Carbide Clusters in Ti-Mo Microalloyed Steels: A HR-STEM and APT Study

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Carbide clusters and nano-precipitates have been successfully introduced in Ti-Mo microalloyed steels to strengthen the ferrite phase, while maintain good ductility and flangeability [1, 2]. Clusters are often considered as the early-form of nano-precipitates. Although the crystal structure and morphology of carbide precipitates have been well characterized for steels, the structure of carbide clusters is still unknown, which is mainly due to their small size and the ferromagnetic property of steel matrix. The lack of fundamental understanding of carbide clusters has hindered the development of mechanism for the early stage of precipitation.

In this work, we've successfully used high-resolution scanning transmission electron microscopy (HR-STEM) and atom probe tomography (APT) to characterize the carbide cluster and nano-precipitates in a Ti-Mo microalloyed steel (Fe-0.04C-1.52Mn-0.2Si-0.22Mo-0.05Ti wt. %). By combining HR-STEM and APT, it provides invaluable information for the crystal structure, chemical composition, and size distributions of carbide clusters and nano-precipitates. The HR-STEM results show that carbide clusters have disc-shape of 2-6 nm in diameter and several atomic layers in thickness. The carbide clusters have the same lattice structure as ferrite matrix, which is different from the NaCl crystal structure of carbide nano-precipitates. The APT results shows that the carbide clusters are composed of (Ti, Mo)C, and their chemical composition has little dependence on cluster size. Furthermore, an intermediate precipitation stage, named GP cluster, has found between the carbide cluster and nano-precipitates, which is analogous to the Guinier-Preston zones in Al alloys.

References

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