Project Closure
December 2018

Project Reference
644039

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1st of February 2015

End Date
31st October 2018

Duration
48 months

Project Total Costs
€ 4.255.743,75

EU Contribution
€ 3.742.961,25

Project webseite
www.m3tera.eu

Consortium
7 partners (4 countries)

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M3TERA

MICROMACHINED TERAHERTZ SYSTEMS

A new heterogeneous integration platform enabling the commercialization of the THz frequency spectrum

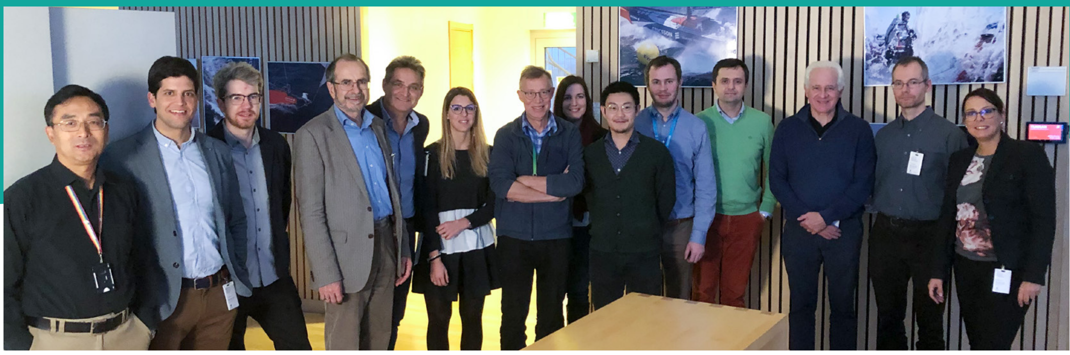
Message from the Coordinator

M3TERA: Project complete!

A Final Review Meeting in November 2018 marked the successful completion of the M3TERA project. The results are ready for dissemination. The final evaluation of the Telecom Prototype became available; it describes the assembly of D-band front-end modules and the test results for the successful demonstration. In addition, an overview of the most recent publications and conference is provided.

Successful Final Review Meeting at Ericsson in Gothenburg

The final M3TERA Review Meeting was held on November 29 at Ericsson in Gothenburg, Sweden. Joachim Oberhammer, the scientific leader, started the meeting with an overview of the main achievements, highlights and the overall impact of the project. The WP leaders then presented their most significant results, achievements and difficulties they had to overcome. The meeting closed with feedback from the reviewers and a final wrap-up.

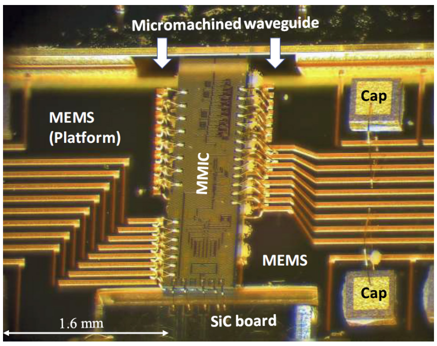


Final Evaluation of the Telecom Prototype

The M3TERA consortium finalized the development of the final telecom prototype and reported its measured performance based on the test carried out at module, radio and link level. Four complete modules were first assembled and tested. While failure analysis and debugging were carried out to identify the root-cause, two other tracks were taking in parallel: 1) reparation of the four fault modules; and 2) assembling additional modules. Now both tracks have turned out to be successful and led to positive measured results.

Mounting the passive components on to the PCBs started in September. Automatic assembly of the MMICs, Si platform, SiC and the PCBs was carried out in end of September and continued till beginning of October. The four D-band modules were completely assembled and wire-bonded by October and were delivered to Ericsson Lindholmen for test.

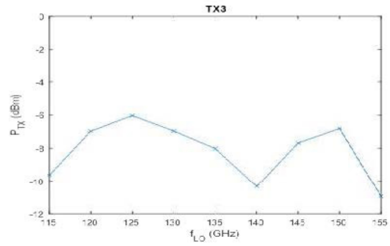
The following figure is a photo showing a Tx MMIC assembled and wire-bonded to a MEMS chip (the Platform) which is assembled on a metal fixture. The MMIC is partially inserted into the micromachined waveguide and is wire-bonded as well with a SiC board. What can be seen also are two chip capacitors at the right used for RF by-pass (grounding).



An assembled platform and a MMIC wire-bonded to the platform. The MMIC is inserted partially into the micromachined waveguide and wire-bonded as well with a SiC board.

Module measurement

Module test started immediately when Ericsson received the modules. Characterized first was a new Tx module, Tx3, produced in Track #3. When it was powered up, DC current and voltage behaved as expected. Its RF output power was measured with a D-band power meter and the results were plotted.

