I4Bags Open Platform and Request to the EMMC for Modelling Inputs

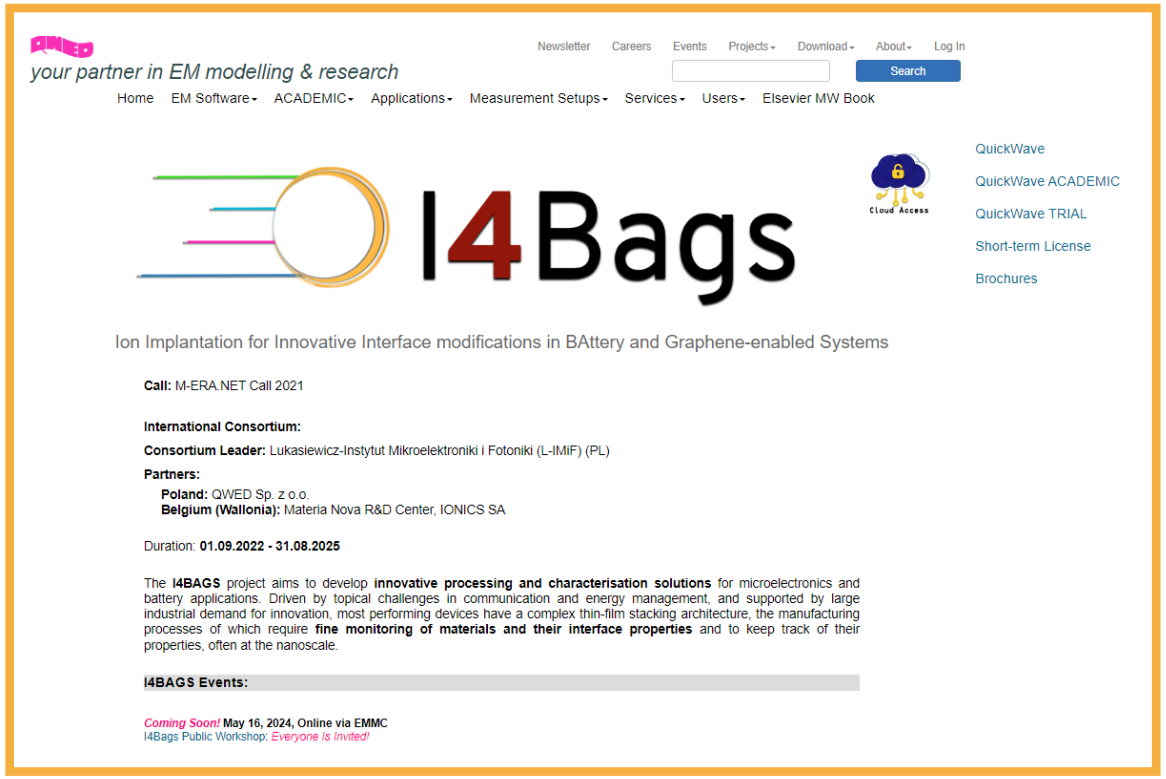
Lukasz Nowicki

QWED, Poland

Outline:

- *I4Bags Open Platform*
  - *I4Bags-Modeller*
  - *I4Bags Modelling Examples:*
    - *3D Split-Post dielectric resonator with circular sample acting as SiC wafer.*
    - *3D Single-Post Dielectric Resonator with circular sample acting as Quartz Wafer with Carbon Coating*
- *Request to the EMMC for Modelling Inputs*

I4Bags Open Platform



I4Bags Open Platform subpage:

https://qwed.eu/i4bags.html

- *Events (including EMMC Meetings) such as:*
  - *4th EMMC International Workshop 2023*
  - *Today's project webinar*
    - *And many more events…*
- *I4BAGS Open Platform Tools and Examples*
  - ***I4BAGS-Modeller** - licence-free CAD modeller developed within the I4BAGS project. Will be described on following slides.*
- *I4BAGS Articles, Presentations, Posters & Outreach:*
  - ***31 positions of research content** including materials prepared for EMMC community.*

I4Bags Open Platform

- *I4Bags project was in:*

USA:
-Anaheim
-Denver (Colorado)
-Las Vegas (Nevada)
-Orlando (Florida)
-San Diego (California)

Italy:
-Milan
-Florence

Canada:
-Winnipeg

Austria:
-Vienna

Germany:
-Mainz

Netherlands:
-Noordwijk

Poland:
-Krakow

Sweden:
-Gothenburg

Taiwan:
-Taipei

UK:
-Cardiff

I4Bags Open Platform

- *Upcoming event:*

- *I4Bags project will present some of its papers, including:*

„Impact of Substrate Parameters on Sheet Resistance Measurements Using iSiPDR at 10 GHz”

