Part I
Introduction

Global warming and air pollution is one of the main problems facing mankind. The main reason for this is the dependence on fossil energy, which is neither sustainable nor environmentally friendly. Fuel cell technologies represent one of the most promising technological advances to contain the situation. In addition to producing clean energy, fuel cells have the advantage of being transportable. Meanwhile, fuel cells are used in many applications, for example in supporting facilities, vehicles and electronic systems. In order to improve cell operational performance, the analysis of operational parameters is required and these parameters are also of central importance in the dimensions of the cell. A three-dimensional high temperature proton exchange membrane fuel cell (HT-PEMFC) with polybenzimidazole (PBI) membrane model developed in Comsol Multiphysics by the group Ubong et al. as part of a publication [1] is used for the simulation in this work.
Next, this thesis deals with an electromagnetic reverberation chamber (ERC). An electromagnetic reverberation chamber serves as an ideally isolated environment where a device under test (DUT) is subjected to electromagnetic waves in order to closely observe the effects. The field for the chamber is generated by a Vivaldi antenna, which in turn stimulates so-called modes by multiple reflections of electrical waves on metal walls. The transmit antenna also irradiates a rotatable metal reflector structure (Stirrer) in the chamber, which swirls the modes and creates a spatially limited, homogeneous electric field in the chamber. The geometry of the stirrer and, furthermore, the quantity of stirrers is decisive for how well the field is distributed homogeneously. Another way to influence the field distribution is to attach geometric objects to the chamber wall, which has been done to a limited extent by the group Selemani et al. [2]. Cases such as the stirrer geometry, the number of stirrers in the chamber and the attachment of geometric objects to the chamber walls are examined in order to obtain the best possible solution. When selecting the antenna frequency, the formula from Hans Georg Krauthäuser's habilitation thesis is taken into account. To be on the safe side when choosing the frequency, three times this limit frequency is used [3].
Whether finding the operating parameters for the fuel cell for a given performance or choosing the right geometry for a better field distribution in the chamber, these are all optimization problems from a mathematical point of view. One can select these desired boundary condition as a prompt and solve it numerically with an algorithm. The genetic algorithms in Matlab, which is connected to Comsol Multiphysics via an interface, is used for the optimization.

References

[1] Ubong, E. U. ; Shi, Z. ; Wang, X.: Three-Dimensional Modeling and Experimental Study of a High Temperature PBI-Based PEM Fuel Cell. In: *Journal of The Electrochemical Society* 156 (2009), Nr. 10, B1276. http://dx.doi.org/10.1149/1.3203309. – DOI 10.1149/1.3203309

[2] Selemani, K. ; Gros, J.-B. ; Richalot, E. ; Legrand, O. ; Picon, O. ; Mortessagne, F.: Comparison of Reverberation Chamber Shapes Inspired From Chaotic Cavi-

ties. In: *IEEE Transactions on Electromagnetic Compatibility* 57 (2015), Februar, Nr. 1, 3–11. http://dx.doi.org/10.1109/temc.2014.2313355. – DOI 10.1109/temc.2014.2313355
[3] Krauthäuser, Hans G.: *Grundlagen und Anwendungen von Modenverwirbelungskammern.* http://dx.doi.org/10.25673/4794. Version: 2007