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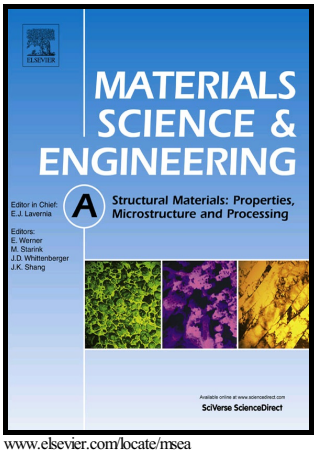


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# Microstructure and property evolution of Fe-N ferrite undergoing early-stages of precipitation

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**Abstract**

The precipitation-hardening phenomenon is well-known in nitrogen-supersaturated ferrite and its precipitation sequence has received extensive attention. Thus far the α″-$Fe_{16}N_2$ phase has been known as the main hardening precipitates in the alloy upon ageing at low temperatures. Here we report that distinct precursors (pre-α″) of the α″-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-α″ 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-α″ 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 α-Fe → N-rich clusters → pre-α″ (GP zones) → α″, where GP zones stands for Guinier-Prestone zones. The pre-α″ precipitates can have even more significant effects on properties of the alloy, as compared with the well-known α″ precipitates.

***Keywords*:** Fe-N alloys; GP zone; α″ phase; Precipitation; Transmission electron microscopy; Property

## 1. Introduction

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