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QWED contributions to MMAMA (1)

QWED is a Polish SME operating since 1997 on the global market.

QWED provides 2 main product lines:

- EM simulation software of QuickWave series for HF / MW / MM-wave design,
- dielectric resonators for material measurements at MW frequencies

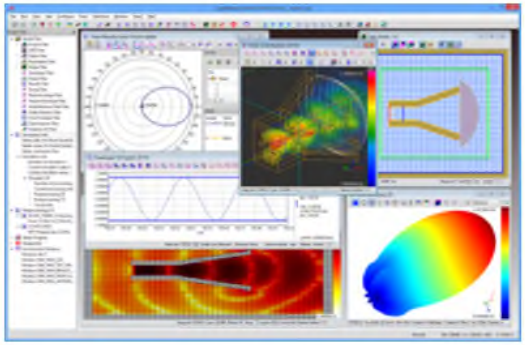
both:

- ✓ based on 4 decades of research of their authors – QWED founders & experts,
- ✓ used worldwide on 6 continents,
- ✓ awarded with prestigious prizes.

QWED contributions to MMAMA (2)

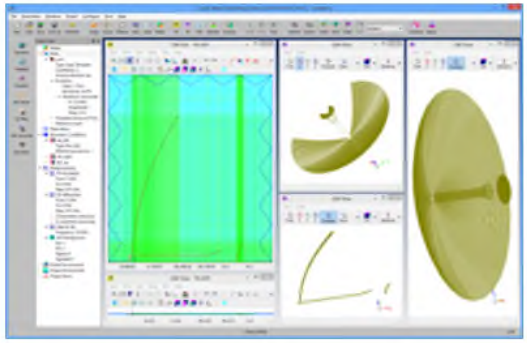
Full 3D EM solver

QuickWave-3D - complete 3D electromagnetic simulation offer a set of various results from wide area of applications. A lot of processing/postprocessings present a complete offer of comprehensive solutions from microwave components (filters, couplers, resonators, etc.) through antennas, TDR applications, optimisation and parameter sweep to simulation of microwave heating process (with Basic Heating Module) with temperature dependent media, static, rotated or moved heated object(s), and heat transfer.



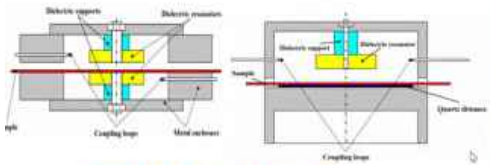
Vector 2D (V2D) solver

QuickWave-V2D - unique on the market and ultra fas Vector 2D electromagnetic solver is applicable to the analysis of axisymmetrical devices (which are also calle Bodies Of Revolution) as large as 2000 wavelengths including antennas (horns, rods, biconical), circula waveguide discontinuities, and resonators. It is based or the Maxwell equations re-expressed in cylindrica coordinates. Definition of a 2D long-section of the structure allows for hundreds times faster simulation than brute force 3D analysis.

