ESRF	**Experiment title:** In-situ Anomalous SAXS measurement at V and Nb K-edges of the precipitation kinetics in medium Mn microalloyed steels	**Experiment number**: MA3529
Beamline: BM02	**Date of experiment**: from: 07 / 04 / 2017 to: 10 / 04 / 2017	**Date of report**: Feb 28 2018
Shifts: 12	**Local contact(s)**: Frederic De Geuser	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Alexis Deschamps, SIMAP – Grenoble INP

Frederic De Geuser, SIMAP

Zelie Tournoud, SIMAP

Patricia Donnadieu, SIMAP

Report:

This experiment aimed at characterizing in-situ the precipitation processes occuring in 3rd generation advanced high strength steels of the "carbide-free bainite" type, based on the Fe-Si-Mn-C system, and more specifically to describe the effect of microalloying additions on the precipitation kinetics. For this purpose, three steels have been studied, with a constant Fe-Si-Mn-C basis, and respective addition of V and Nb microalloying. These steels have been subjected in-situ to various types of heat tretaments, including an austenitization treatment, followed by rapid and controlled cooling to the bainite formation temperature (350, 400 or 450°C) and holding at this temperature. In parallel, samples subjected to prior heat treatments more relevangt to industrial applications have been subjected to futher in-situ annealing to evaluate the evolution of the precipitation processes. Anomalous scattering measurements at the Nb K-edge have been performed on the Nb-containing steel to evaluate if the observed precipitates contained this microalloying element.

Overall the experiments have been very successful, with a satisfactory performance of the furnace for in-situ measurements. Most conditions that were initially considered haven been successfully measured, providing for the first time a complete view of the effect of microalloying on the precipitation in these systems. The interpretation of the results is still under way, however, it will clearly result in a significant part of the PhD thesis of Zelie Tournoud (co-proposer) and several publications.

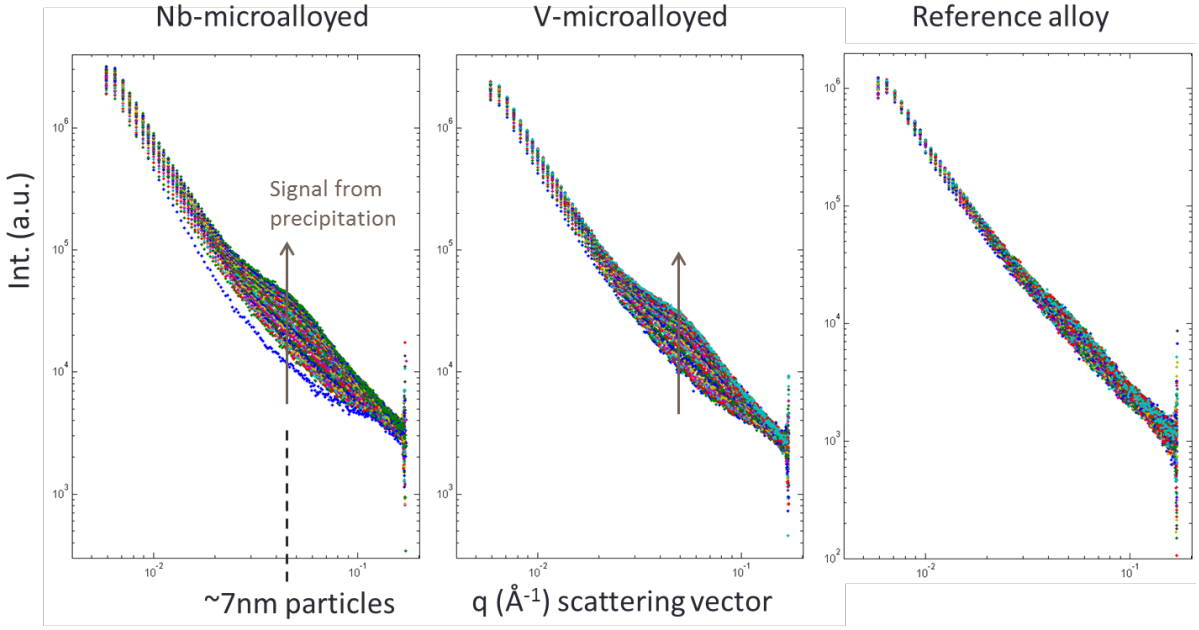

Figure 1: SAXS results during in-situ re-heating and holding at 400°C of samples that were quenched ex-situ after isothermal holding of two minutes. A signal from precipitation of around 7nm particles can be seen for microalloyed samples.

The results above clearly show that a strong precipitation process takes place during isothermal annealing (in this case of samples subjected to 2 min prior annealing in order to control the first stages of the overall austenite-to-ferrite phase transformation).
A strong effect of microalloying is observed, yet anomalmous scattering demonstrates that these precipitates do not contain appreciable amounts of Nb. Therefore an indirect effect of microalloying on precipitation of carbides is demonstrated.

When the fulml heat treatment is realized in-situ (with less controlled cooling from austenitization to annealing) the behaviour is qualitatively the same, however the precipitation process is less pronounced.