TREASURE

Grant Agreement: 250056

Project Acronym: TREASURE

Project Title: Terahertz room-temperature integrated parametric source

Call : FP7-ICT-2009-C

Funding Scheme : Collaborative Project

Deliverable D6.5: Public Progress Report 4

Nature: Deliverable

Due Date: 01/06/2012

Delivery Date: 01/06/2012

Start date of the project: 01/05/2010

Duration: 36 months

Dissemination Level: Public

SEVENTH FRAMEWORK PROGRAMME

www.treasure-project.eu

Specific Targeted Research Project
Grant agreement: 250056
Seventh Framework Programme: FP7-ICT-2009-C4

WorkPackage Number	6
Type of Activity	OTHER
Lead Contractor for this Deliverable	Beneficiary N°1 University Paris Diderot – Paris 7
Due date	Month 24
Actual Submission Date	01/06/2012
Other Beneficiaries involved	-
List of authors	G. Leo, A.S. Réfloc'h,
Revision	Version Number 1
Nature	Report
Dissemination Level	Public

Executive summary

This internal project report consists of six sections, which describe the current state of the active work packages (WP1, WP2, WP3, WP4, WP5, WP6).

WP1: Project Coordination

• WP1 Objectives

WP1 entitled Project coordination is specifically devoted to the Management and Coordination of the TREASURE project.
The objectives of WP1 are the following:

- To ensure the smooth running of the project
- To supervise the global administrative/ financial aspects of the project
- To drive the project targets according to the work plan
- To guarantee information exchanges among all partners

The management activities include the following components:
- Initiating, managing and administering the project in the most efficient manner,
- Ensuring the timely progress of the project with respect to the workplan and contractual commitments,
- Preparing project meetings
- Controlling the scientific and technical quality of the work performed
- Ensuring project reporting to the EC
- Affording a communication channel between the consortium and the EC.

This workpackage is composed of two main tasks:
- Task 1.1: Consortium Steering
- Task 1.2: Scientific and technical management

• WP1 tasks and achievements

• Implementation of the Project Management Structure:

The management structure of TREASURE consists of:

- A Project Coordinator, supported by a part-time Project Manager
- The Committee of the work-package leaders (CWPL)

Since the beginning of the TREASURE project, the project progress has been monitored mainly throughout continuous exchanges among partners, conducted mainly by e-mail but also with bilateral meetings, teleconferences and CWPL meetings.

• The TREASURE mailing lists

Members of University Paris Diderot have implemented internal mailing lists, based on the French open source Sympa mailing list manager. Members of the consortium use these mailing lists for scientific, administrative and coordination issues. The RTD mailing list includes 18 subscribers, and there are regular exchanges between the consortium members via this mailing list. The MGT mailing list has 13 subscribers, including the people involved in the TREASURE project management-related activities. This mailing list is used to inform the partners on all coordination issues and provides administrative or financial information.

- **Conference Calls**

The management team at the University Paris-Diderot has implemented regular Phone conference meetings between all partners since the beginning of the project. In the second half of the project, the frequency of these Skype meetings has been increased to one every two months, in order to discuss the latest results, and enable a closer interaction between all partners in the most crucial part of the project.

- **Quality procedure of the deliverables:**

The TREASURE coordination and management team has reviewed all the reports and deliverables to check the consistency with the project tasks before transmitting them to the European Commission.

This procedure enables the consortium to ensure the quality of deliverables. This quality procedure implies two aspects:

- The scientific quality of the deliverables (soundness of the content and coherence with what is stated in the other deliverables)
- The editorial quality of the deliverables (English and form)

- **The TREASURE Project website:** www.treasure-project.eu

The TREASURE website and intranet objectives are to:

- Ensure a wide information on the project and an efficient dissemination of its results
- Provide specific information on the TREASURE project to four specific target audience:
  - Scientific community
  - General Public
  - Industry - Innovation and Technology Transfer
  - EU Stakeholders – policy-makers
- Provide the Beneficiaries with the appropriate tools to ensure efficient implementation and monitoring of the project throughout its lifetime (intranet).