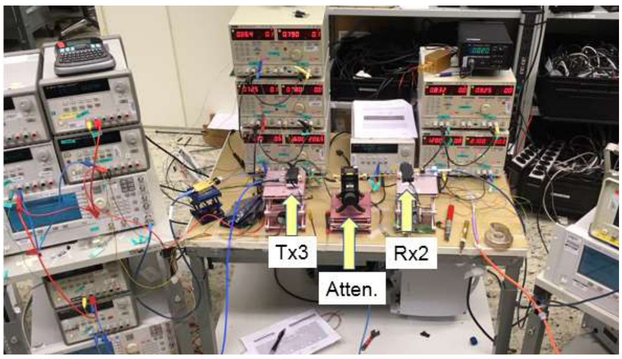


Measured output power vs LO frequency for Tx3 module (IF=1.5 GHz)

The output power of -6 dBm is obtained at 125 GHz. The dip round 140 GHz is believed due to the transition between the MEMS open waveguide and the metal waveguide. According to the original transition design, the MEMS chip should have a shape as shown in Figure "MEMS-to-metal waveguide transition" to suppress leakage, while in reality the MEMS chip used in Tx3 has a straight sidewall, because it was a cut-out from a chip not intended for this purpose.

Link test (continuous wave)

As the MEMS platform in module Rx3 has also a straight sidewall at the open waveguide, Rx2 was chosen to pair with Tx3 for initial link test. Rx2 is a repaired module and has the desired MEMS-to-metal waveguide transition.
The Rx2-Tx3 pair were connected first through a D-band attenuator using metal waveguides.Continuous wave was used to see whether any IF signal might be detected at the receiver.



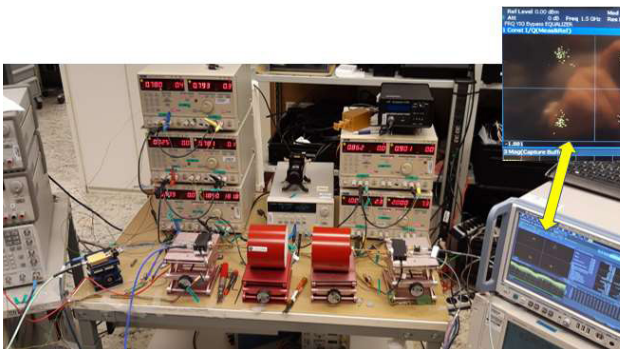
Test setup for the first link test. Tx3 and Rx2 are connected with a D-band attenuator

Link test (modulated signal)

To further test the link, an arbitrary waveform generator (AWG) was used as a source providing a modulated IF signal. A signal-and-spectrum analyzer (SSA) was used to detect the data at the received IF. When QPSK modulation is used, the link worked.

In brief summary, the output power of a Tx module is measured over the D-band, the received IF signal is detected when the Tx module is paired with a Rx module. Data transport using 16-QAM and 32-QAM modulated signals is successfully demonstrated using both waveguide interface and antennas (over-the-air) in the test setup.

A mmW D-band radio link, based on the SiGe MMICs mounted on the micromachined silicon platform, has been successfully demonstrated using the antennas developed by M3TERA. Data transport over the link has been verified using 32 QAM. Although detailed measurement is necessary to further characterize the radios and the link, we can conclude that the interconnect and package solution based on the 3D micromachined technology works. Quantitative comparison with existing technology will require a full characterization of the demonstrator in terms of cost and performance.



OTA link test using QPSK modulation

"One of the biggest challenges of this project was to align the research driven mentality with that of industry to produce a working prototype in the end. Despite the challenges, the project goal of building a micromachined prototype terahertz communication platform was achieved. Using this project as a model in the future, we can build cheaper and more efficient systems using terahertz frequencies."

Resume of the M3TERA scientific leader, Joachim Oberhammer

Publications

(1) Feasibility of Remote Vital Signs Sensing with a mm-Wave CW Reflectometer (April 2018)
Vorobyov Alexander, Daskalaki Elen, Farserotu John

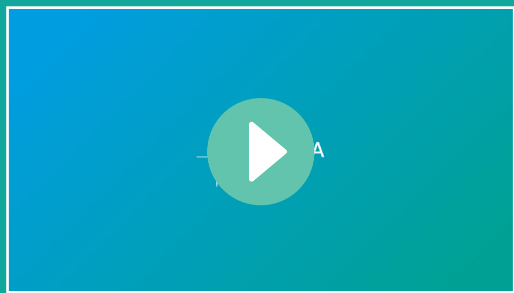
(2) An Ultra Low-Loss Silicon-Micromachined Waveguide Filter for D-Band Telecommunication Applications (October 2018)
Campion James, Glubokov Oleksandr, Gomez Adrían, Krivovitca Aleksandr, Shah Umer, Bolander Lars, Li Yinggang, Oberhammer Joachim

Conference

M3TERA team members represented the project at the Asia-Pacific Microwave Conference (APMC) 2018 from 6th-9th November in Kyoto, Japan. Upon invitation by the APMC 2018 Technical Program Committee, the M3TERA project and its results were presented in a special session.

Podcast

We invite you to listen to our new Podcast featuring Franz Dielacher and Chiara Mariotti:



Video

We invite you to watch our new Video about the M3TERA project:

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