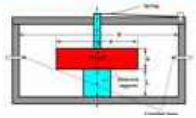


Typical dielectric resonators for **laminar samples:**

SPDR **SiPDR**



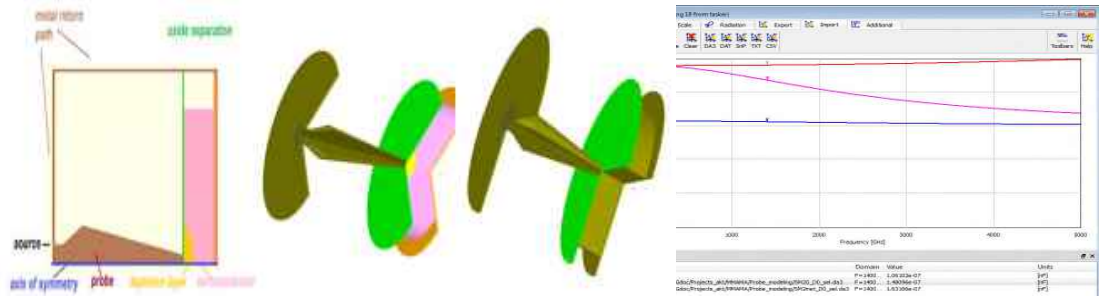
TE01δ for bulk samples



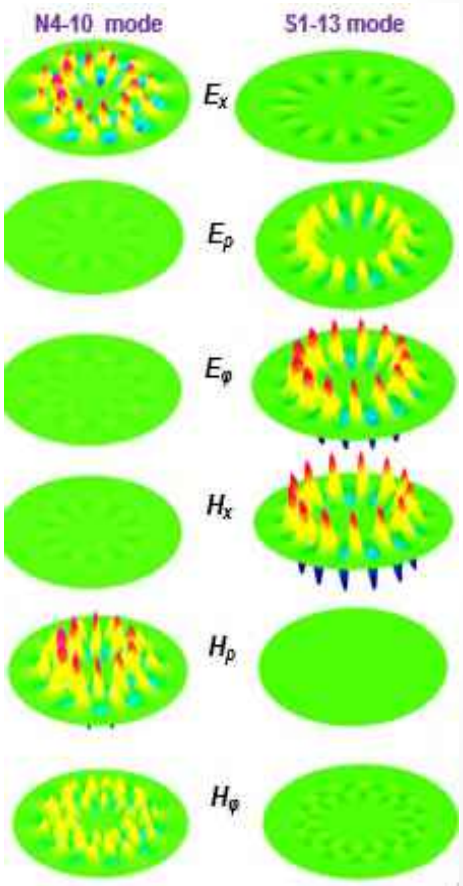
A set of representative SPDRs at different nominal frequencies, from left to right: 1.1 GHz, 2.45 GHz, 5 GHz 10 GHz, 15 GHz

QWED results in MMAMA so far, e.g:

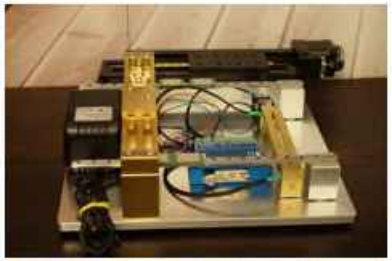
Accurate EM models of tip-sample interaction & extraction of capacitance:



Competitive EM FDTD modelling of whispering gallery modes in dieletric resonators:



Advanced developments of new portable surface imaging device based on 10 GHz SPDR:



~ 8 kg
360*330*120 [mm]
scanning area 80 mm*80 mm
precision in *x*-dir. 2.5 µm, in *y*-dir 25 µm
planned scanning step ~ 1mm
details sent to partners in February and April 2018

QWED expectations from MMAMA

a) to gain new insight into the microwave behaviour of materials relevant to the project (eg. solar cells)

b) to learn technical aspects of microscopic microwave measurements of materials,

c) to assemble data and make comparative analysis of representative results of microscopic (project partners) and macroscopic (QWED in-house) microwave material measurements,

d) to assemble data and make comparative analysis of representative results of EM simulations for 3 types of material measurement scenarios (dielectric resonator, open- ended coax, SMM probe) run with at least 3 methods of mathematical physics (or 3 different implementations thereof, of 3 different authorships), with focus of FDTD and FEM as well as full 3D versus 2D axisymmetrical formulations, with respect to measurements

e) to prepare and make publicly available through QWED website (or other project websites) at least 3 white papers and/or applications notes based on the finding of c), d) above

QWED objectives in MMAMA

develop and *introduce into the market* **new types of dielectric resonators** for measuring MMAMA-relevant semiconductor materials (e.g. solar cells)

develop and *introduce into the market* **portable motorised surface scanning setups**, incorporating a dielectric resonator and Q-Meter

develop new calibration software for post-processing direct measurement results (Δf, ΔQ) for enhanced resolution of surface imaging, with the use of pre-simulated EM field patterns (**bridging the gap between macro- and micro-scale**)

develop and *introduce into the market* **QW-BOR** – a version of EM FDTD software fine-tuned for simulations of axisymmetrical microwave material measurement scenarios

develop and *make openly available* (via open platform) **SMM-Modeller** – parametric GUI based on open source FreeCAD libraries, dedicated to convenient definition of axisymmetrical microwave material measurement scenarios