„Investigation of the Electromagnetic Properties of Silicon Carbide in the mmWave Frequency Range Using Density Functional Theory”

„Towards a Robust BCDR Design for Out-Of-Plane Permittivity Measurements”, and more…

I4Bags Open Platform

Modelling-Based Characterisation of Materials

Recent Developments and Cross-Calibration of Resonator-Based Techniques for Microwave and mmWave Materials Assessment

Malgorzata Celuch and Marzena Olszewska-Placha

Graphene on Silicon Carbide Platform for Magnetic Field Detection under Extreme Temperature Conditions and Neutron Radiation

Tymoteusz Ciuk, PhD

Łukasiewicz Research Network

Institute of Microelectronics and Photonics, Warsaw, Poland

Graphene Week 2023 September 7, 2023

IMPACT 2023

International Microsystems, Packaging, Assembly and Circuits Technology conference

www.impact.org.tw

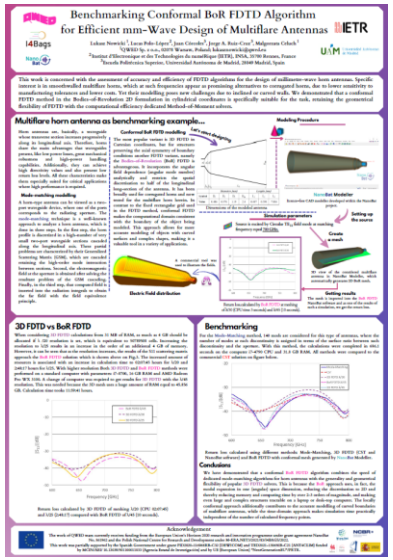
Oct. 25-27 Taipei Nangang Exhibition Center, Hall 1

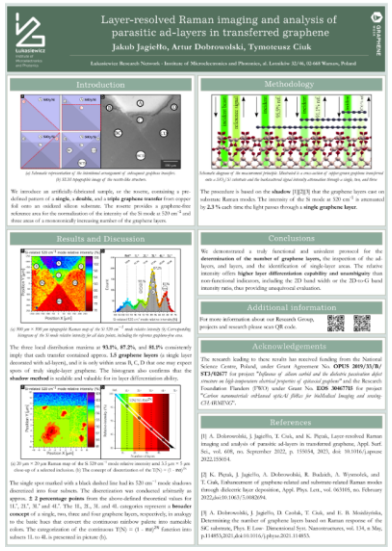
Modelling-based characterisation of copper foils for mmWave applications

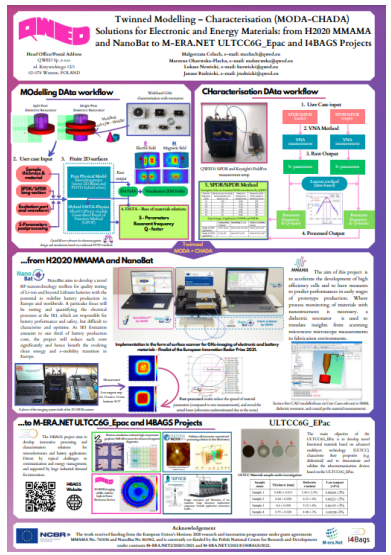
Rapporteur: Dr. Malgorzata Celuch; mceluch@qwed.eu

