**Deliverable 10.1**

**WP10 Final Report (period 01/01/2021-31/12/2022):**

**Frequency Conversion in Microresonator with Chi(2) Nonlinearity**

Date: 27 June 2022

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Project acronym: MICROCOMB

Project website: <https://www.microcomb-eu.org/>

Project full title: Fundamentals and Applications of Microresonator Frequency Combs

Project start date: January 2019

Actual submission date: …

Work Package: WP10 – Report

Type: Report

Dissemination Level: Public

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| **Version** | **Date** | **Released by** | **Comments** |
| **0.1** | 27/06/2022 | Joanna Łucyszyn | First draft - circulated internally to beneficiaries involved in tasks |
| **0.2** |  | Final draft circulated to the Consortium, including WP Leaders, for feedback |
| **1.0** |  | Final version with the Consortium’s input |

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| **Lead Beneficiary** | 1. University of Bath (BATH) | |
| **Collaborating Partners** | 1. École polytechnique fédérale de Lausanne (EPFL) 2. NPL Management Limited (NPL) - TERMINATED 3. Chalmers Tekniska Hoegskola AB (CUT) 4. Universiteit Gent (UGent) 5. Universitat Politecnica de Valencia (UPV) 6. Karlsruher Insitute Fuer Technologie (KIT) 7. Menlo Systems GmbH (MENLO) 8. Max-Planck-Gesellschaft Zur Feorderung De Wissenschaften EV (MPQ) (Institute for Quantum Optics (MPQ)) & (Institute for the Science of Light (MPL)) 9. Kungliga Tekniska Hogskolan (KTH) 10. Albert-Ludiwigs-Universitaet Frieburg (FRB) 11. IBM Research GmbH (IBM) | |
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# **Work package summary**

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| **MICROCOMB WP10 Report**  Work package title: ***Frequency conversion in microresonator with chi(2) nonlinearity*** | | |
| **Beneficiary** | **Principal Investigator** | **ESR number according to the GA**  [**ESR numbering explained**](https://www.microcomb-eu.org/esr-numbering) |
| 1 – BATH | D. Skryabin | ESR N°1 – Mr Zhiwei Fan  ESR N° 2 - Mr Vladislav Pankratov; |
| 10 – KTH | K. Gallo | ESR N°12 – Mr Halvor Rogers Fergestad |
| 11 – FRB | K. Buse & I. Breunig | ESR N°14 – Mr Nicolás Amiune |
| 12 – IBM | P. Seidler | ESR N°15 – Mr Alberto Nardi |
| **Lead Beneficiary** | 11 – FRB / K. Buse & I. Breunig | |

# **Partner progress on tasks in Work Package 10**

|  |  |  |
| --- | --- | --- |
| ***Milestones*** | ***Milestone title*** | ***Means of verification*** |
| ***MS3 (BATH)*** | *ESRs 1 & 2 have numerical codes for modelling of comb solitons and comb generation in the experimental schemes developed by consortium* | *ESRs 1,2 have numerical codes for modelling of comb solitons and comb generation in the experimental schemes developed by consortium* |
| ***MS4***  ***(EPFL)*** | *Demonstration of octave spanning dual dispersive wave comb spectra, solitons and low phase noise microwaves on SiN and GaP platforms* | *ESRs 1,2 have numerical codes for modelling of comb solitons and comb generation in the experimental schemes developed by consortium* |
| ***MS10***  ***(MENLO)*** | *Operational and characterised microring resonator for generation of a visible, broadband and flat spectrum with mode spacing > 10GHz suitable for integration into AstroComb module; design of the module* | *Operational and characterised microring resonator for generation of a visible, broadband and flat spectrum with mode spacing > 10GHz suitable for integration into AstroComb module; design of the module* |
| ***MS11 (KTH)*** | *Demonstration of supercontinuum generation in quasi-phasematching (QPM) LNOI waveguides; fabrication and characterisation of microresonator samples* | *demonstration of frequency*  *stabilized dual-comb*  *with counter-propagating*  *waves, multi-heterodyne*  *measurements and designs for*  *spectroscopy experiments* |
| ***MS13 (FRB)*** | Design and fabrication of AgGaSe2, CdSiP2 microresonators, demonstration of chi(2) frequency conversion (sum frequency, second harmonic); measuring cascading (effective chi(3)) nonlinearity; preliminary comb observations | Design and fabrication of AgGaSe2, CdSiP2 microresonators, demonstration of chi(2) frequency conversion (sum frequency, second harmonic); measuring cascading (effective chi(3)) nonlinearity; preliminary comb observations |

