A Multi-objective Approach to the Design of Conducting Polymer Composites for Electromagnetic Shielding

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Abstract. This work deals with the design of new shielding materials for the protection of electrical devices. Since there are many different requirements for modern materials, we have chosen a multi-objective approach to this problem. As material under consideration we chose conducting polymer composites due to their excellent electromagnetic properties in the microwave band and their high potential for the optimization process. In this paper, we start this process with the formulation of a novel model, deal further with the approximation of these solution sets, and finally consider the decision support related to this problem.

1 Introduction

Electromagnetic interferences have become an important problem due to the proliferation of commercial, military, and scientific electrical devices and equipments in high frequencies. Electronic devices must be shielded to be protected against the incoming and potentially disturbing radiation.

Conducting polymer composites (CPCs) like Polyaniline Polyurethane (PAni/PU) are very promising for applications in electromagnetic interference shielding ([9]). These materials are e.g. characterized by relatively high conductivities and permittivities. Since these properties can easily be tuned via chemical processes in the making of these composites, CPCs are well-suited for the demanding optimization in this field. Further, these materials are lighter, more flexible and offer better environmental stability compared to the classical shielding materials subjected to corrosion which make them an interesting potential alternative.

In this work, we are particularly interested in the design of new high-protecting and light-weight materials which are realisable for reasonable prices. In search of

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these materials, we propose in the following a new multi-objective optimization model, address the numerical treatment of these problems, and present possible techniques which are designed to support the decision maker (DM) to find the preferred solution according to the specific problem.

The remainder of this work is organized as follows: in Section 2 we state the background required for the understanding of the particular design problem which is proposed in Section 3. Section 4 deals with the approximation of the Pareto sets of the resulting MOPs, and in Section 5 we show how these sets can be visualized according to the preference of the DM. Finally we make a conclusion in Section 6.

2 Background

In this section we briefly summarize the background required for this work: we introduce the electromagnetic properties which are interesting in our context, present a theoretical model for these properties which serves as the basis for further considerations, and finally address the concept of multi-objective optimization.

2.1 Electromagnetic Properties

Since our aim is to design new protecting materials we are particularly interested in what happens when an electromagnetic wave (EM) arrives at the surface of a material. In that case, three physical phenomena can occur: *absorbtion*, *reflection* and *transmission* of the incidental wave (see Figure 1).

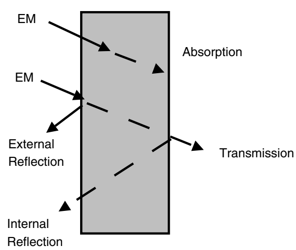

Fig. 1. The three kinds of physical wave interaction

For our purpose it is sufficient just to consider the reflection and the transmission. In [17] a theoretical model for these two wave interactions was proposed which will be used in this work and which will be described in the following. For this, we consider a compound consisting of N layers and assume each layer to be homogeneous and isotropic. The design parameters of the i-th layer, $i = 1, \ldots, N$, are the conductivity σ_i, the permittivity ϵ_i, and the thickness d_i of the material of each layer.