Affiliation: QWED Sp. z o.o., Warsaw, Poland; www.qwed.eu

IMPACT Session [S1] iNEMI 25 Oct. 2023





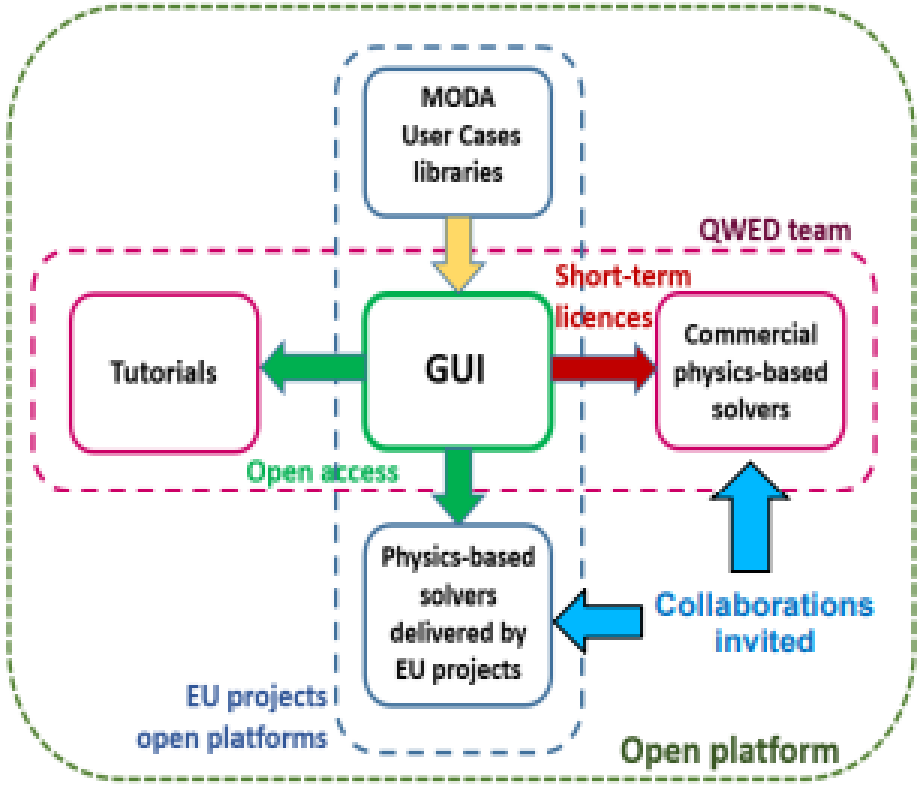


I4BAGS Articles, Presentations, Posters & Outreach:

