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Investigation of the microstructural features induced by the reaction of NdFeB powders with the degradation products during the debinding step in the Powder Injection Molding process

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Rare earth (RE) permanent magnets are strategic and essential components for many applications such as electric cars, wind turbines, robotics, aeronautics or electronics and play a crucial role in the electrification of our society, necessary to achieve carbon neutrality. The growing demand in NdFeB magnets raises the question of the availability of critical raw materials, namely the RE elements [1].

The advanced manufacturing processes reduce the amount of material required to produce a magnet and allows for complex shapes with an optimized magnetic architecture. They could offer substantial benefits by combining better system performances and material savings. Powder Injection Molding (PIM), combining the advantages of plastic injection molding and powder metallurgy, brings a large freedom of building design, without wasting material during machining. For the particular case of the NdFeB magnets, this process could be advantageous as it offers the possibility to align the magnetic particles during the injection molding step and to obtain high density anisotropic magnets. However, the resulting parts must present features of the particular microstructure of NdFeB sintered magnets and low oxygen and carbon contaminations to avoid the weakening of the magnetic performances. Several specific steps of the PIM process, (mixing, injection molding and debinding) are crucial to avoid the organic contamination.

In this work we investigate the evolution of the microstructure and the magnetic properties, of PIM produced parts with various carbon contamination levels. High magnetic performances, equivalent to the ones of conventionally sintered counterparts, are obtained for the PIM magnets showing low level of carbon contamination [2]. Carbon contamination effect on the microstructure, given by structural and microstructural analysis, is correlated to the measured magnetic properties.

This study provides new insights of the reactions occurring during the debinding step of the PIM process and highlights the importance of the different process conditions of the organic contamination levels of the PIM produced magnets.

References:

- [1] R. Gauß *et al.*, 'Rare Earth Magnets and Motors: A European Call for Action'. A report by the Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliance. Berlin 2021.
- [2] T. Bioud *et al.*, 'Net-Shape NdFeB magnets made by Powder Injection Molding: Lowering the organic contamination'. Proceedings of World PM 2022 Conference

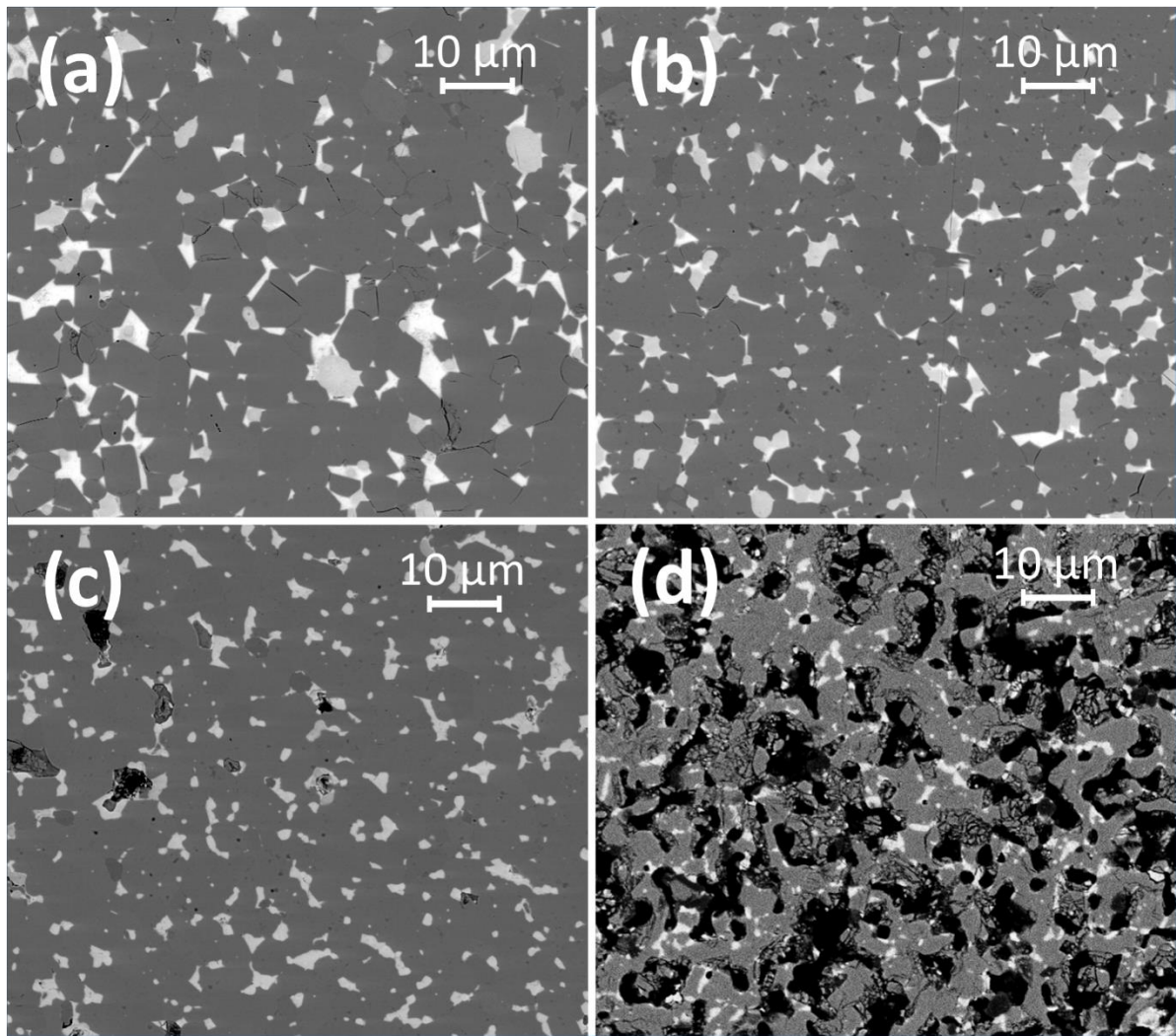


Figure 1-Evolution of the microstructure of a) the conventional processed magnet compared to the PIM produced magnets with b) 1140 ppm of C, c) 5300 ppm of C and d) 8500 ppm of C, observed by SEM-BSE