Advanced microstructure analysis of ordered domains in thermally aged Ni_2Cr alloy with low iron content

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Ni_2Cr alloys are subjected to chemical ordering with thermal ageing. Ordering modifies the mechanical properties of the alloy, which is a potential issue for their use in industrial applications such as pressurized water reactors. Accurate description of the aged alloy microstructure is then required in order to understand the evolution of its mechanical properties with ageing time. Influence of addition elements such as iron as used for industrial applications is also to be considered. In this work, using complementary TEM techniques, we conducted a full description at various scales of the microstructure of a model Ni_2Cr alloy containing 3% (wt) Fe aged 10,000 hours at 500°C.

First, a global evaluation of the proportion of ordered phase has been obtained using scanning precession electron diffraction phase mapping. Data have been acquired along three different orientations of the initial face-centred cubic disordered structure in order to reveal all the possible $<010>_o$ orthorhombic Ni_2Cr variants growing along the $<110>_{fcc}$ directions of the matrix. Results leaded to about 90% of ordered phase, with a mean domain size of about 50 nm. Acquired at the same scale, electron energy loss spectroscopy (EELS) chemical mapping clearly showed that the iron was essentially segregated around ordered domains. Chemical maps thus gave another visualisation of the ordered domains repartition that fully confirmed the previous analysis. Nevertheless, some iron is still found in the ordered phase. The actual completeness of the state of order of the Ni_2Cr phase has then been studied using a quantitative analysis of microdiffraction patterns acquired on the ordered domains. Results confirmed the non-complete ordering state for the studied domains. Finally, performing probe corrected high-resolution scanning imaging and atomic scale EELS analysis on ordered domains revealed, for the first time in this kind of alloys, that residual iron preferentially substitutes for chromium (Figure 1). This could be of prime importance to understand the growth mechanism of the ordered phase within the disordered matrix.

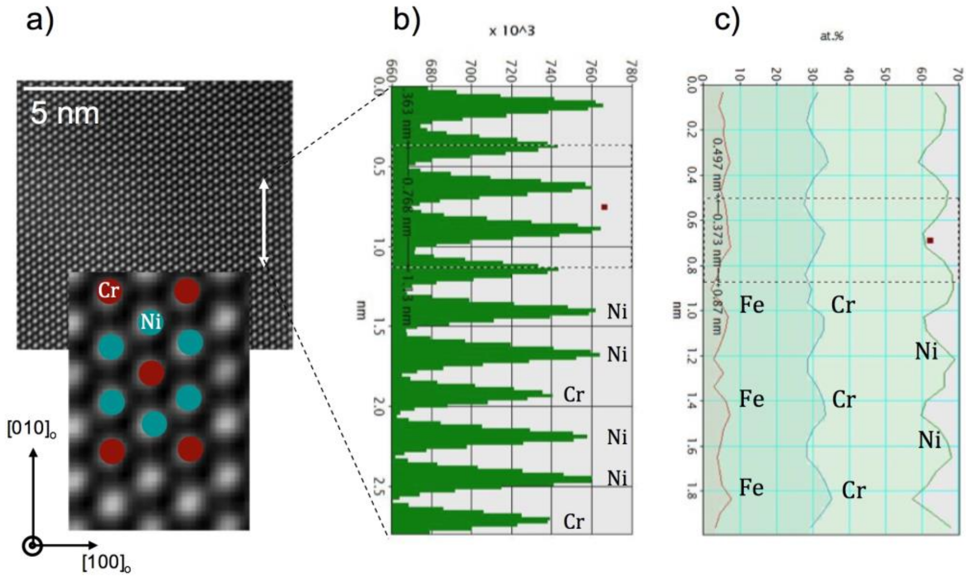

Figure 1: a) Filtered HRSTEM image of an ordered domain together with a projection of the structure superimposed to an enlarged area, b) Intensity profile along the [010] orthorhombic direction (white arrow) and c) composition ratio as deduced from EELS (average profile).