1. Presentation: I4Bags technical kick-off meeting, **January 10, 2023, Online**.
2. Presentation: "Microwave characterisation and modelling of materials in European initiative", M. Celuch, 2nd IEEE Ukrainian Microwave Week UkrMW, **November 14-18, 2022, Online**.
3. Presentation: "Bridging the gaps between microwave modelling and materials measurements and between women and engineering", Malgorzata Celuch, 52nd European Microwave Week: Microwave and Radar Week EuMW, September 26-29, 2022, Milan, Italy.
4. Information leaflet on the exhibition - The launch of the I4BAGS project, **September 26-29, 2022**, Milan, Italy European Microwave Week: Microwave and Radar Week.
5. Workshops: "Microwave and Millimetre-Wave Characterization of Dielectric Sheets" and "Short Course on EM modeling", **September 12-14, 2022**, 24th International Microwave and Radar Conference MIKON.
6. M. Olszewska-Placha, E. Mozdzynska, J. Rudnicki, M. Celuch, "2D Imaging Technique for Quantitative and Qualitative Characterisation of High-Resistivity GaN Semiconductor Wafers for Light and Power Electronics", 24th International Microwave and Radar Conference, **12-14 Septemeber 2022**, Gdansk, Poland. - presentation.
7. R. Henderson, "Let Them Eat Cake! [President's Column]", in IEEE Microwave Magazine, vol. 23, no. 12, pp. **10-14, Dec. 2022**, doi:10.1109/MMM.2022.3204006 - Article.
8. Presentation: "Modelling Based Characterisation of Materials from Micro to Millimetre Waves", Malgorzata Celuch, IEEE Radio & Wireless Week, Women in Microwaves Event Las Vegas, Nevada, **January 22, 2023**.
9. Presentation: "Evaluation and extensions of resonator techniques for the characterization of ceramics and energy materials relevant to 6G applications", Marzena Olszewska–Placha, Malgorzata Celuch, Lukasz Nowicki, Janusz Rudnicki, Electronic Materials and Applications 2023, S21: Materials, Devices, and Applications in 6G Telecommunications, **19 January 2023**
10. "Benchmarking Conformal BoR FDTD Algorithm for Efficient mm-Wave Design of Multiflare Antennas", Lukasz Nowicki, Lucas Polo-Lopez, Juan Corcoles, Jorge A Ruiz-Cruz, Malgorzata Celuch, 17th European Conference on Antennas and Propagation (EuCAP), **30 March 2023**: Poster and Paper.
11. "Advances in computational modeling and materials characterization for microwave power industry and bridging the gap to classical MTT-S disciplines", M. Celuch, M. Olszewska–Placha, IMS 2023 Workshop, **11-16 June** - accepted.
12. Presentation: "Ion Implantation for Innovative Interface modifications in BAttery and Graphene enabled Systems", Olivier Douhéret, Materia Nova, EU-Taiwan Investment Partnership Forum on EV Clusters, **13 April 2023**.
13. Poster: "Twinned Modelling - Characterisation (MODA-CHADA) Solutions for Electronic and Energy Materials: from H2020 MMAMA and NanoBat to M-ERA.NET ULTCC6G_Epac and I4BAGS Projects", M. Celuch, M. Olszewska-Placha, J. Rudnicki and L. Nowicki, 4th EMMC International Workshop 2023, **26-28 April 2023**.
14. Movie: Ion Beam Implantation - Smart technology for smart materials, Materia Nova
15. Presentation: "From Computational Electromagnetics to Modelling Based Characterisation of Materials for Electronic and Energy Technologies", M. Celuch, 4th EMMC International Workshop 2023, **26-28 April 2023**.
16. Presentation: "Benchmarking of Current Industrial Best Practices and Emerging Techniques for the Consistent Electric and Dielectric Characterisation of Materials from Microwave to Millimetre Wave Ranges", Malgorzata Celuch , Marzena Olszewska Placha, Lukasz Nowicki, Janusz Rudnicki, 1st Space Microwave Week 2023, **8-12 May 2023**: Presentation and Paper.
17. Presentation: "Advances in Computational Modeling and Materials Characterization for the Microwave Power Industry", M. Celuch, M. Olszewska–Placha, WMG-4 Workshops on International Microwave Symposium 2023, **12 June 2023**
18. Presentation: "A New Non-Destructive Microwave Technique for Quantitative Testing of Large-Scale Panels of Graphene-Based Polymer Composites for EMI Applications", M. Celuch, M. Zdrojek, K. Filak, M. Olszewska–Placha, J. Rudnicki, L. Nowicki, TUMA23 MicroApps on International Microwave Symposium 2023, **13 June 2023**
19. "A Fast Modelling-Based Technique for the Characterization of Graphene-Based Polymer Composites", L. Nowicki, Karolina Filak, Malgorzata Celuch, Mariusz Zdrojek, Marzena Olszewska–Placha, Janusz Rudnicki, IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization (NEMO'2023), **29 June 2023**: Presentation and Paper
20. M. Celuch, "Women in Science and Engineering Matinee: WISE at Microwave and Radar Week 2022 [Women in Microwaves]", in IEEE Microwave Magazine, vol. 24, no. 7, pp. 86-90, **July 2023**, doi: 10.1109/MMM.2023.3265521
21. Poster: "Layer-Resolved Raman Imaging and Analysis of Parasitic Ad-Layers in Transferred Graphene", Jagiełło J., Dobrowolski A., Ciuk T., Graphene Week (GRAPH23), **4-8 September 2023**.
22. Presentation: "Graphene on Silicon Carbide Platform for Magnetic Field Detection under Extreme Temperature Conditions and Neutron Radiation", Ciuk T., Graphene Week (GRAPH23), **4-8 September 2023**.
23. Poster: "Investigation on Graphene on SiC under Neutron Irradiation by Raman Spectroscopy", Dobrowolski A., Jagiełło J., Ciuk T., Graphene Week (GRAPH23), **4-8 September 2023**.
24. M.Celuch, "Women in Science and Engineering in Krakow: From Legends and Saints to Pioneers in Emancipation", EMC Europe 2023, Krakow, PL, Sep. 2023.
25. "Fast and Rigorous BoR FDTD Algorithm for the Modelling of Coupled EM-Thermal Processes in Axisymmetrical Devices", L. Nowicki, M. Celuch, M. Olszewska–Placha, J. Rudnicki 19th International Conference on Microwave and High-Frequency Applications: AMPERE 2023, **14 September 2023**: Presentation and Paper
26. M.Celuch and M.Olszewska-Placha, "Recent Developments and Cross-Calibration of Resonator-Based Techniques for Microwave and mmWave Materials Assessment", 12th International Conference on Microwave Materials and their Applications, Mainz, Germany, **25-28 September 2023**; conference leaflet.
27. Presentation: "Characterisation of Compounding Methods for Graphene-Based Thermoplastic Composites using 2D Microwave Imaging Technique", L. Nowicki, K. Filak, M. Celuch, M. Zdrojek, 12th International Conference on Microwave Materials and their Applications, **25 September 2023**.
28. Presentation: "Microwave characterisation of implanted carbon thin films for semiconductor battery applications", L. Nowicki, F. Monteverde, C. Nouvellon, M. Celuch, O. Douheret, W. Wojtasiak, 12th International Conference on Microwave Materials and their Applications, **25 September 2023**, (full paper under review).
29. "Extension of Reference Materials for Standardization in the Production of Large Deployable Antennas", L. Nowicki, M. Celuch, M. Olszewska–Placha, J. Rudnicki, 41st ESA Antenna Workshop, **26 September 2023**: Presentation and Paper.
30. New September flyer for the I4Bags available to download here.
31. M.Celuch, "Modelling-based characterisation of copper foils for mmWave applications", IMP... Microsystems, Packaging, Assembly and Circuits Technology Conf., Taipei, Taiwan, 25-27 Oct. 2023.

Available to download via I4Bags website...

