# The Study of Magnetic Layer for Soft Magnetic Composite Materials via Layer-by-Layer Assembly

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The soft magnetic composite materials are prepared using specific layers. Layers must show electrical insulated behaviour and provide mechanical strength. In general, the layer does not own the magnetic properties. Using the Layer-by-Layer process, it is possible to obtain multi-functional layers. For the polymer/silica layer system, a layer is doped with magnetic nanoparticles in order to improve some magnetic properties. The use of a magnetic layer in LbL SMC products permits the reduction of iron losses.

*Keywords:* Soft Magnetic Composite, Layer-by-Layer, Silica, Magnetite, Iron Losses

## 1. Introduction

Magnetic materials play an important role in green energy transactions and telecommunication sectors. The research is focused on both magnetic materials, soft and hard. For hard magnetic materials, the investigation concerns several fields: rare-earth-free magnets, recycling or improved cheaper Nd-alloy magnets. For soft magnetic, the research is focused on solutions with new magnetic materials with reduced eddy currents, such as Soft Magnetic Composite (SMC) or with better magnetic performance, such as Additive manufacturing materials.

The proposed activity is based on producing SMC materials using the layer-by-layer technique [1]. The obtained layers are nanometric, and their assembly allows the use of many types of materials. The layers can be of various natures: organic, inorganic and hybrid. Also, the number of layers can be designed and structured. From this point of view, we doped a layer with magnetic particles with the aim of improving magnetic and energetic performance on the final SMC materials. In this way, the layer function is not only the electrical insulation and provides mechanical strength but also facilitates the magnetic behaviour.

## 2. Materials and methods

The ferromagnetic base powder is FeABC 100.30 from Höganäs with a grain size distribution between 45µm and 250 µm and very high purity (99.95%). The proposed polymer/silica system is based on 1.5 layers deposition. The positive layers of the produced systems contain polymer Branched Polyethylenimine (BPEI). The negative layers contain Colloidal Silica (LUDOX® TM-409) and Polyacrylic acid (PAA). The BPEI concentration in the deionized watery solution is 1 wt%, and the Silica and Polyacrylic acid are dissolved in water with 4 wt% and 1 wt%, respectively. The first and last layers have positive polarity (BPEI). Another system is prepared where the positive layer of PAA/Silica is doped with magnetite nanoparticles with 0.2 wt%. The deposition time was fixed at 5 minutes for all systems. The process is illustrated in Figure 1.

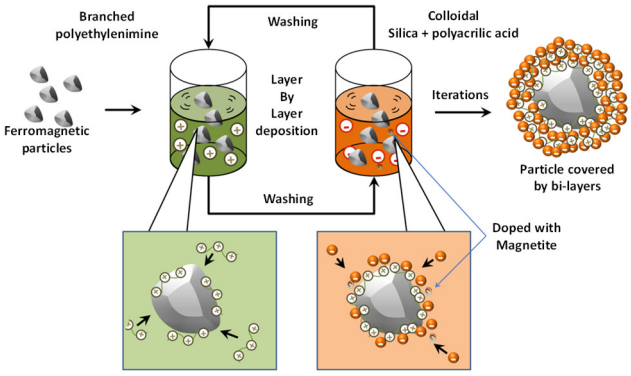


Figure 1 - Layer by layer Deposition technique used to produce the proposed SMC materials with a magnetic layer

## 3. Results and discussion

The results concerning the specific iron losses, maximum magnetic permeability and magnetic saturation are shown in Figure 2. The reference system, indicated as 100% in absolute values, is BPEI+PAA/Silica without doped with magnetic nanoparticles. The doped system shows lower iron losses related to coercitivity value and insulated behaviour of the magnetic layer. Further analysis will be performed considering the increment of the layers, varying the doping percentages and using other soft magnetic nanoparticles.

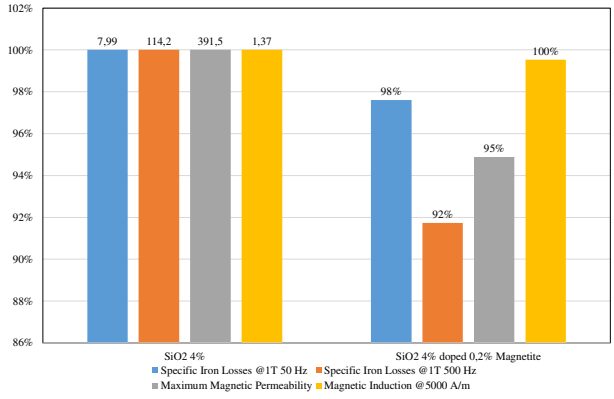


Figure 2 – Comparison of the magnetic properties between doped and no doped produced SMC system

## References

[1] E. Pošković et al., "A new approach in the implementation of insulating layers in soft magnetic composite materials", J. of Magnetism and Magnetic Materials, Vol. 597, 2024.