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Colossal Carbon Supersaturation of Delta Ferrite in 17-7 PH Stainless Steel

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Low processing temperatures allow an interstitially-hardened case to be formed on the alloy with no carbide formation [1]; a "colossal" carbon supersaturation can be achieved in austenitic stainless steels such as the 316L grade [1, 2]. In addition to the notable mechanical property improvements [3, 4], such interstitially-hardened stainless steels show surprising improvements in corrosion resistance in marine environment [5].

Low-temperature carburization has been successfully used to surface harden 17-7 precipitation hardening stainless steel, a semiaustenitic steel containing austenite, martensite, and delta ferrite. Under TEM (transmission electron microscopy), stainless steel 17-7 PH exposed to gas-phase carburization at low temperature reveals delta ferrite grains that show no diffraction contrast from extended structural defects. Plates of this "TEM-featureless" phase were observed in the ferrite grains near the interface between the carbon-infused layer and the non-carburized core. Compositional analysis shows that these grains contain carbon concentrations that are orders of magnitude higher than the solubility limit (as high as 18 at.%). However, TEM diffraction does not reveal any sign of tetragonality (<5 %) or precipitation.

A model based on segregation of carbon interstitials into dislocation cores is proposed, the featureless appearance being ascribed to strain field overlap of a massive dislocation network.

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