Effect of alloying elements addition to Fe-Cr system on low-temperature aged microstructure and mechanical properties

Jianling Liu, Wangzhong Mu, Joakim Odqvist, Peter Hedström

Department of Materials Science and Engineering, KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden

Motivation

Phase separation → Fe-rich (α) + Cr-rich (α')
Spinodal Decomposition or Nucleation & Growth

Methodology

Experimental methods:
- Mössbauer spectroscopy (MS), transmission electron microscopy (TEM), atom probe tomography (APT), mechanical tests

Computational methods:
- CALculation of PHAs Diagram (CALPHAD)

Literature review

Fe-Cr-Ni
- Ni increases the hardness.
- Ni accelerates phase separation.

Fe-Cr-Al
- Small Al addition increases the hardness while large addition decreases it.
- Al can promote the kinetics of decomposition.

Fe-Cr-Co
- Co addition can raise and skew the miscibility gap to a lower Cr concentration.
- Co can increase kinetics of phase separation.

CALPHAD Study

Miscibility Gap
- Ni and Co can increase the critical temperature while Al decreases it when their contents increase.
- Al can skew the miscibility gap to a lower Cr concentration, whereas Ni and Co shift the MG to higher Cr concentration.

Driving Force
- Ni addition can accelerate the phase separation of Fe-Cr alloys during aging.
- Ni addition can increase the hardness.
- Small addition of Al can increase hardness while large addition decreases it.
- Ni and Co can raise the miscibility gap while Al decreases it.

Summary

Conclusions
- Ni, Al and Co can accelerate the phase separation of Fe-Cr alloys during aging.
- Ni addition can increase the hardness.
- Small addition of Al can increase hardness while large addition decreases it.
- Ni and Co can raise the miscibility gap while Al decreases it.

Future Plan
- Try to summarize the underlying mechanism of phase separation in the aspects of lattice misfit, electron structure, magnetic properties, etc.
- Investigate the miscibility gap of Fe-Cr-Ni, hardness change of Fe-Cr-Al and magnetic properties of Fe-Cr-Co, etc.

Jianling Liu
- Doctoral student

Department of Materials Science and Engineering, KTH Royal Institute of Technology, Brinellvägen 23, 100 44, Stockholm, Sweden
- Tel: 072 920 80 32
- Email: jianling@kth.se