- **Domain name and hosting:**

The project website and intranet have been registered on a .eu domain by the University Paris Diderot – Paris 7 and can be accessed at http://www.treasure-project.eu

According to article II-12 of the grant agreement, the TREASURE website specifies that the TREASURE project has received funding from the European Union and displays the European emblem, as well as the FP7 and ICT FET OPEN logo.

- **Description of the TREASURE project website:**

The TREASURE website is dedicated to a wide audience and contains general information on the TREASURE project. The user has access to a search tool, links, calendar, and news.

The TREASURE website includes the following sections:

- *TREASURE Homepage*
  This homepage provides general information on the FP7 TREASURE project with a specific presentation for each target audience, linking to the « About TREASURE » page. On this homepage, the following information is also provided: project full title, acronym, start date and duration, project logo, source and level of EU funding.

- *About TREASURE*
  This is a specific section dedicated to the presentation of the TREASURE project to four different target audiences: Scientific community, General public, Industry, EU stakeholders and policy makers. There is a link to a specific page with a short presentation of the TREASURE project adapted to each target audience. This section also includes TREASURE "Latest results and images".

- *TREASURE partners*
  This section is devoted to the presentation of all the organisations taking part to the TREASURE project. This section, with the logos of all partner institutions involved, is devoted to the detailed presentation of each partner organisation, their role in the project and the presentation of the key staff involved in the TREASURE project.

- *Publications*
  This section lists all the relevant publications within the project. This section is regularly updated and contains project-related patents, project presentations, project publications, and related literature in the domain. This publication page also provides the pdf versions of the project presentations and publications (included only after approval from the publisher)

- *TREASURE seminar*
  This section introduces future events to be organised by the TREASURE project and therefore ensures wide dissemination and promotion of the project objectives and results.

- *Links*
  This page lists all the relevant websites linked to the TREASURE project, including CORDIS and FET OPEN.

- *Contact*
  This section allows the audience to contact the Project Coordinator.

Each page includes three boxes indicating the "Hired people" in TREASURE, the "Conferences" and "Industrial exhibits" attended by TREASURE members.

Appropriate resources are devoted by the Coordinator and his management team to ensure that the content remains accurate and up to date at all times.

- **The TREASURE intranet**

The Intranet provides the internal communication medium in the TREASURE project, along with email and conference calls. Only registered users can access the Intranet, the private part of the Website, through secure authentication (login and password). By doing so, they can collect deliverables, reports and other relevant information via an upload/download system.
The Intranet ensures efficient data exchange and information sharing between all the consortium members, as well as easy access to all the relevant documentation for the TREASURE project.

WP2: Design

• WP2 Objectives

This workpackage is dedicated to the design of the TREASURE source, covering both the electromagnetic aspects, QD laser issues and parametric generation of THz radiation. Its objective is to provide solid grounds to WPs 3 to 5.

• Workprogress and achievements during the period

Task 2.1: Electromagnetic simulation of WGMs

This task was closed in month 12.

Task 2.2: THz DFG in AlGaAs microstructures: theory and simulations

Although this task was scheduled to end at month 18, in the days following SRV1, during which we discussed in detail the exploitation of ring-like MRs, UPD and CEA have completed their work on the idea of making use of the hollow part of a ring to gain some control on the frequency of the THz WGMs. The results of this work have been included in the recently registered patent BD13460SG (filed by UPD and CEA) and also in a paper that will appear shortly on Optics Express.

Task 2.3: Modelling and design of the near–IR QD microlaser

This task aimed at dimensioning the QD gain medium so as to ensure lasing operation at room temperature. It has been completed during year 1, and no further effort has been made in year 2.

Task 2.4: Design of dopant/composition profiles for electrical pumping

The purpose of task 2.4 was to provide realistic designs for the TREASURE source, in order to ensure WGM lasing in the near infrared at room temperature and maximise the emitted power for the near-IR microlaser.

During year 1, focus has been put on the design of the dopant and composition profiles, in view of electrical pumping. The results have been presented in the deliverable D2.3 on M12.
Year 2 has been devoted to the study of thermal effects. **Following the recommendations of the review panel on M18, the main objective of this work has been since then a full modelling of the coupled optical, electrical and thermal properties of the near-IR microlasers.** Some delays have been generated by a bug in the commercial software we have used (wrong electrical current unit in the output files). After fixing this problem, reliable simulation results have been obtained from month M22. As shown by this report, the modelling of the microlasers under realistic operation conditions is now fully operational. This work, which has been conducted by the CEA partner, is reported in deliverable D2.4, submitted on M25.

