The ternary Fe-C-N system: Homogeneous distributions of nitrogen and carbon

The ternary Fe-C-N system was used for synthesizing homogeneous samples of iron carbides and (carbo)nitrides. Homogeneous distributions of interstitial nitrogen and carbon were obtained without long treatment times due to limited required diffusion distances in the porous material. By adjustments of the nitriding and carburizing potentials, tailored nitrogen and carbon contents can be achieved, which allows assessment of a phase stability diagram for the Fe-N-C system, for which available experimental data is limited. Thermal decomposition sequences were established for the various iron carbides and (carbo)nitrides using in situ synchrotron X-ray diffraction. Hägg carbide ($\chi$) and ε-carbonitride, Fe$_2$(N,C)$_{1-z}$, with high carbon content decompose to cementite (θ) above 850 K, while ferrite (α) forms above 950 K and austenite (γ) above 1025 K. For high nitrogen contents $\zeta$ Fe$_2$(N,C)$_{0.5}$ is transformed to ε from 680 to 770 K, which decomposes to γ′ Fe$_4$(N,C)$_{1+x}$ between 795 and 900 K as nitrogen is released as N$_2$. Ferrite forms above 850 K while austenite may be briefly formed around 900 K. The two iron carbides, cementite and Hägg carbide, exhibit different coefficients of thermal expansion. Below approximately 480 K, cementite is ferromagnetic and a volumetric thermal expansion coefficient of $\alpha_V = 1.5 \times 10^{-5} \text{ K}^{-1}$ is obtained. The average value in the paramagnetic state is $\alpha_V = 4.3 (3) \times 10^{-5} \text{ K}^{-1}$. For Hägg carbide the average value is $\alpha_V = 3.8 (5) \times 10^{-5} \text{ K}^{-1}$ and only a minor change in unit cell volume is observed at the magnetic transition temperature.

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