

TREASURE



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Dissemination Level: PU



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Specific Targeted Research Project

Grant agreement: 250056

Seventh Framework Program: FP7-ICT_2009-C4

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Other Beneficiaries involved	CEA - UW - DTU - AL
List of authors	G. Leo – A. S. Réfloc'h
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WP1: Project Coordination

• *WP1 Objectives*

WP1 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 work plan and contractual commitments,
- Preparing project meetings
- Controlling the scientific and technical quality of the work performed
- Ensuring project reporting to the European Commission
- Affording a communication channel between the consortium and the European Commission.

This work package is composed of two main tasks:

- Task 1.1: Consortium Steering
- Task 1.2: Scientific and technical management



- **Work progress and achievements during the period**

➤ **Implementation of the Project Management Structure:**

The management team has monitored the compliance by beneficiaries with their obligations under the TREASURE grant agreement.

Continuous Progress Monitoring: so far, besides the Kick-off and the CWPL meeting, the project progress has been monitored throughout continuous exchange among the partners conducted mainly by emails, but also with bilateral meetings and regular conference-call meetings.

➤ **Setting up of communication tools:**

- **TREASURE Website:** www.treasure-project.eu
- **TREASURE Intranet and mailing lists**

➤ **TREASURE Deliverables:**

During the first 30 months of the project, 39 deliverables have been produced in due time.

➤ **TREASURE Milestones:**

TABLE 2. MILESTONES							
Milestone no.	Milestone name	Work package no.	Lead beneficiary	Delivery date from Annex I dd/mm/yyyy	Achieved Yes/No	Actual / Forecast achievement date dd/mm/yyyy	Comments
MS1	WGM lasing of optically pumped MRS at 300K	3	UW	Month 18 (28/10/11)	Yes	Month 15	
MS2	Low threshold WGM lasing in electrically pumped MRs at 300k	3	CEA	Month 24	Yes	Month 25	Threshold < 1 mA
MS4	THz emission from electrically pumped MRs at 300K	4	UPD	Month 30	No	Month 36	



➤ **Project meetings dates and venue:**

The TREASURE consortium met according to the schedule planned in annex I of the Grant Agreement, stating that the CWPL meetings will occur every six months:

- Kick-Off Meeting: May 25, 2010 in Paris, France, with representatives from all partners organizations
- The first CWPL meeting was held on November 3, 2010, in Würzburg, Germany, with representatives from all partners organizations
- A bilateral meeting was held on March 29-30, 2011, in Copenhagen, Denmark, with representatives from DTU and UPD.
- Three bilateral phone meetings were held on March 17, April 15 and May 3, 2011, between representatives from CEA and UW.
- A Video Conference was held on May 11, 2011. This videoconference focused on scientific work progress. Members of CEA, DTU, UW and UPD attended this videoconference, which was headed by the project coordinator.
- A bilateral meeting was held on June 15, 2011, in Paris, France, with representatives from UPD and DTU.
- The month-12 CWPL meeting took place on June 23, 2011, in Brussels, Belgium, with representatives from all partners' organizations.
- The first Technical project review was held on June 24, 2011, in Brussels, Belgium.
- A bilateral meeting was held on October 21, 2011, in Grenoble, France, with representatives from UPD and CEA.
- The month-18 CWPL meeting took place on November 10, 2011, in Brussels, Belgium, with representatives from all partners' organizations.
- The first special EC review meeting was held on November 11, 2011, in Brussels, Belgium.
- Skype meeting between representatives from UPD, CEA and UW, on December 11, 2012.
- A bilateral skype meeting was held on March 6, 2012 between UPD and CEA.
- A skype meeting between representatives from UPD, CEA and UW, was held on March 12, 2012.



- TREASURE PhD student from UPD stayed at DTU from April 5 to April 11, 2012 for an experimental activity and scientific exchange.
- A bilateral meeting was held on April 10 2012, in Copenhagen, Denmark with representatives from UPD and DTU.
- A bilateral skype meeting was held on April 30, 2012 between UPD and DTU.
- Bilateral phone meetings with representatives from AL and DTU on March, April and May 2012.
- Bilateral phone meetings with representatives from AL and UPD on December 2011, April and May 2012.
- The month-24 meeting took place on June 21, 2012, in Brussels, Belgium, with representatives from all partners' organizations.
- The second Technical project review was held on June 22, 2012, in Brussels, Belgium.
- Bilateral phone meetings with representatives from UPD and CEA in September and October 2012.
- Bilateral phone meetings with representatives from UPD and UW in September and October 2012.
- A two-day videoconference was held on September 4-5, 2012, and it focused on finalizing the GANNT chart for the last year. Members of CEA, DTU, UW, AL and UPD attended this videoconference, which was headed by the project coordinator.
- A videoconference was held on September 18, 2012, and it focused on scientific work progress. Members of CEA, DTU, UW, AL and UPD attended this videoconference, which was headed by the project coordinator.
- A videoconference was held on September 20, 2012, and it focused on finalizing the preparation of the revised deliverables. Members of CEA, DTU, UW, AL and UPD attended this videoconference, which was headed by the project coordinator.
- The month-30 meeting will take place on November 14, 2012, in, Kongens Lyngby, Denmark, with representatives from all partners' organizations.
- The second special EC review meeting will be held on November 15, 2012, in Kongens Lyngby, Denmark.



