In-situ transformation texture determination and transformation behavior analysis in electrical steels, titanium and high Mn steels

University of Science and Technology Beijing. Ping YANG

1. Introduction

The in-situ neutron diffraction technique equipped with heating and loading capability is very powerful to reveal the complicated mechanisms of phase transformation and texture formation influenced by deformation. In this study three kinds of materials are selected for such issues, they are high Mn steel sheets with sandwich structure, low Si electrical steels with columnar grains and rolled pure Ti sheets. The understanding of such complicated mechanisms is the key to improve the deep drawing ability, the magnetic property and the mechanical property of materials respectively.

2. Experiment

The high Mn steel sheets with Fe-16.58Mn-3.32Si-1Al-0.02C are hot rolled and annealed in vacuum for Mn removal from sheet surface so as to produce a special sandwich structured sheets with hard ferrite surface layers. These sheets are tensile deformed at room temperature and 250°C for in-situ neutron diffraction analysis. The 0.35Si/0.64Si electrical steels are cut from cast slabs containing {100} columnar grains and small ferrite variants due to transformation. They are heated to nearly 1000°C to distinguish the phase transformation behaviors of small ferrite variants from that of matrix coarse columnar grains by in-situ neutron diffraction. The pure Ti sheets are also heated to transformation temperature of about 900°C and then subjected to tensile deformation under the in-situ neutron diffraction to determine if dynamic transformation can take place.

3. Results

3.1 high Mn TRIP steel

The σ-ε curves at two temperatures are shown in Fig.1. The zig-zag positions in two curves are due to the loading stop for data acquisition. A higher strain hardening rate for TRIP process at room temperature is seen, whereas no TRIP process is present at 250°C during loading. Fig.2 shows the volume fractions of three phases during loading which indicate the transformation kinetics. It is seen that no transformation occurs at 250°C during loading.

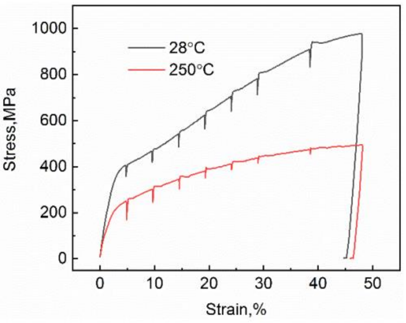

Fig.1 σ-ε curves at two temperatures.

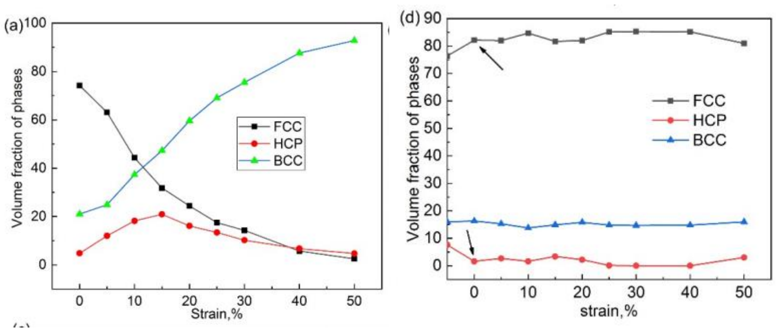

Fig.2 transformation kinetics at two temperatures

Fig.3 shows the evolution of texture components in FCC and BCC phases during straining at room temperatures. During tensile loading, the <100> texture in FCC phase of center layer decreases and <111> texture increases, whereas the <110> texture decreases faster than those of <100> and <111> textures in BCC phases of ferrite and α′-martensite. These results are used in the doctoral thesis supervised by principle investigator.

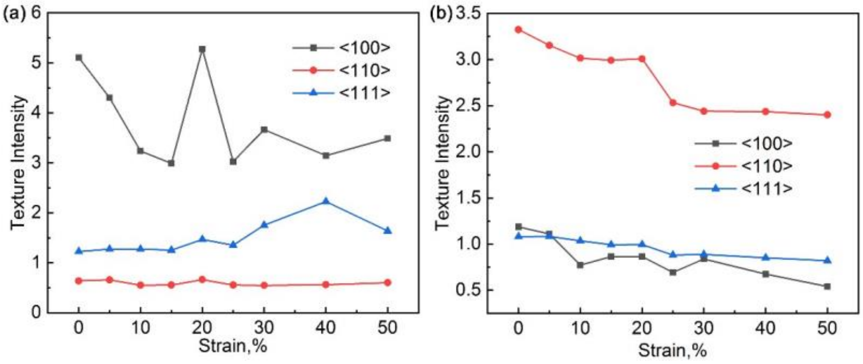

Fig.3 Evolution of texture components during tensile loading in high Mn steel, at 28°C. (a)austenite in center layer; (b)ferrite in surface and α′ martensite in center layer

3.2 Low Si electrical steels

For 0.35Si steel, at 1000°C, around 20% of austenite is determined by in-situ neutron diffraction. Since this sample contains mainly coarse columnar ferrite grains and roughly 20-30% fraction of small ferrite variants, it can be easily determined that this 20% austenite must be transformed from the small grains, rather than columnar grains. This confirms the dependency of transformation temperature on initial grain sizes. For 0.64Si steel, a lower fraction of austenite at 1000C is determined. According to the detected austenite fractions, the {100} ferrite subgrains should not transformed. A detailed analysis will be performed after processing whole data.

3.3 pure Ti sheet (TA2)

At 890°C before deformation, the fraction of alpha Ti was determined to be ~11%. However, sheet was broken at tensile straining to 50% and temperature was dropped to 860°C where the average fraction of alpha Ti was 26%. At 800°C the α phase fraction was 53%. A detailed analysis will be performed after processing whole data.

4. Conclusion

1) At room temperature, the center austenite layer in high Mn steel experienced the TRIP process which is similar to normal austenite single phase material, whereas at 250°C no TRIP process occurs during loading.

2) For low Si electrical steel, only small ferrite grains transform to austenite at 950-1000°C with <100> coarse ferrite grains remaining untransformed.

3) For pure Ti, the transformation of β to α is not enhanced by tensile deformation of 50% and even cooled to 800°C the transformed α phase is only about 53%. Due to the sheet rupture at the straining of 50% and subsequent temperature drop to 860°C, no exact information on dynamic transformation and texture is obtained. A lower strain should be applied in future experiment.