WP3: Micro and Nano-fabrication, WGM lasing performances

• WP3 objectives

The central objective of WP3 is to achieve a high lasing power in the WGM optical modes of the TREASURE source at room temperature under electrical pumping. A high circulating power in the near-IR WGMs is a prerequisite for efficient THz generation by DFG in WP4 and WP5. WP3 requires input from WP2, in which a structure design that optimises the lasing performances (as well as THz generation) is investigated. The work package comprises four subtasks dealing with the epitaxial growth (T3.1), the micro and nanofabrication of the TREASURE source (T3.2), the optical properties of near-IR WGM microlaser (T3.3) and the micro-fabrication of advanced structures and arrays of THz sources (T3.4). In the following we will provide an overview of the progress of work in WP3 towards the objectives of the project.

• Main results achieved during year 2

- Growth of passive layers for flip-chip device fabrication
- Realization of passive WGMs coupled to an access waveguide
- Demonstration of electrically pumped ring lasers with a threshold below 1 mA at room temperature
- Investigation of mode selective structures for two-color laser operation
- Fabrication of arrays of THz resonators for FTIR measurements

• Workprogress and achievements during the period

Task 3.1: Epitaxial growth

With respect to epitaxial growth UW realized a doped AlAs/GaAs microcavity structure with a single layer of InGaAs in the active layer. This structure was optimized for efficient electrical current injection in high-Q whispering gallery mode (WGM) lasers (cf. Task 3.2 and Task 3.3). Moreover, to achieve room temperature operation of the WGM lasers UW grew test samples with different designs for improved carrier confinement in the quantum dots. Best results in terms of activation energy have been obtained for PCA (partial GaAs capping and annealing) InGaAs quantum dots. The activation energy could be increased from 15 meV for standard InGaAs QDs up to 66 meV for the PCA QDs. Future work will focus on a further improvement of the carrier confinement in the QDs and the growth of microresonator structures for WGM lasers operating at enhanced temperatures. In addition, WU will grow test samples based on design inputs from WP2.

At CEA, a carbon cell has been added to the existing MBE setup in order to provide p-doped GaAs structures. All measurements performed on a first series of electrically contacted samples allowed us to calibrate the deposition parameters. Combined with the Si cell, this now allows us to grow both p-doped and n-doped samples with a high accuracy on the dopant concentrations.

Task 3.2: Micro and nanofabrication

In order to obtain two-color lasing with a defined spacing between the modes, mode selective elements which suppress unwanted modes have to be introduced in the resonator. The approach investigated at UW relies on increasing the losses of undesired modes by inserting notches at specific locations at the ring circumference. Modes with an even number of nodes will not be affected by the notches, but modes with an uneven number of nodes will have a maximum of the standing wave at one node, leading to increased losses. In effect, every second mode in the laser spectrum will be suppressed. Adding more notches to the ring, additional modes can be suppressed, eventually resulting in a two-color laser spectrum.

Task 3.3: Optical properties of the near-IR WGM microlaser

Characterization of electrically pumped ring lasers was carried out on a temperature controlled heat sink. The top (p-contact) metallization was contacted with a probe needle, the light output of the laser was picked up by an optical fiber. Rings with diameters of 80µm and 40µm, and ring widths ranging from 10µm to 1µm were investigated.

Task 3.4: Microfabrication of advanced structures: arrays of THz sources

In view of finding the good mode triplets (2 near infrared and 1 THz) for non linear THz generation, an experimental characterization of the THz resonances is highly desirable. THz spectroscopy can be done using a THz FTIR spectrometer available at Univ. Paris Diderot.

WP4: Nonlinear optical characterization

• WP4 Objectives

This experimental work package is dedicated to the nonlinear optical characterisation of MR THz sources. Its final objective is the demonstration of an electrically pumped, coherent THz source op-erating at 300K, obtained through intra-cavity DFG involving WGM modes.

