Promoting isothermal martensite formation by high temperature heat treatments in a precipitation hardening austenitic stainless steel

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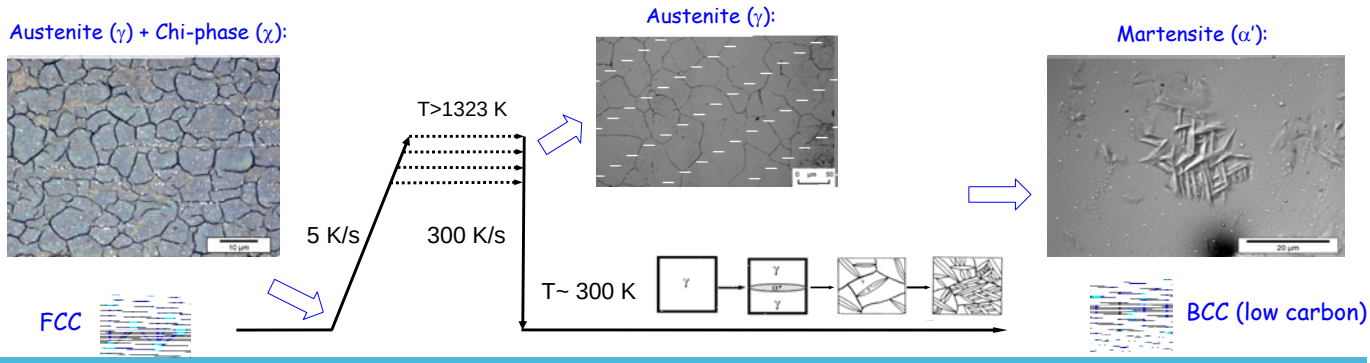
Introduction

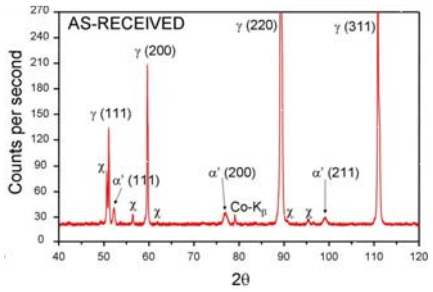
To obtain the final mechanical properties, the steel investigated (12Cr-9Ni-4Mo-2Cu-1Ti) is solution treated and cooled down to 300 K to promote the isothermal formation of martensite, followed by a precipitation stage (723-823 K). This investigation focuses on continuous heating transformations and, specially on the influence of the solution temperature on the isothermal martensite formation.

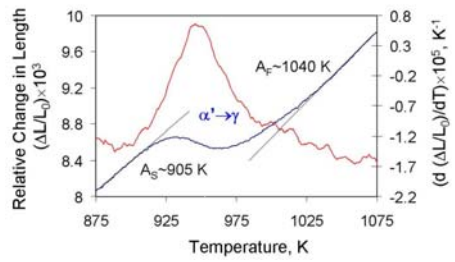


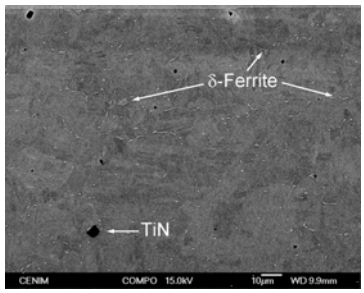
Phase Transformations During Continuous Heating

The initial microstructure is austenitic (~5-10 μm). It contains some isothermal martensite and Chi-phase (χ, $Fe_{32}Cr_{12}Mo_{10}$) precipitates [1]. A fully austenitic microstructure is obtained above A_F~1040 K. Chi-phase precipitates dissolved completely above ~1323 K. Delta (δ) ferrite nucleation is promote above ~1473 K.

Initial Microstructure ⇒ Martensite to Austenite ⇒ Austenite to δ-Ferrite

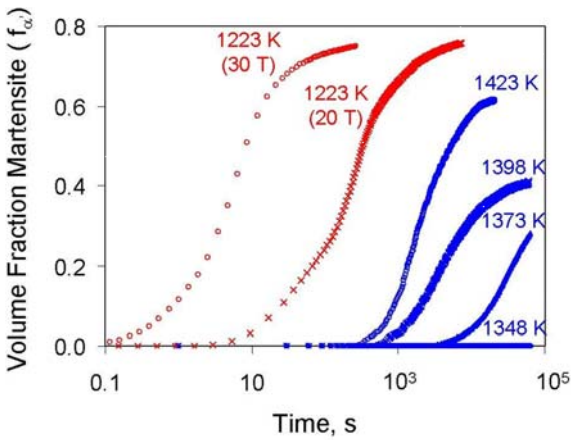




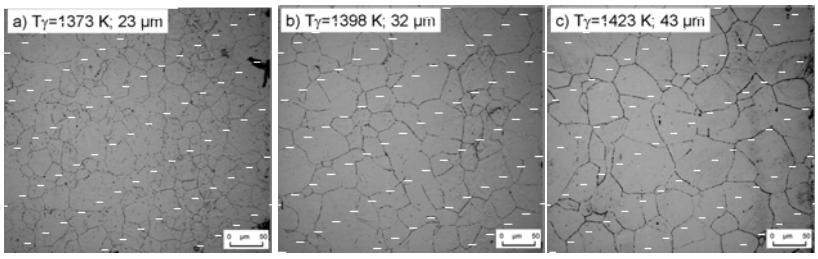


Isothermal Martensite Formation

Solution heat treatments were carried out at 1373, 1398 and 1423 K. As the solution temperature increases, the kinetics of martensite formation at 300 K speeds up (blue curves). The kinetics has been recorded in-situ using dilatometry. The results are compared to those obtain after a solution treatment at 1223 K and isothermal transformation at 233 K under the influence of external applied magnetic fields [2,3].



Evolution of the Prior Austenite Grain Size



Summary

The solution temperature should be above 1040 K in order to promote a microstructure free of martensite. However, this temperature should be above ~1323 K and below ~1473 K to dissolve the χ-phase and prevent δ-ferrite formation, respectively. Finally, it is shown that the higher the solution temperature, the higher the austenite grain size and the faster the kinetics of martensite formation at room temperature. External magnetic fields is an alternative way of promoting this transformation.

[1] D. San Martin, P.E.J. Rivera Diaz del Castillo, E. Peekstok, S. van der Zwaag, Mater. Char. 58 (2007) 455-460.
[2] D. San Martín, K.W.P. Aarts, P.E.J. Rivera-Díaz-del-Castillo, N.H. van Dijk, E. Brück, S. van der Zwaag, J. Magn Magn Mater. 320 (2008) 1722-1728.
[3] D. San Martín, N.H. van Dijk, E. Jiménez-Melero, E. Kampert, U. Zeitler, S. van der Zwaag, Mater. Sci. Eng. A, doi:10.1016/j.msea.2010.04.085.