Effects of High Magnetic Field on High Purity Fe-C Alloys during Diffusional Phase Transformation

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Magnetic field demonstrates thermodynamic capabilities to modify phase transformation of magnetic materials, especially those with magnetism change during the phase transformation, hence can be used as an additional controlling variable for microstructure tailoring.

In this work, the influence of the magnetic field on diffusional phase transformation in high purity Fe-C alloys was investigated. The magnetic field induced microstructural features and crystallographic orientation characteristics were studied in two different carbon content steels. Results reveal that magnetic field induces aligned and elongated microstructures along the field direction, due to the two scaled magnetic dipolar interaction. Magnetic field increases the amount of ferrite in hypoeutectoid alloys and this field effect becomes more pronounced with the increase of the carbon composition. Magnetic field inhibits the formation of Widmanstätten ferrite by introducing additional driving force to ferritic transformation and thus reducing the need for low energy interface which is required to overcome the transformation barriers during slow cooling process. Magnetic field also induces enhancement of carbon solution in ferrite. *Ab-initio* calculations revealed that the presence of an interstitial carbon atom in bcc Fe modifies the magnetic moments of its neighboring Fe atoms. This leads to the decrease of the demagnetization energy of the system and makes the system energetically more stable under a magnetic field. Due to the atomic-scaled magnetic dipolar interaction, magnetic field favors the nucleation and growth of the ferrite grains with their distorted <001> direction parallel to the transverse field direction, and thus induces the enhancement of the <001> fiber component in the transverse field direction. Three orientation relationships (ORs) between pearlitic ferrite and cementite have been found in the present work. Magnetic field hardly changes the types of the appearing ORs, but it considerably increases the occurrence frequency of the P-P2 OR, by favoring the nucleation of ferrite.

The above results provide insights into magnetic interaction between the applied magnetic field and the treated materials during heat treatments.

Keywords: Magnetic Field, Phase Transformation, Magnetic Dipolar Interaction,
Texture, Orientation Relationship