I4Bags Open Platform



Concept of the Modelling Open Platform

- **Interoperable, licence-free, time-unrestricted CAD-based GUI**
- **Tutorials** – teaching and project's results dissemination
- **Library of modelling examples** – also documented in EC supported MODA format
- **Physics-based solvers** - solvers coming from EU projects or other initiatives, willing to provide their tools as open-access.
- **Commercial solvers** – linked through reading and processing the data in text files exported by GUI. This creates a unique capability to run full-power simulations of examples created in the free-to-use GUI

A common GUI is developed to meet four objectives:

- industrial adequacy through import and export of standard CAD and Gwyddion files,
- convenient choice of the most relevant meshing and solver,
- robust cross-comparisons of the different solvers,
- free access, in accordance with the European strategy of open innovation environments

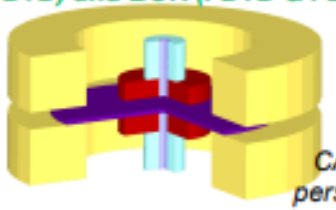
I4Bags Open Platform

- it serves as a freely accessible CAD modeling tool finely tailored for seamless compatibility with QuickWave software. Users can harness its capabilities without encountering any constraints while preparing extensive projects for electromagnetic simulations using QuickWave.

I4BAGS-Modeller

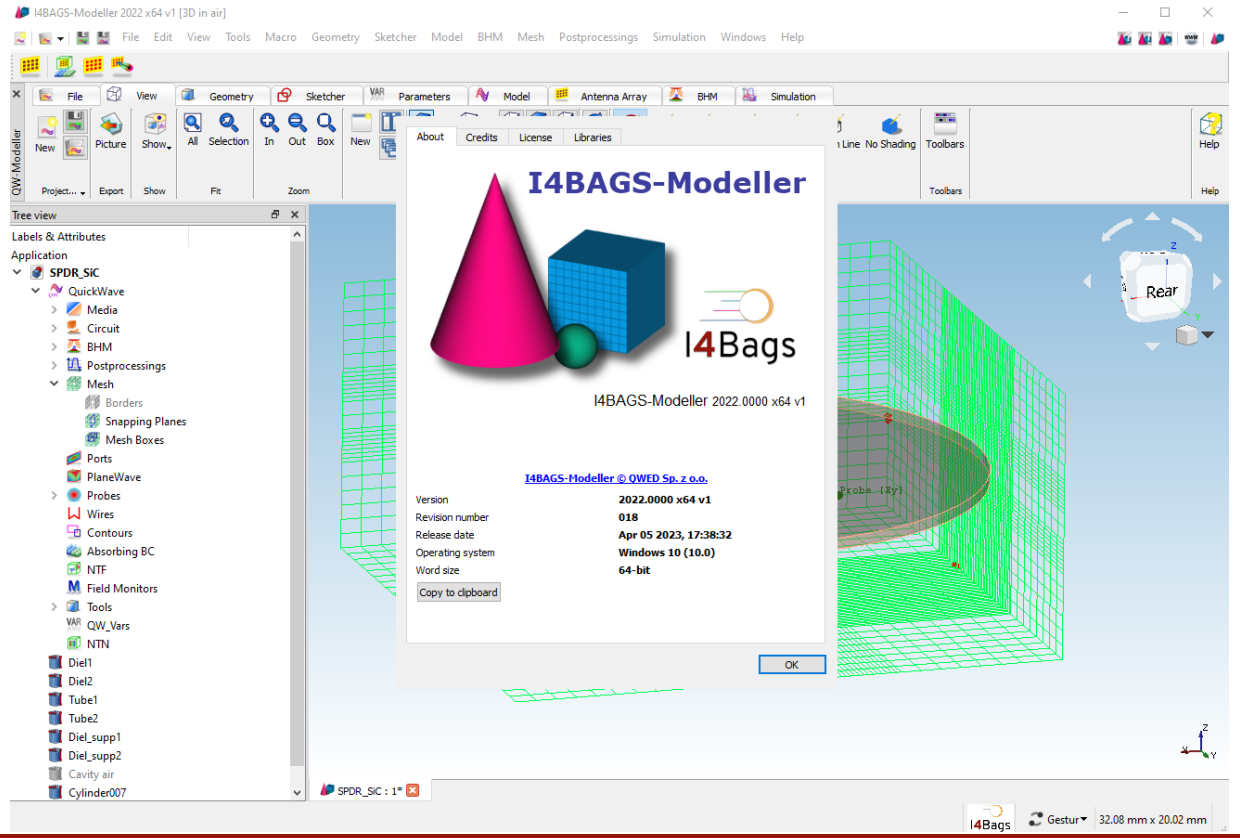
Split-Post Dielectric Resonator test-fixture for low-loss dielectric measurements – 3D (FDTD) and BOR (FDTD & FEM)