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• Workprogress and achievements during the period

Task 4.1: THz DFG in passive AlGaAs microstructures

The main purpose of this task is to assess the basic features of CW THz DFG in a MR containing no QDs and working at room temperature. After completing the experimental set-up already described in D1.3, the work we performed from month 18 has consisted in the linear characterization - both in the near-IR and in the THz - of the passive samples sent by CEA and UW. For the linear characterization in the THz, part of the work has been carried out in collaboration with DTU during a visit of Ph.D. student Silvia Mariani.

Task 4.2: THz DFG in an active MR: optical pumping

This task was canceled.

Task 4.3: THz DFG in an active MR: electrical pumping

Active microresonators have yet to be fabricated so that, at the moment, no result is available.

WP5: Source optimisation and evaluation of other application prospects

- ## WP5 Objectives

The aim of this work package is to optimise the out-coupling of the THz radiation from the TREASURE device into free space, to explore its multi-spectral operation, and to investigate its use as a room-temperature detector.

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- ## Workprogress and achievements during the period

➢ **Task 5.1: TREASURE source optimisation & encapsulation**

we can highlight the main results of the period by

- Detailed and precise eigenmode analysis of modified microring design
- New simulation method for verification of experimental results
- Fabrication-ready design for the first TREASURE device
- A discussion of fundamental aspects of array configurations
- Encapsulation of TREASURE device

➢ **Task 5.2: DTU Realisation of 2D array emitters**

This task will start in year 3

➢ **Task 5.3: Feasibility study of a MR coherent THz detector**

This task will start in year 3

WP6: Dissemination and exploitation

• WP6 objectives

The aim of this work package is twofold. On the one hand, it will ensure broad and open dissemination of project results, identifying opportunities to publicise the achievements and capabilities that will be developed, with a potential public in academia, industry, and the wider European and International public. On the other hand, it will ensure an effective and timely exploitation of the technologies and capabilities that will be developed. The work package will attract some out-of-field interest from application areas or groups that the systematic review may not have uncovered. Finally, it will pursue general image benefits for both the Beneficiaries and the overall FP7 FET programme.

• Work progress and achievements during the period

Task 6.1 Exploitation, technological transfer and IP Management

The preliminary marketing research for possible application of the TREASURE device showed that the unique selling points (USP) is compactness, low power requirements, narrow spectral line width and room temperature operations. As requested by the Commission, Alpes Lasers has pursued its efforts to identify and refine the application requirements for low-power TREASURE emitters.

Task 6.2 Dissemination

Patents

- J. M. Gérard, J. Claudon, M. Munsch, G. Leo, A. Andronico, “Dispositif laser d'émission d'onde Térahertz à structure trouée”, patent BD13460SG.

Publications

- A. Andronico, J. Claudon, M. Munsch, I. Favero, S. Ducci, J. M. Gérard, G. Leo, “Quantum-dot based nonlinear source of THz radiation”, Proceedings of SPIE, Paper 8119-22 (2011).

- G. Leo, J. M. Gérard, S. Reitzenstein, P. U. Jepsen, “Towards a THz Terahertz room-temperature integrated parametric source”, Procedia Computer Science 7, 205-206, Elsevier (2011).

- A. Andronico, S. Mariani, F. Ghiglieno, J. Claudon, M. Munsch, J. M. Gérard, I. Favero, S. Ducci, and G. Leo, “Tuning of a Nonlinear THz Emitter”, submitted to Optics Express.

- K. Iwaszczuk, A. Andryieuski, A. Lavrinenko, X. C. Zhang, and P. U. Jepsen, "Terahertz field enhancement to the MV/cm regime in a tapered parallel plate waveguide," Opt. Express 20, 8344-8355 (2012)

- M. Munsch, J. Claudon et al., “Room temperature, continuous wave lasing in microcylinder and microring quantum dot laser diodes”, Appl. Phys. Lett. 100, 031111 (2012)

Presentations

- M. Munsch, “Room temperature continuous-wave lasing in microcylinder and microring quantum-dot laser diodes”, SPIE Photonics Europe 2012, April 16-19th 2012, Brussels, Belgium

- M. Munsch, “ Room temperature, continuous-wave lasing in microcylinder and microring quantum-dot laser diodes”, 7th International Conference On Quantum Dots (QD 2012), May 13-18, 2012, Santa Fe, New Mexico, USA, (Poster Presentation)

