive material. Unfortunately, the growth temperature, at which an LT-GaAs sample shows optimal properties, lacks very often from fabrication reproducibility. This problem has been solved by the use of high energy ion-implantation in GaAs wafers (publications list [2], [3], [7]). The collision of incoming ions with the lattice atoms creates - amongst others - arsenic antisites, which are responsible for ultra-fast electron trapping, so that the material can exhibit similar carrier trapping mechanisms as LT GaAs.

The precise control over implantation energy and dose during implantation makes defect tailoring possible. Currently, the ion-implantatio technique is applied to optimized epitaxial designs. Apart from reproducibility, ion-implanted photomixers show state-of-the-art terahertz performance in bandwidth (~ 500 GHz) and power (10 µWatts @ 1 THz –experimentally confirmed). Novel photomixer antenna, epitaxial design and electrode structures have been implemented, from which a dramatic power increase is expected.

2. Laser system developments

The linewidth and long-term stability of the THz signal which results from photomixing two semiconductor free-running lasers is insufficient for any radio-astronomy application. To address this problem a laser frequency stabilization scheme was performed. The semiconductor lasers were locked using a self made optical comb generator. This optical reference, which is based on a high efficiency resonant $MgO:LiNbO_3$ phase modulator and a high finesse Fabry-Perot cavity, allows laser frequency stabilization in a range up to 3 THz (dispersion limited). By using a frequency discriminator and a high speed phase phase locking scheme, the linewidth of the photomixing signal was stabilized to less than 2 KHz (3dB linewidth @ 30ms integration time). [to be published].

In addition a laser system has been constructed in a dual-mode -working simultaneously in two longitudinal modes- Littrow configuration, (publications list [1], A. Schmitz. Aufbau und

Charakterisierung eines Zwei-Farben Diodenlasers. Master's thesis, Rhein-Ahr Campus, 2005.). Since the laser medium is the same for both modes the mixing signal benefits from a drastic linewidth reduction (120 KHz @ 150ms). This new system allows in-field operation and its volume requirements are 20 times less than that of the laser system used before. The tuneability range of this novel laser unit allows terahertz generation up to 5 THz. A fiber optic at the laser output drives our pigtailed photomixers – a special photomixer pigtailing technique has been developed: a portable robust tuneable terahertz source has become a reality.

3. Terahertz Local Oscillator Application results for Radio Astronomy

Our group is a leader in the application of photonic technology for delivering the local oscillator signal to terahertz heterodyne radio astronomical receivers. Our last achievement has been the installation, testing and commissioning of a compact terahertz local oscillator system at 1.05 THz in the Atacama desert at 5100m height. The system was installed in the radiotelescope APEX (Atacama Pathfinder Experiment) and consisted on a stand-alone laser system delivering two NIR single mode laser signals with enough power to drive a high-performance photomixer. The laser system included a novel phase-locking scheme based on a comb generator which enabled a relative frequency and phase stabilization of both lasers. The terahertz signal resulting from the photomixing of both lasers showed excellent spectral properties (< 2 kHz 3 dB linewidth!!), continuously tunable over the whole receiver band. Regarding the photomixer, we demonstrated successful pumping of the receiver. The measured noise temperature of the receiver system (780 K) was similar to that of classical solid-state LO.

It is important to remark that this is the highest reported frequency (1.05 THz) at which a heterodyne receiver has ever been pumped with photonic technology.

In addition we were the first team to report pumping of a hot-electron bolometer (HEB) mixer with a photonic local oscillator (@ 750 GHz, see [4])

Our next goal is to develop a photonic LO capable of pumping HEB mixers at 2.7 THz for the SOFIA NASA-DLR project.

4. CW Terahertz spectroscopic system based on photomixers

Our partners from the industry have demonstrated state-of-the-art performances in their CW Terahertz spectroscopic system using our photomixers (85 dB SNR @ 100 GHz, ~ 40 dB @ 2 THz).

Referenzen

Prof. Dr. Karl Maier.
Helmholtz-Institut für Strahlen- und Kernphysik
Nußallee 14-16
53115 Bonn
Germany
Tel.: +49 228/73-3540
Fax: +49 228/73-2505
maier@hiskp.uni-bonn.de

Prof. Dr. Javier Alda
Applied Optics Complutense Group.
Department of Optics.
School of Optics. University Complutense of Madrid
Av. Arcos de Jalón s/n. 28037 Madrid. Spain
Tel.: +34.91.394.6874
Fax: +34.91.394.6885
j.alda@opt.ucm.es

Prof. Dr. Robert E. Miles
School of Electronic & Electrical Engineering
Chair of Semiconductor Electronics
Tel.: +44 (0) 113-343-2081
R.E.Miles@leeds.ac.uk

Dr. Peter van der Wal
Max Planck Institut für Radioastronomie
Submmtechnologie Abteilung
Tel.: +49 228 525 346
Fax: +49 228 525 229
pvdwal@mpifr-bonn.mpg.de