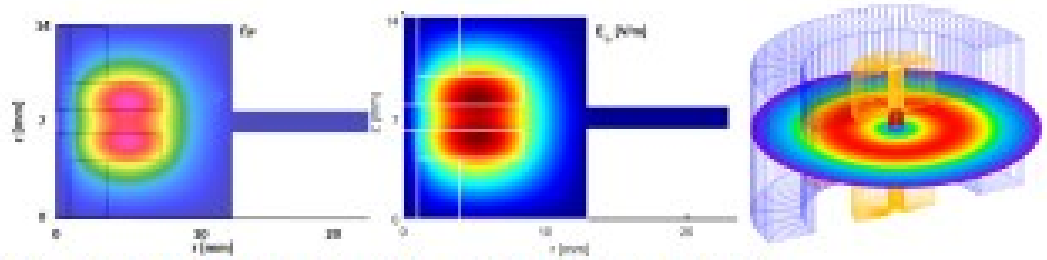
QWED's commercial SPDR



CAD model – perspective view

	FDTD			FEM
meshing	0.4 mm	0.2 mm	0.1 mm	0.1 mm
BOR: [GHz]	4.9151	4.9097	4.9075	4.9075
comp. time	35 sec	50 sec	1min 30sec	1.16sec
3D: [GHz]	4.9245	4.9145	4.9099	-
comp. time	2min	6min 30sec	1h 20min	



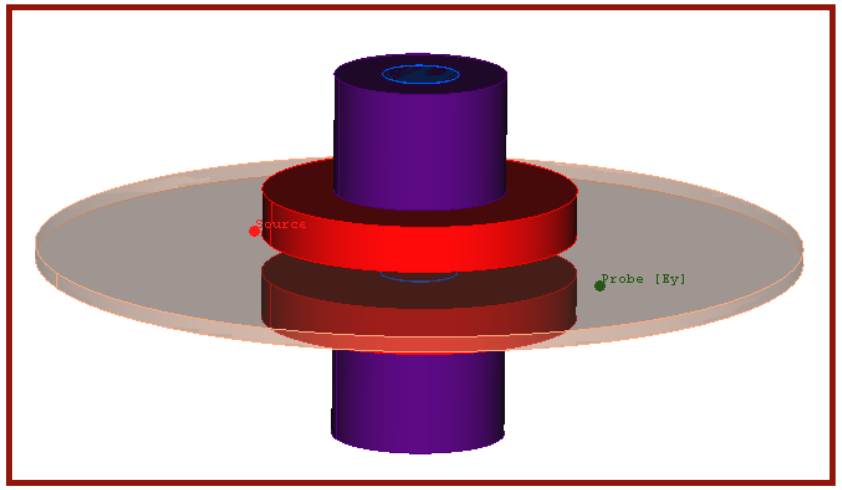


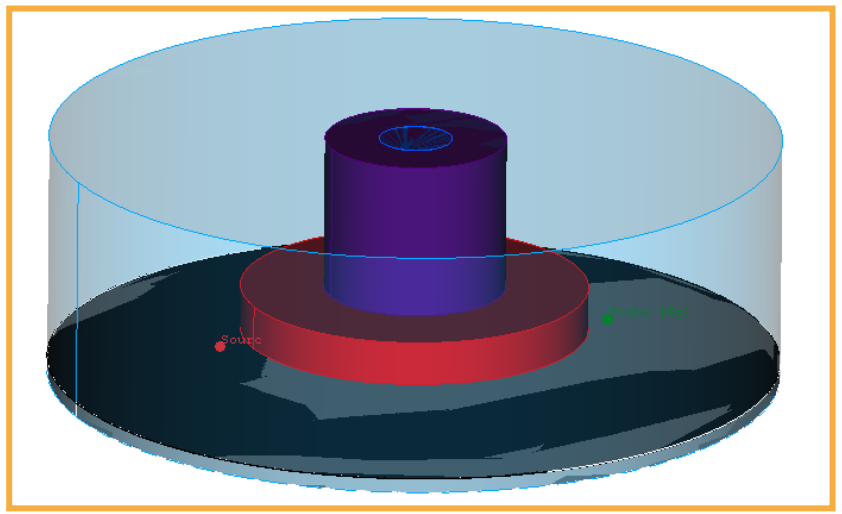
Electric field distribution form BOR FDTD & FEM