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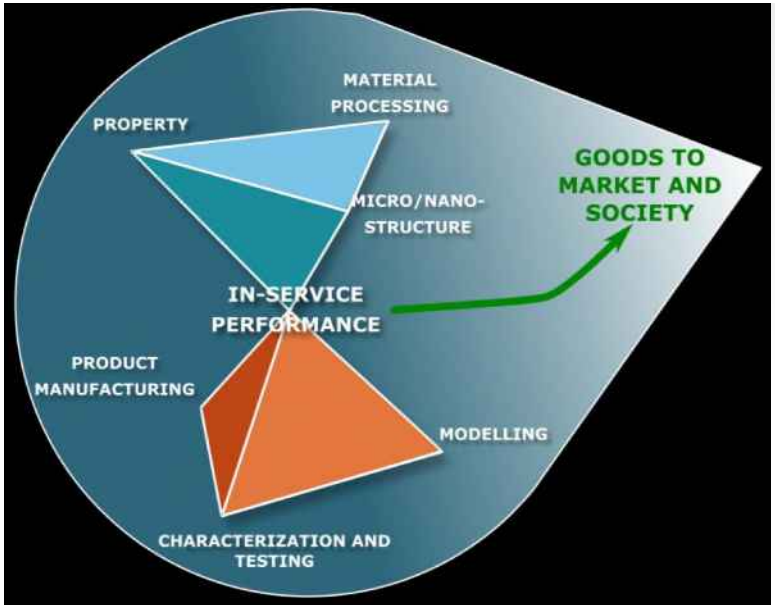

Extracted from « EMCC Roadmap for Materials Characterisation »

MMAMA's Open Innovation Environment

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METAS

MMAMA - a European Project supported with H2020 Framework program

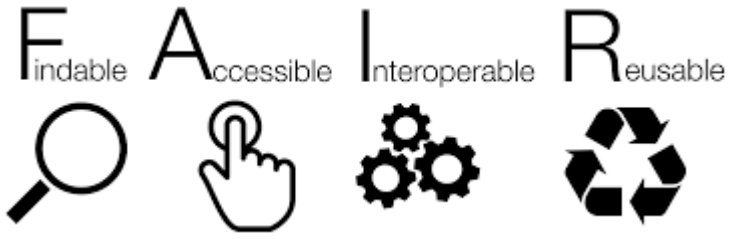
Aims of Open Innovation

- **Forming of a research and application community for the techniques used in MMAMA**
- Make the uptake for industry easier
- Have a positive long term effect on our business (more customers, better image)
- Include stakeholders into the project
- Enable future collaborations
- Make the research results easier to access

Open Innovation Strategy

- Data needs to be stored in a way that all interested parties can access it easily
- Communication with the public needs to take place (preferably through the internet)
- Explanatory documents are needed to describe the techniques used in MMAMA
- Example data helps to better understand the techniques of MMAMA

FAIR Data



- Findable → metadata, filenaming
- Accessible → open software
- Interoperable → widely accepted vocabulary, English
- Reusable → clear and accessible licence

