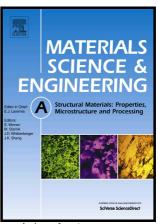
## Author's Accepted Manuscript

Microstructure and property evolution of Fe-N ferrite undergoing early-stages of precipitation

Y. Hong, C.L. Wu, L. Tian, N. Li, Q. Xu, J.H. Chen



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## **ACCEPTED MANUSCRIPT**

## Microstructure and property evolution of Fe-N ferrite undergoing

## early-stages of precipitation

Y. Hong, C. L. Wu\*, L. Tian, N. Li, Q. Xu, J. H. Chen

Center for High-Resolution Electron Microscopy, College of Materials Science & Engineering, Hunan University, Changsha, Hunan 410082, China

\*Corresponding author: E-mail: Tel.: +86 731 88664009; Fax: +86 731 88664010. cuilanwu@hnu.edu.cn

#### **Abstract**

The precipitation-hardening phenomenon is well-known in nitrogen-supersaturated ferrite and its precipitation sequence has received extensive attention. Thus far the  $\alpha''$ -Fe<sub>16</sub>N<sub>2</sub> phase has been known as the main hardening precipitates in the alloy upon ageing at low temperatures. Here we report that distinct precursors (pre- $\alpha''$ ) of the  $\alpha''$ -phase exist and they also play a crucial role in the precipitation-hardened alloy. Using (in-situ) high-resolution transmission electron microscopy, property characterization and first-principle energy calculations in association with varying thermal processes, it is shown that lying on the  $\{001\}_{\alpha}$  planes, the pre- $\alpha''$  precipitates have a plate-like morphology and are the major hardening precipitates in natural aged Fe-N ferrite. They are stable without much change even after tempering at 60 °C for 2 h. Furthermore, the plate-like pre- $\alpha''$  precipitates typically consist of needle-like domains, due to energy minimization. The in-situ observations demonstrate that the precipitation sequence upon ageing is as follows: N-supersaturated  $\alpha$ -Fe  $\rightarrow$  N-rich clusters  $\rightarrow$  pre- $\alpha''$  (GP zones)  $\rightarrow \alpha''$ , where GP zones stands for Guinier-Prestone zones. The pre- $\alpha''$  precipitates can have even more significant effects on properties of the alloy, as compared with the well-known  $\alpha''$  precipitates.

*Keywords*: Fe-N alloys; GP zone;  $\alpha''$  phase; Precipitation; Transmission electron microscopy; Property

#### 1. Introduction

Age-hardening phenomena are often observed in N-supersaturated ferrite or martensite,

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