## **Task 10.1 Fabrication of low-loss microresonators based on bulk non-oxide crystals**

**Beneficiaries and partners involved in the task: ESR 14 (FRB)**

[***Milestones met***](#_Partner_progress_on)***:***

Publications:



Please complete this [Dissemination and communication spreadsheet](https://drive.google.com/drive/folders/1olgxot8mwzAmIHA6vsDjBbLBKZyKNzqg?usp=sharing) for your individual project

Please complete the [secondments google sheet](https://docs.google.com/spreadsheets/d/1-eNy0gbfJLk2rj-iqzO2CyLso6uCpvEb/edit#gid=1369407323) and if the secondment didn’t take place please provide the justification in the column “L”.

## **Task 10.2 Investigation of cascaded second order nonlinearities and optimization regarding efficiency, broadband output, and coherence properties**

**Beneficiaries and partners involved in the task: ESR 14 (FRB); ESR 2 (BATH); ESR 15 (IBM); ESR 12 (KTH), TOPTICA**

The objectives of this tasks are to demonstrate microcombs based on second-order nonlinearities

**ESR 14 (FRB):**

**ESR 2 (BATH):**

**ESR 15 (IBM):**

**ESR 12 (KTH):**

[***Milestones met***](#_Partner_progress_on)***:***

Publications:



Please complete this [Dissemination and communication spreadsheet](https://drive.google.com/drive/folders/1olgxot8mwzAmIHA6vsDjBbLBKZyKNzqg?usp=sharing) for your individual project

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## **Task 10.3 Design of electrode structures and implementation of electro-optic tuning**

**Beneficiaries and partners involved in the task: ESR 14 (FRB); ESR 12 (KTH);**

The objectives for this task are to demonstrate electro-optic tuning and stabilization of microcombs

**ESR 14 (FRB):**

**ESR 12 (KTH):**

[***Milestones met***](#_Partner_progress_on)***:***

Publications:



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## **Task 10.4 Benchmark with state-of-the-art chi(3)-based comb**

**Beneficiaries and partners involved in the task: ESR 14 (FRB); ESR 12 (KTH); TOPTICA**

**ESR 14 (FRB):**

**ESR 8 (KTH):**

[***Milestones met***](#_Partner_progress_on)***:***

Publications:



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Please complete the [secondments google sheet](https://docs.google.com/spreadsheets/d/1-eNy0gbfJLk2rj-iqzO2CyLso6uCpvEb/edit#gid=1369407323) and if the secondment didn’t take place please provide the justification in the column “L”.

## **Task 10.5 Prediction, demonstration and interpretation of two-frequency combs**

**Beneficiaries and partners involved in the task: ESR 14; (FRB); ESR 12 (KTH); ESR 2 (BATH);**

Objectives for this task are to develop a numerical model and theory of microcomb generation due to χ(2) effects

**ESR 14 (FRB):**

**ESR 12 (KTH):**

**ESR 2 (BATH):**

[***Milestones met***](#_Partner_progress_on)***:***

Publications:



Please complete this [Dissemination and communication spreadsheet](https://drive.google.com/drive/folders/1olgxot8mwzAmIHA6vsDjBbLBKZyKNzqg?usp=sharing) for your individual project

Please complete the [secondments google sheet](https://docs.google.com/spreadsheets/d/1-eNy0gbfJLk2rj-iqzO2CyLso6uCpvEb/edit#gid=1369407323) and if the secondment didn’t take place please provide the justification in the column “L”.