Human resource development program, application course (metallurgy)

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1. Introduction

High entropy alloys (HEAs), or complex concentrated alloys (CCAs), are newly developed concepts of alloys containing constituent elements in equiatomic or near equiatomic ratio. To enhance their properties more, the modification of microstructure is desired. In this study, we prepared 1%C-doped CoCrFeNi alloy. By adding C as the interstitial alloy element, solute hardening and more likely precipitation hardening are expected. We studied the developments of microstructure and dislocation structure in 1%C-doped CoCrFeNi by rolling and annealing processes by means of the line profile analysis using neutron diffraction data.

2. Experiment

The rolled and annealed samples were inserted into the vanadium cells for the measurement at BL20 iMATERIA. The diffraction pattern was measured by the whole backscattering banks (145° < 2θ < 165°) to evaluate the phase identification dislocation density. Those were respectively analyzed by using MAUD software and Convolution Multiple Whole Profile (CMWP) method.

EBSD and TEM analyses were also applied to see the spatial information about microstructure and dislocation structure.

3. Results

Fig. 1 shows the diffraction patters for the current samples. The evere peak broadening is observed for the as-rolled sample whereas the annealed ones show shaperr shapes. It is also noted that the peaks for $M_{23}C_6$ carbides are more obvious for the samles annealed at higher temeratures.

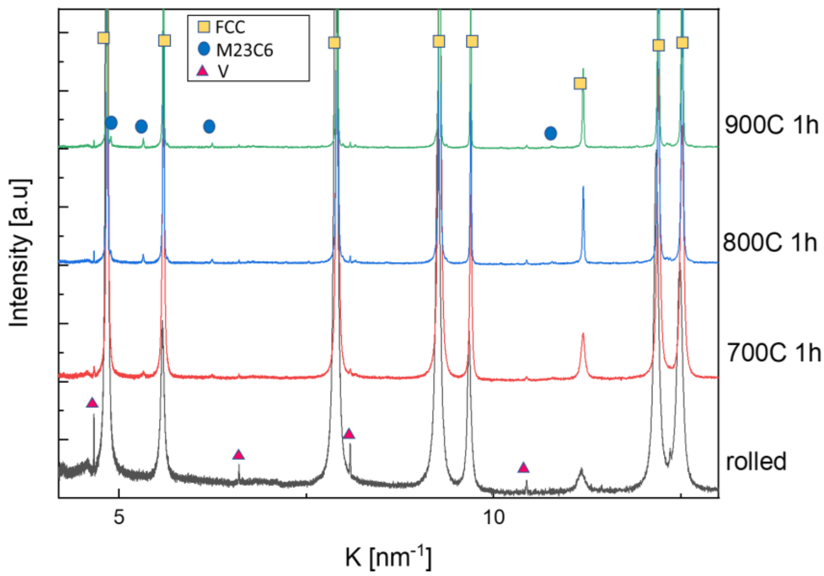

Fig. 1 Neutron diffraction patterns of 1 %C-doped CoCrFeNi CCA after cold rolling and 1 h of annealing at 973 K, 1073 K and 1173 K.

The results of quantitative analyses for the carbide fraction and dislocation density are shown in Fig. 2. As long as the author knows, This is the first atempt to determine the $M_{23}C_6$ type carbide fraction, quantitatively. The dislocation density of the as rolled sample reached to 10^{16} m^{-2}, which cannot be reached by moderate rolling, just 60% of thickness reduction. This is one of the particular features of this alloy, probably due to the solute hardening effect by interstitial carbon in highly distorted lattice.

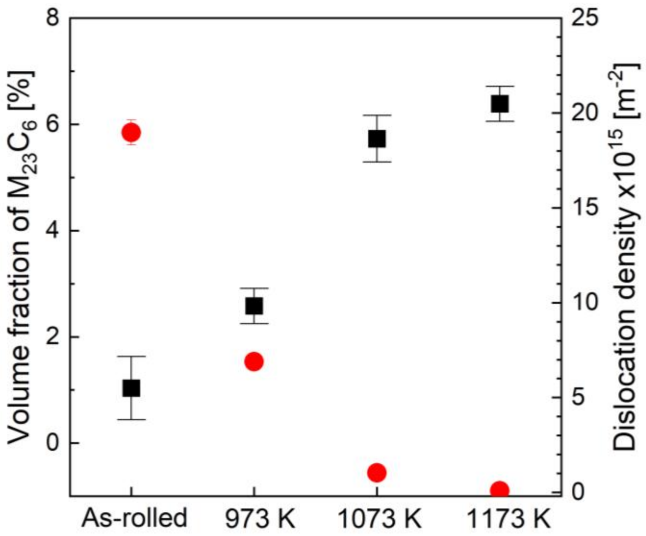

Fig. 2 Volume fraction of $M_{23}C_6$ phase (black square) and dislocation density (red circle) of 1 %C-doped CoCrFeNi CCA after cold rolling and 1 h of annealing at 973 K, 1073 K and 1173 K.

4. Conclusion

The microstructure evolution by 60% rolling and subsequent annealing in1%C-dope CoCrFeNi was studied by using neutron diffraction and electron microscopy. The line profile analysis revealed quite high dislocation density after rolling, which indicated a high stored strain energy was introduced. This brought the fine recrystallized grains after annealing. At higher annealing temperatures, more carbide particles were precipitated, which might retard the grain growth. As the conclusion, addition of carbon has beneficial effects on the modification of microstructure by mechanical and thermal processing.