Microstructural effects in low loss power ferrites

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Power ferrites of the system Mn-Zn-Fe-O are important soft magnetic materials for many electronic applications. The microstructure of the sintered magnets is one of the key factors determining the magnetic properties. Fine grained homogeneous microstructures with increased resistivity at the grain boundaries are desired to minimize eddy current losses.
The microstructure of the ferrite is determined by a variety of factors: raw material quality, calcination temperature, milling procedure and sintering regime. Moreover, the concentration of dopants and impurities effectively regulates the densification process. The effect of CaO, SiO_2, SnO_2 and Nb_2O_5 on the microstructure and magnetic properties has been studied. The grain size is strongly affected by the concentrations of CaO and SiO_2. HRTEM studies show that Ca and Si are enriched in very thin grain boundaries and triple junctions. Sn is completely incorporated into the bulk of the ferrite while Nb was found to be segregated at grain boundaries.
The microstructure has been further analyzed by impedance spectroscopy. Ca and Si doped ferrites with fine-grained microstructure have an increased grain boundary resistance. From the temperature dependence the activation energy for charge transport in the bulk and grain boundaries has been verified to be almost identical; thus it is concluded that the microstructure is not formed as a network of isolated grains, but rather by grains which are not completely separated by a very thin insulating film. Power losses of the ferrites show minimum values if the microstructure is dense and fine-grained. This is mainly controlled by Ca and Si additions; Nb and Sn show minor effects.
Correlations between sintering temperature, impurity concentration and magnetic properties will be discussed underlining the importance of process control for the preparation of low loss Mn-Zn ferrites.