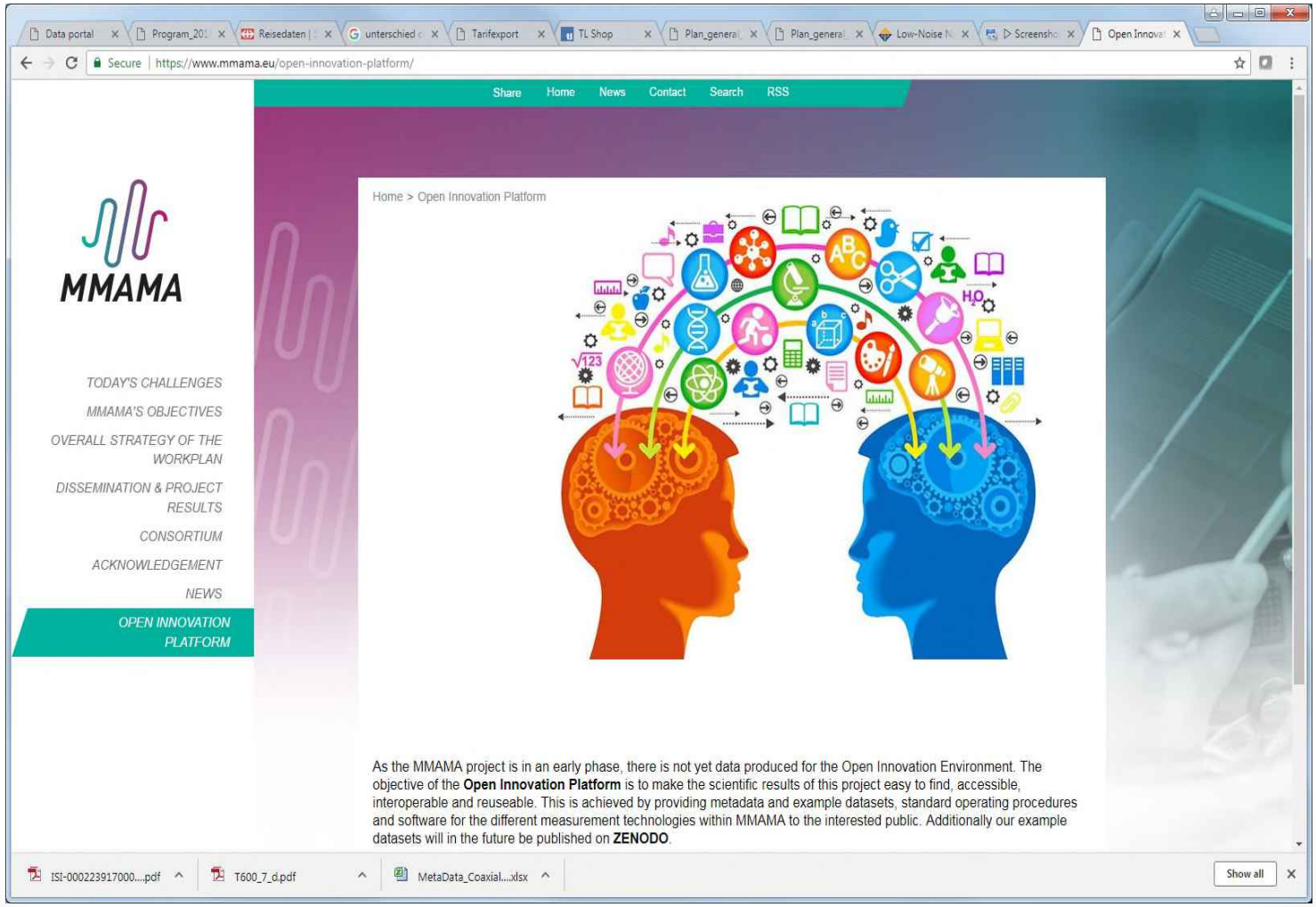
Data Management

- Data Summary → Which data?
- FAIR Data →Which measures to generate FAIR data?
- Allocation of resources →Who does what ?
- Data security → What is the backup plan?

Open Innovation Environment

- There are three layers of online access, and online platforms:
  - General public, read only, download area
  - Stakeholder, read write, file sharing
  - Project partners, read write, file sharing
- Workshops with training on SMM techniques

Open Innovation Environment



Standard Operating Procedures

- SOPs are a first step towards standardization
- SOPs help potential users in taking up the technique
- 3 SOPS will be written
  - Scanning Microwave Microscope
  - Resonators
  - Coaxial Probe

Example Datasets

- Example data sets help potential users to understand the technique
- Different example datasets will be published
  - 2 scanning microwave microscope measurements
  - Uncertainty budgets for these measurements
  - Modelled scanning microwave microscope data

MMAMA

www.mmama.eu

Thank You