IN-PLANE MAGNETIC ANISOTROPY DETECTION OF CRYSTAL GRAIN ORIENTATION IN GOSS-TEXTURED FERROMAGNETS

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The quality of Goss-textured ferromagnets is expressed in terms of the orientation of their crystal grains. In real grain-oriented (GO) materials, the grains are not completely oriented according to the Goss pattern, and their performances can be severely reduced. Since the crystal grains orientation plays such an important role in the quality of magnetic materials [1-4], the study of their crystallographic textures has to be consider of great interest for process engineering and material design. Traditional approaches for the analysis of the orientation of the grains include domain viewer images construction, X-ray diffraction method, neutron-diffraction method, electron-diffraction, synchrotron radiation [5-7]. The first one is a very useful method to investigate the easy direction of the grains but no further information are available. On the other hand, diffraction methods provide a complete analysis of grains orientation, but this approach is very expensive, destructive, and it is an off-line procedure, applicable only after the material is produced and accurately prepared. Recently we are studying the possibility to obtain information about the orientation of the crystallites by means of a non-destructive technique based on the evaluation of the lag angle between magnetization vector and applied field vector, during a rotational magnetization process, by means of contactless measurements [8]. This approach seems to be particularly suitable for non destructive, on-line diagnostics of crystal grains orientation in laminated GO ferromagnetic materials, such as the electrical steels. In order to deduce the crystal orientation from measurements of the lag angle, the accurate modelling of the in-plane magnetic anisotropy is necessary.

Fig. 1. Disk of Fe-Si oriented steel with selected grains marked with colored numbers
The main scope of the presented research is to derive, for each crystallite of the material, the tilt angles of the cubic lattice respect to the lamination plane. In a first approximation we can assume that one axis of the crystal grain always lies in the lamination plane, so it can be possibly tilted, by an amount $\phi$, respect to the rolling direction. The other fundamental angle, that we indicate with $\psi$, is the one formed by the closest off-plane axis and the lamination plane. In the figure 1 a sample of a grain oriented electrical steel sheet is shown. It is possible to see the grain boundaries, the different coulors is for small orientation differences. For the grains 1 to 4, using the method described above is possible to define the grains orientations as presented in the figure 2.

$$\psi^{(1)} = 41.0^\circ, \psi^{(2)} = 33.5^\circ, \psi^{(3)} = 43.0^\circ, \psi^{(4)} = 36.0^\circ.$$  

Fig. 2. Tilt angles $\psi$ of the four grains, estimated from the zero crossing points using the proposed model.

References