Open platform GUI for comparative FDTD and FEM computation of material microwave measurement scenarios

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***Abstract*—We report the developments of an open platform graphical user interface (GUI) for the modelling of microwave setups popularly used in material measurements. The GUI is based on FreeCAD libraries and designed to launch EM solvers in FEM and FDTD, full 3D and BOR formulations.**

***Index Terms*—FDTD, FEM, GUI, open environment.**

I. MOTIVATION AND OBJECTIVES

While reliable electromagnetic (EM) simulations require accurate knowledge of the simulated materials, material measurements must be supported by accurate modelling of the measurement scenarios. In the H2020 MMAMA project, FDTD and FEM algorithms are being enhanced for the modelling of representative microwave test-fixtures [1], such as scanning microwave microscopy (SMM), split-post dielectric resonators (SPDR), and coaxial probes. A common GUI reported herein 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.

II. SOFTWARE DEVELOPMENT APPROACH

Our GUI is implemented as a workbench for the open source FreeCAD general purpose parametric 3D CAD modeller [2], following the ideas in [3]. It allows definition of microwave test-fixtures, such as the SPDR of Fig. 1, through primitives, Python scripts, and imported CAD files. Parameters of EM simulations (e.g. meshing, sources) are added. The original features of this workbench, with respect to the concepts of [3], reside in parametrisation including the choice of 3D or BOR 2D meshing and a relevant solver.

III. EXAMPLE COMPUTATIONAL RESULTS

Fig. 1 presents a real-life SPDR for a nominal frequency of 5 GHz, with dimensions from the open literature [4]. With meshing refined from ca. 10 to 40 cells per wavelength in the ceramic, 3D and BOR FDTD [5] are launched and the results are collated in Table 1. As expected [6], the BOR approach is advantageous in terms of accuracy and computer effort for the axisymmetrical resonator. However, a full 3D approach will become necessary to model e.g. the coupling loops (Fig. 1 right). An independent FEM solver [1] is run with triangle mesh of 55000 elements, and it obtains the resonant frequencies of SPDR, included in Table 1 for reference.

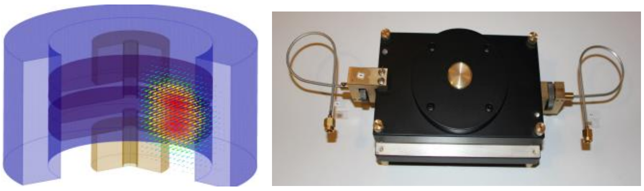

Fig. 1. Left: electric field of the TE01δ measurement mode obtained by 2D BOR FDTD and displayed against a 3D CAD model of SPDR. Right: a photo of SPDR for ca. 5 GHz manufactured based on the 3D CAD model.

	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	

Tab. 1. Resonant frequencies of SPDR of Fig.1, calculated by launching BOR and 3D FDTD with gradually refined meshing from the open GUI. Computing times are given for GPU implementation on nVidia GeForce GTX Titan. For FEM, a converged result is shown as reference.

IV. OUTLOOK TOWARDS THE CONFERENCE

At the time of writing this abstract, the open platform GUI has been established, from which FDTD solvers in 3D and BOR versions are automatically launched. FEM solvers of the same scenarios have been run independently, but generation of FEM models from the same GUI is ongoing and results will be presented at the Conference.

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