- G. Leo, J. M. Gérard, S. Reitzenstein, P. U. Jepsen, “Towards a THz Terahertz room-temperature integrated parametric source”, FET11, 4-6 May 2011, Budapest, Hungary. (poster)

- A. Andronico, J. Claudon, M. Munsch, I. Favero, S. Ducci, J. M. Gérard, G. Leo, “Quantum-dot based nonlinear source of THz radiation”, SPIE Optics + Photonics 2011, 21-25 August 2011, San Diego, CA, USA. (invited oral)

- S. Mariani, F. Ghiglieno, A. Andronico, I. Favero, S. Ducci, Y. Todorov, C. Sirtori, M. Kamp, M. Munsch, J. Claudon, J. M. Gérard, and G. Leo, “Optical Characterization of AlGaAs Nonlinear THz Emitters”, GDR-I 2012 THz Workshop, 24-27 April 2012, Tignes, France. (poster)

- S. Reitzenstein, Invited talk on “Nonlinear optical processes in high quality quantum dot micropillar systems” FOPS (Fundamental Optical Processes in Semiconductors), 30.07.-06.08.2011, Lake Junaluska, USA.

- F. Albert, Talk on “Room temperature, continuous wave lasing in microcylinder and microring quantum dot laser diodes” Spring meeting of the German Physial Society, 26.03.-30.03.2012, Berlin, Germany.

- J.M. Gérard, A. Andronico, F. Ghiglielmo, G. Leo, S Reitzenstein, S. Höfling, J. Claudon, M. Munsch, N.S. Malik, P. Jaffrennou,” A novel microcavity parametric source of THz radiation” (poster presentation), International Conference on Modulated Semiconductor Structures (MSS 15), July 2011, Tallahassee, USA

Conferences (to be held, but for which a paper has been already accepted)

- S. Mariani, F. Ghiglieno, A. Andronico, I. Favero, S. Ducci, Y. Todorov, C. Sirtori, M. Kamp, M. Munsch, J. Claudon, J. M. Gérard, and G. Leo, “Linear Characterization of THz DFG Emitters”, 3rd EOS Topical Meeting on Terahertz Science & Technology (TST 2012), 17-20 June 2012. (poster)

- S. Mariani, F. Ghiglieno, A. Andronico, I. Favero, S. Ducci, S. Reitzenstein, M. Kamp, M. Munsch, J. Claudon, J. M. Gérard, and G. Leo, “Optical Characterization of Nonlinear THz Emitters”, Nonlinear Photonics, 17-21 June 2012, Colorado Springs, CO, USA. (poster)

Participation to industrial exhibits

- Pittcon 2012, Orlando, FL from 11 March to 15 March 2012. Major new products and technologies in the field of analytical and laboratory instruments. (Olivier Landry)

- Laser Applications to Chemical Security and Environmental (LACSEA), 29 January - 1 February 2012, Rancho Bernardo Inn, San Diego, California, United States (Olivier Landry)

- SPIE Defense Security & Sensing, "International Defense, Security & Sensing Exhibition", April 23-27 2012, Baltimore, United States (Antoine Muller)

- Swiss NanoConvention 2012, “the prime showcase for nanotechnology in Switzerland”, Lausanne May 23rd 2012, Lausanne, Switzerland (Michel Rochat)

Other actions

- The technology offer (TO) “Ultra-miniaturized room temperature electrically driven continuous wave THz source for mobile and compact applications”, ref. 12 CH 84FB 3NZQ, was published on January 27th on the Enterprise Europe Network (EEN) database. Action done in collaboration with Alliance, the Industrial liaison program of Western Switzerland Universities in Lausanne.

- Successful R&D in Europe 4th European Networking Event, 8-9 March 2012 in Düsseldorf. The technology offer concerning TREASURE was selected by the national EEN to be promoted during the event “successful R&D in Europe” in Düsseldorf. The abstracts of the profiles were printed incl. the reference number that one could avulse (like the phone numbers of private advertisement in the supermarket). All profiles hanged up on thematic panels. Event participant could avulse the reference number, staple it on their business card and leave it in a box.

Contact

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