I4Bags Open Platform

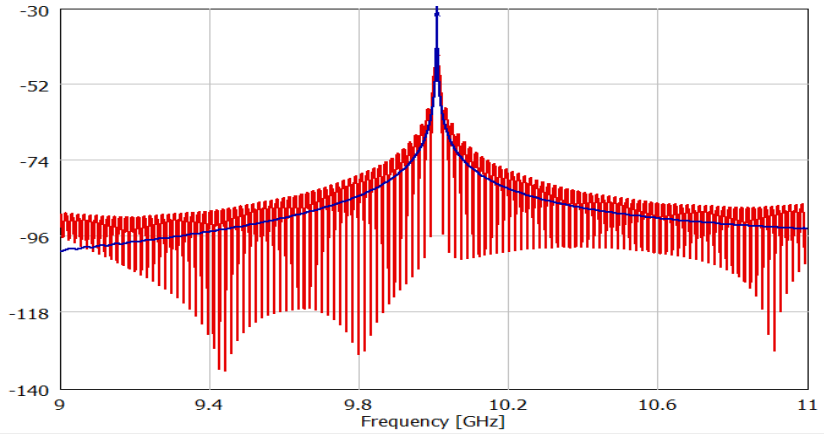
I4BAGS-Modeller - Examples

I4Bags-Modeller



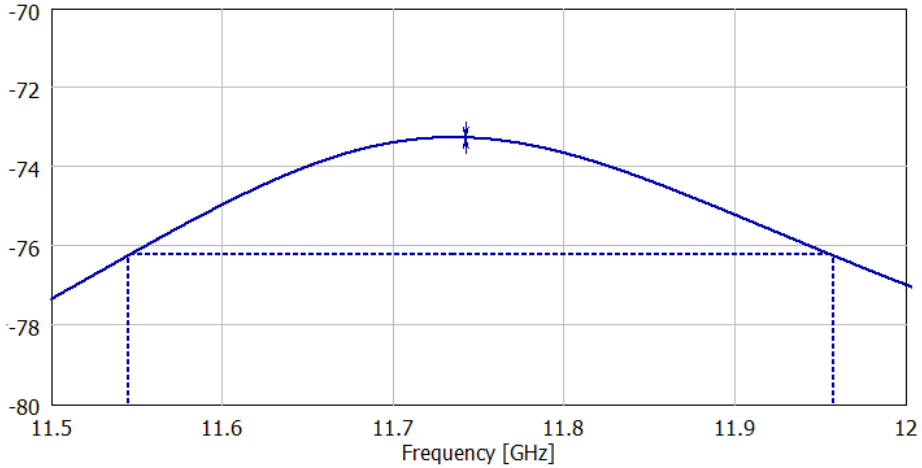


Short term - licences



Values				
Symbol	Name	Domain	Value	Units
	|S21|	F= 10.0103 [GHz]	-45.128296	[dB]
	|S21| $pm100000....	F= 10.0103 [GHz]	-29.738972	[dB]

Results



Request to the EMMC for Modelling Inputs

Linking and Coupling Computational Chemistry to Electromagnetics

Actions:

a. define the scope of Computational Chemistry (CChem) and Computational Electromagnetics (CEM):

- what is it used for?

  CEM:

  - predict electromagnetic characteristics of high frequency devices (radiation patterns of antennas, transmission & reflections chcs of filters, heating effects in MW ovens & biomedicine,...),
  - design devices of desired parameters

- under what assumptions is is valid? (e.g. CEM: matter continuity, deterministic problems)
- what are its governing eqs.? (models) - e.g. CEM: Maxwell eqs. (incl. Gauss Law and charge conservation), MR e.g. ε(x,y,z,t)

b. review & catalogue platforms & databases available for linking through the New Platform

c. define first User Cases to be modelled (in a coupled multiphysics workflow) via the New Platform

-Half-Cell (MODA for CEM for battery testing)
- wearable antenna or sensor

} *electrical parameters obtained via CChem*
performance evaluated with CEM

Request to the EMMC for Modelling Inputs

Actions & values of coupling Computational Chemistry to Computational EM

Joint projects (incl. student apprentice & summer jobs)

1. Material libraries (added data bases)

2. Computational chemistry solvers launched from the Platform (added tools)

3. Materials parameters calculated off-line (added services)

Strategic:

