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Additive manufacturing of soft magnetic materials and components (invited)

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Soft magnetic materials pose several challenges for additive manufacturing. The presentation will provide an overview of the current state of additive manufacturing of soft magnetic materials. Efficient electrical energy converters require high-performance magnetic materials such as Fe-Si, Fe-Co or Fe-Al materials. Today's soft magnets are reaching their limits, particularly in high-speed electric machines. E.g. the rollability of material compositions like FeSi6.5 with a higher specific electrical resistance is restricted due to enhanced brittleness. Here, additive manufacturing based on laser powder bed fusion (L-PBF) offers new possibilities for soft magnetic cores in electrical energy converters. For compositions such as FeSi6.7 with higher electrical resistivity, a maximum permeability of μmax = 31.000 and a minimum coercive field of 16 A/m and hysteresis losses of 0.7 W/kg at 1 T and 50 Hz were obtained. To further limit eddy current losses, novel topological structures such as internal slits or multilayers of soft magnetic layers and electrically insulating interlayers such as Fe-Si phases or Si are also useful. Feasibility, functionality and potential of the various approaches are discussed on the basis of first prototypes. The results are compared with conventional electrical steel and SMC material. Chambers developed for laboratory-scale experimentation were used for the additive manufacturing process.