3-dimensional Atom Probe Analysis on Intergranular Segregation and Precipitation Behavior in Ti-Nb stabilized low Cr Ferritic Stainless Steel

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The general method to prevent the intergranular corrosion (IGC) is to reduce the content of carbon and nitrogen and to add the stabilizer such as Ti and Nb. For type 409L ferritic stainless steel (FSS) which contains 11% Cr, the commercial practice generally recommends to add the stabilizer more than 16~20 times the total amount of carbon and nitrogen. However, our previous studies have reported that IGC occurs in 409L steel by segregation and consequent depletion of Cr near the grain boundary even though stabilizer is added up to 20 times the total amount of carbon and nitrogen.

To resolve a clear and direct evidence of segregation of un-reacted Cr in the grain boundary, transmission electron microscope (TEM) with electron energy loss spectroscopy (EELS) and 3-dimensional atom probe (3DAP) analysis were performed. The material used in this experiment was 11% Cr FSS stabilized with Ti and Nb. The specimen was solution-treated at 1300 ^{o}C for 10 min, quenched by water, and then aged at 500 ^{o}C in 5 min, 30 min, 2 hr and 100 hr.

In the early stage of aging for 5 min, segregation of Ti and C was observed along the grain boundary. After 30 min aging, Nb and Cr diffused to grain boundary and (Ti,Nb)C precipitates were observed with weak signal of Cr mapping overlapped with the precipitate. By TEM and 3DAP analysis, it was verified that (Ti,Nb)C precipitates formed along the grain boundary instead of Cr carbide, and segregation and consequent depletion of Cr induced IGC.