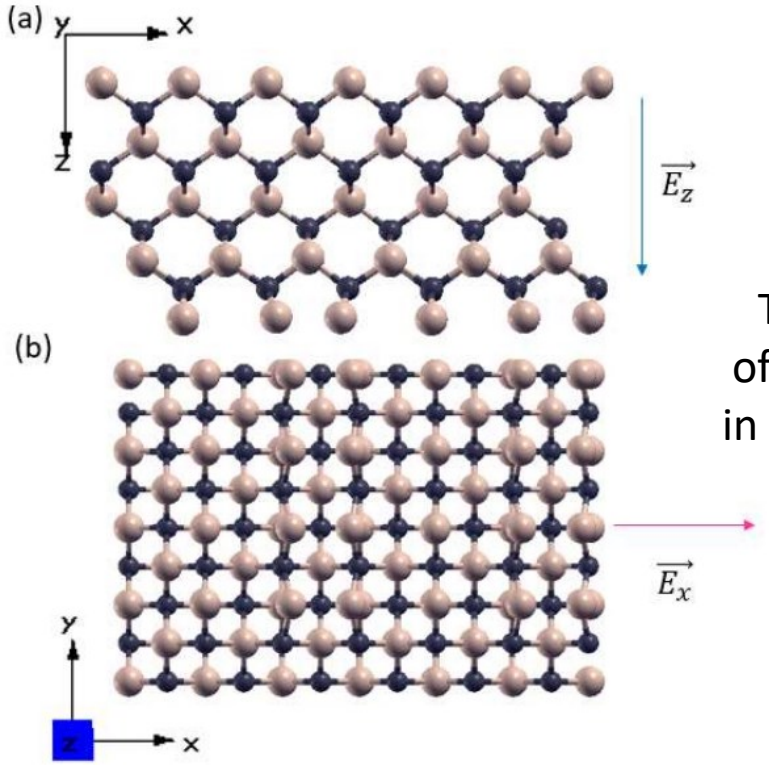
"Materials by Design" for Electronic Design for GHz to THz applications

www.qwed.eu

Request to the EMMC for Modelling Inputs

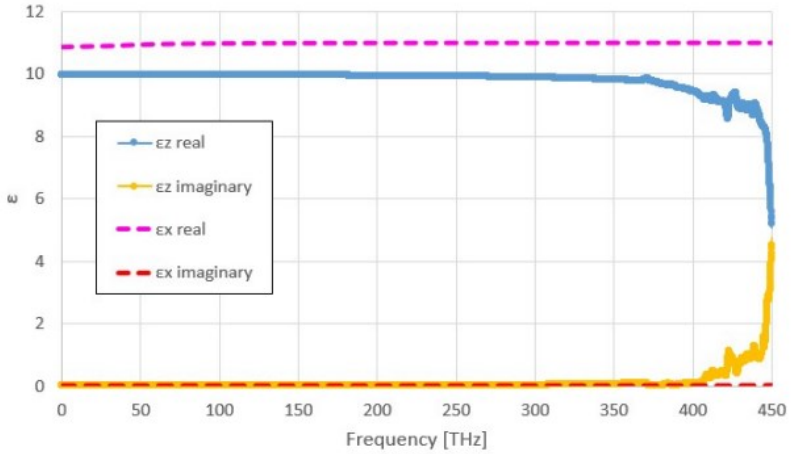
Bridging the gaps - own steps…

„Investigation of the Electromagnetic Properties of Silicon Carbide in the mmWave Frequency Range Using Density Functional Theory" – accepted paper on MIKON 2024

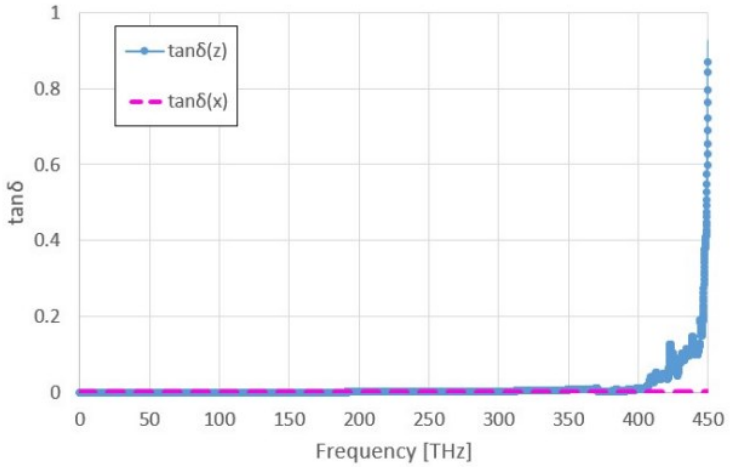


The application of an electric field in a given direction

SIESTA



The real and imaginary parts of the electric permittivity obtained for the electric field oriented along the X and Z directions.



Loss tangent tanδ calculated for the electric field oriented along the X and Z directions.

Fig. 1. SiC Structure utilized in DFT simulations: visualization in (a) XZ plane and (b) XY plane, and the applied electric field.

Thank you for your attention!

I4Bags

Łukasiewicz
Institute of Microelectronics
and Photonics

MATERIA NOVA

ionics
surface technologies