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Superdense microbands strengthening of textured low alloy ferritic steel

Lei Cheng[a,c], Qingwu Cai [b,]*, Jinlong Lv[c], Wei Yu[a], Hideo Miura[c]

[a] Institute of Engineering Technology, University of Science and Technology Beijing, Beijing 100083, China

[b] Collaborative Innovation Center of Steel Technology, University of Science and Technology Beijing, Beijing 100083, China

[c] Fracture and Reliability Research Institute, School of Engineering, Tohoku University, Sendai 9808579, Japan

* Corresponding author.

E-mail address: caiqw@nercar.ustb.edu.cn

Abstract: Microstructure evolution of Ti-Mo microalloyed ferritic steel was studied via warm rolling process. Results revealed that rolling at 500 ℃ (R3) mainly facilitated the formation of superdense microbands (~200 nm in spacing), especially in the γ textured region. Average spacing of microbands (MBs) increased with temperature and it turned to be about 850 nm when rolling at 650 ℃ (R2). As rolling temperature further increased to 700 ℃ (R1), average ferritic grain size was refined to near 1.9 μm whereas no MBs appeared. Additionally, due to the preexisting superdense MBs, ultimate tensile stress of R3 increased to 1041 MPa and the elongation kept high at 22.9% simultaneously. MBs are characterized by high density dislocation walls and formed through the activation of {112}<111> slip systems, which is induced by the pile up of dislocations during grain boundary sliding. In that process steps appear in the grain boundary and gradually heighten with the extension of MBs. Large dynamic recovery rate could slack the dislocation pile up rate and increase the spacing of MBs. Moreover, preexisting of superdense MBs sheds new insights on the development of high strength ferritic steels with excellent combination of strength and ductility.

Keywords: Ferritic steel; Microbands; Ductility; Texture; Warm rolling

1. Introduction:

Low alloy ferritic steels as structural material are widely used in architecture, high-pressure vessel and so on. In recent years, grain refinement and nanoscale precipitation as main mechanism improved the yield strength of ferritic steels to 700~800 MPa, whereas the ductility decreased more seriously [1-3], especially for the nanoscale microstructures [4, 5]. Moreover, ferritic steels with yield strength more than 800MPa generally show large yield ratio (>0.9) [6, 7], which implies they are unsafe in various service conditions. Unlike multiphase steels, where ductility can be enhanced by transformation induced plasticity (TRIP) [8] or twinning induced plasticity (TWIP) [9, 10], ductility of ferritic steels is hard to be improved, especially when the strength has been increased significantly.

Deformation of polycrystalline materials mainly involve slip process, during which dislocations arrange orderly to homogenize the macroscopic strain. It is reported that during tensile process, formation of microbands (MBs) in metals with FCC structure [11], such as high-Mn steel [12-15] and aluminum alloy [16], could induce plasticity effect (MBIP). Additionally, this effect will bring a continuous strain hardening [13] and restrain the fracture of material [16, 17],