Magnetic-field-induced novel phenonmenon of the phase transformation in Fe-based alloy

Tingping Hou[1*], *Kaiming Wu*[1]

[1,*]*Wuhan University of Science and Technology, China*

[1*]Houtingping@wust.edu.cn.

[1]Wukaiming@wust.edu.cn.

Abstract.

Nuclear fusion reactors, often referred to as "artificial suns," have the Tokamak as their core device, which features both fully superconducting magnets and active cooling structures. In Tokamaks, the toroidal magnetic confinement of plasma utilizes low-activation steel, which operates under conditions of high temperature and steady strong magnetic fields (300 – 550 ° C, 3 – 4 Tesla). Thus, understanding and controlling the magnetic behavior and phase evolution of iron-based materials under high temperatures and strong magnetic fields are key to unraveling their mechanical and magnetic properties.

Experimental observations have also proven that the microstructures in steels including ferrite, martensite, autenite and precipitates are influenced by high magnetic fields which has a great effect on the stability. This work breaks through the limitations of first-principles calculations under zero magnetic field, absolute zero temperature, and the absence of magnetic fields. By incorporating the effects of magnetic field and temperature within the framework of Weiss molecular field theory, it was found that a strong magnetic field significantly influences atomic diffusion behavior, carbide nucleation, bainite transformation, martensite recovery, and austenite nucleation. The investigation of magnetism evolution could contribute to a better understanding of physical mechanism underlying magnetic field phase transformation in Fe-based materials.

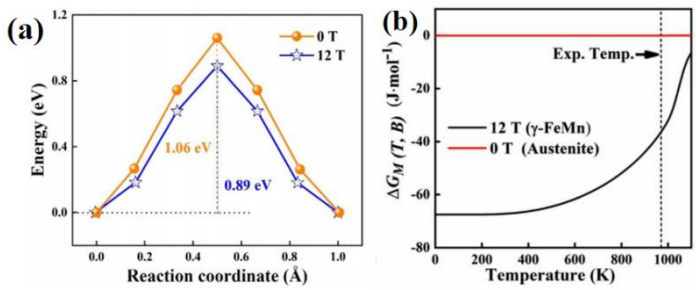

Figure 1. Under zero and high magnetic fields: (a) the energy barrier for carbon atoms transitioning between octahedral interstitial sites; (b) the energy variation of austenite.

[1] D. Zhang, T. Hou, X. Quan, J. Zhou, C. Yin, H. Lin, Z. Lu, K. Wu, Journal of Materials Research and Technology, 25 (2023) 210-221.