➤ **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
- The editorial quality of the deliverables

➤ **Summary of results towards fulfillment of MS4:**

The main contribution of semester 5 is related to the marked improvement of thermal dissipation (metallic bonding + p side down bonding, see master document). Thanks to this, and despite the high series resistance of the structure (with the related Joule effect), now we expect a weak heating (+35K) and a microlaser operation mode-hopping free up to the working point. Moreover, this small temperature increase allows us to take into account its effect on the mode frequency and possibly counterbalance it for phase-matching purposes.

WP2: Design

- ***WP2 Objectives***

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

- ***Work progress and achievements during the period***

➤ **Task 2.1 Electromagnetic simulation of WGMs**

This task was closed at month 12.



➤ **Task 2.2 THz DFG in AlGaAs microstructures: theory & simulations**

This task was initially scheduled to end at month 18, but it has been extended so that UPD could complete the work on ring-like MRs before SRV2. This work resulted in a joint patent filed by CEA and UPD, and in a paper published in Optics Express during the reporting period (A. Andronico et al, Opt.Exp. 20, 17678, 2012).

➤ **Task 2.3 Modeling & design of 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 maximize 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 modeling 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 that we have used. After fixing this problem, reliable simulation results have been obtained from month M22. A first version of deliverable D2.4, submitted on M25, showed that the modeling of the microlasers under realistic operation conditions was fully operational.

A few aspects of the work performed since M24 are worth being highlighted at this stage.

- **Heat sinking :**
- **Vertical design :**

Conclusion

The additional modeling effort performed within WP2 since M24 has provided solid grounds for the final part of the project. The vertical design presented in the Master document, combined with a novel heat sinking geometry, should provide a stable WGM lasing without mode jumps up to the operating point of the TREASURE device. A total emission in the near IR around 20 mW can be achieved. Assuming Q factors in the 10^5 range for the near IR WGMs, we predict a CW THz output power around 10 nW.



WP3: Micro and Nano-fabrication, WGM lasing performances

- **WP3 objectives:**

The central objective of WP3 is to achieve 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 indeed a prerequisite for efficient THz generation by DFG in WP4 and WP5. WP3 requires an input from WP2, in which a structure design that optimizes the lasing performances (as well as THz generation) is investigated.

- **Work progress and achievements during the period**

- Task 3.1 Epitaxial Growth
- Task 3.2 Micro- and Nanofabrication
- Task 3.3 Optical properties
- Task 3.4 Microfabrication of advanced structures: arrays of THz sources

WP4: Nonlinear optical characterization

- **WP4 objectives**

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

- **Work progress and achievements during the period**

- Task 4.1: THz DFG in passive AlGaAs microstructures

The experimental work performed during Year 2 has focused on the linear characterization of passive micro-cylinders in order to test our modeling tools and validate the material parameters used in the simulations. In order to investigate the spectral features of the cavities in the two frequency ranges of interest (near-IR for the pump fields and THz for the difference-frequency field), different measurements have been performed. For the study in the telecom range, the micro-pillars were integrated with waveguides for distributed coupling and characterized via transmission measurements. In the THz range we measured reflectivity spectra on 2D arrays of identical pillars.



➤ **Task 4.3: THz DFG in an active MR: electrical pumping of the QDs**

The first active micro-resonators have been fabricated by UW at the end of month 30. Their nonlinear characterization is expected to start within the first two weeks of month 31.

WP5: Source optimization and evaluation of other application prospects

- **WP5 objectives**

The aim of this work package is to optimize 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.

- **Work progress and achievements during the period**

➤ **Task 5.1: Optimization and encapsulation of the TREASURE source**

The initial planned development timeline for the encapsulation of the TREASURE device was the following:

1. TREASURE integration process development and optimization:

Formerly planned to end by March 2012, this work will resume when the consortium validates the final design, which is expected to occur during November 2012, to be able to handle and assemble dummy samples on the carrier when available.

2. TREASURE Packaging Concept:

Following the integration strategy, two alternative assembly concepts have been proposed: the integration of the TREASURE device with the grating, and the device without the grating.

3. Design of host substrate and validation of 3D structuring (substrate, antenna, encapsulation): Initial planning for this task: September 2012.

4. Fabrication of the host substrate: November 2012

The procurement of the carrier is still pending on the validation of the design and the specifications.



