# Sintering and evolution of NdFeB magnets microstructure during thermal treatments: influence on magnetic properties

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**Abstract**: NdFeB hard magnets are the most powerful magnets commercially available. Their outstanding properties originate from Nd2Fe14B intrinsic properties and from the microstructure imposed by the manufacturing process. These magnets are generally obtained by liquid phase sintering of an oriented monocrystalline powder which enables a microstructure made of grain magnetically decoupled by a thin neodymium-rich layer which is optimally distributed in the magnet after a low temperature annealing. For them to be used in electrical engines and generators, dysprosium is usually added so that the coercivity is high enough at the working temperature. But dysprosium is rare and expensive and lowers the remnant induction. It is therefore important to get free of its usage by a better understanding of the links between the manufacturing process and the microstructure, so that the final magnetic properties can be optimized.

First, this thesis deals with NdFeB sintering on an alloyed commercial grade. The high shrinkage anisotropy during densification is not clearly explained and its interpretation could bring information on the magnetic properties. Dilatometric studies have been performed along orientation direction as well as along the transverse direction. Sintering has been interrupted at different times and the microstructure was observed. Image analysis has enabled to understand, thanks to an analytical model, that a part of the anisotropy could be explained by an anisotropic contact orientation distribution, originating from the magnetic orientation step. Discrete element modelling has confirmed this approach.

The second part of the thesis deals with the role of the most commonly used alloying elements on the magnetic properties: aluminum, cobalt and copper. Around twenty different model grades were examined with composition close to the ones of commercial magnets. After having been sintered, the samples were annealed at temperatures deduced from DSC measurements. Results show that the three elements have cross effects on coercivity. Beyond coercivity, demagnetizing curve shape is sensitive to the composition and annealing temperature and gives important information on the role of the alloying elements on the microstructure.