5. **Assembly and encapsulation of working dummies and characterization of the packaged mock-up:** end of March 2013

6. **Assembly and characterization of the TREASURE device:** end of May 2013

➤ **Task 5.2: Realization of 2D arrays emitters**

No work carried out on this in the present period, except the results presented in deliverable D5.2. Additional work will be carried out in M31-36.

➤ **Task 5.3: Feasibility study of MR-based coherent THz detector**

No work carried out on this task in the present period. Work will be performed as planned in M31-36.

➤ **Ad hoc Task: Optical characterization of doped AlGaAs thin films**

Transmission properties of 2 μm thick AlGaAs films with different n- and p-type doping levels were characterized by ultra-broadband THz time-domain spectroscopy (samples grown at UW).

WP6: Dissemination and exploitation

- ***WP6 objectives***

The aim of this work package is twofold. On the one hand, it ensures broad and open dissemination of project results, identifying opportunities to publicize 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 program.

- ***Work progress and achievements during the period***



➤ **Task 6.1 Exploitation, technological transfer and IP management**

The strategy presented in the exploitation plan is the development of *an integrated THz system* that will allow instrument companies to offer an *affordable THz platform* specifically designed for material research. As the aim is to offer a THz platform to instruments companies with the necessary support to develop high value tools, we have pursued the actions of identifying and contacting scientist and companies potentially interested with these objectives.

➤ **Task 6.2 Dissemination**

Presentations and participation to industrial exhibits

- 3rd EOS Topical Meeting on Terahertz Science & Technology (TST 2012), June 17th-20th, Prague, Czech Republic (Olivier Landry, Peter Jepsen, Giuseppe Leo, Silvia Mariani): Paper title: Linear Characterization of THz DFG Emitters, Paper number: poster TST2012_5283_005 
- Nonlinear Optics, 17-21 June 2012, Colorado Springs (Colorado), United States (Alessio Andronico), Paper title: Optical Characterization of Nonlinear THz Emitters, Paper number: poster JM5A.16
- International Quantum Cascade Lasers School & Workshop 2012, September 2nd-6th, Baden bei Wien, Austria (Romain Terazzi)
- Future Security, Security Research Conference, September 4th – 6th, Bonn, Germany (Antoine Muller),
- The 37th International Conference on Infrared, Milimeter and Terahertz Waves (IRMMW-THz), September 23rd-28th, Wollongong, Australia (Olivier Landry, Peter Jepsen)
- NLO 50 International Symposium, 8-10 October 2012, Barcelona, Spain (Giuseppe Leo), Paper title: AlGaAs micropillars for THz DFG, Paper number: oral TO.6
- IEEE International Semiconductor Laser Conference San Diego, USA, October 7-10, 2012 (Martin Kamp), Paper title: Room Temperature, Continuous Wave Lasing in Microcylinder and Microring Quantum Dot Laser Diodes, Paper Number: TuC2

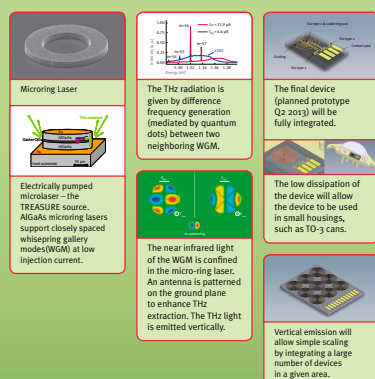


TREASURE



TREASURE is a project funded by the European Commission within the Seventh Framework Programme (FP7) under ICT FET OPEN scheme. This project will demonstrate a radically new continuous-wave, electrically pumped terahertz emitter. Compared to existing THz sources, the TREASURE source will bring together several crucial advantages that are far from being simultaneously available in any existing source today:

- › compact size
- › room-temperature operation
- › output power scalable up to the microwatt range
- › custom emission frequency from 1 to 5 THz
- › spectral purity
- › feasibility of multi-spectral array of emitters
- › perspective of coherent detection schemes



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Fig. 6.1 Poster featuring TREASURE at TST 2012,

Other actions

- Different potential end users have been contacted and Alpes Lasers has started to collect “dream specifications”. The aim is to distill the needs of potential users to inform the final specifications of the product.
- The TREASURE workshop planned in the last semester of the project will take place in the form of a session dedicated to electrically-injected nonlinear THz emitters at 300K, within the 7th Terahertz days and GDR-I workshop to be held in Cargèse, Corsica, France, from the 25th to the 27th of March 2013. The conference organizers have accepted that we take in charge about 6 talks (2 invited and 4 orals). Other details about the conference can be found on the website <http://www.lob.polytechnique.fr/thzdays>.



Conclusion and outlook of future work

All delays encountered since month 24 were due to equipment-related problems and not to fundamental roadblocks. The time left until the end of the project is still sufficient to perform a couple of process iterations for the final design of the TREASURE device.

Since the last review at month 24, the TREASURE consortium has made important progress towards its final goal, and this within all active WPs.