Microstructural caracterization of Ti-added ultra-low carbon interstitial-free steel submitted by drawing test

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Ultra-low carbon interstitial-free (IF) steels are extensively used in cold forming operation, basically in automobile body application. In order to avoid strain aging (Lüders bands), the "C" and "N" content must be maintained below 50 wt ppm by vacuum degassing and, further, the "C" and "N" must be removed from solid solution (stabilized) by the addition of "Ti" and/or "Nb". During the termomechanical treatment occurs precipitation processes ($Ti_4C_2S_2$, TiC, TiS, NbC, etc.) [1]

In this study was used samples of galvanized titanium based IF steel (basically 0,0020% C, 0,0023% N and 0,065% Ti, by weight). Mechanical properties were determined by tensile tests (YS= 160MPa, TS= 320MPa, EL(%)= 50%, r = 2,5). The drawability was determined by Olsen test and the Ti-IF steel presented extra deep-drawing quality (sheet thickness = 0,85 mm, Tension= 160PSI, and drawability index = 12,1 mm).

The drawed steel was investigated in a TEM with voltage accelerating of 200kV, Jeol JEM 200C . After deep-drawing the material acquired a shape of a crater. The microstructural investigation localized above the crater (region 1), at the crater wall (region 2) and at the bottom of the crater (region 3). Thin foil were first mechanically thinned to approximated 0,1 - 0,13 mm by wet grinding on 320, 400, 600 and 1200 grit SiC paper. Discs with 3 mm diameter were punched out. The discs were then polished at room temperature (0 - 10°C) to perforation in a tenupol twinjet electro-polisher with an electrolyte of 10% perchloric acid and 90% methanol (by volume) at a polishing current of approximately 450 mA.

The figure 1 shows inner grain with a few dislocation structure generated during termomechanical treatments. There are fine precipitates of TiC, $Ti_4C_2S_2$ and TiS. The figure still shows interaction between precipitates and dislocations. Hier, the dislocations curved during interaction. The grain size in region 1 was more uniforme than another regions. In the crater wall (region 2) the grains are elongated due to stretching deformation. In figure 2, inner grain are composed by small sub-grain generates by dislocation arrangement. Microbands are still created in response to deep-drawing. Inner original grains exhibit very small sub-grain and dense dislocation structure with creation of cells (figure 3).

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Reference

1. Kitamura M. et al., *Effect oc Carburizing after Recristalization on Formability of Ultra Low Carbon Ti-added Cold-rolled Sheet Steels*, ISIJ International, Vol 34, p.115, 1994.

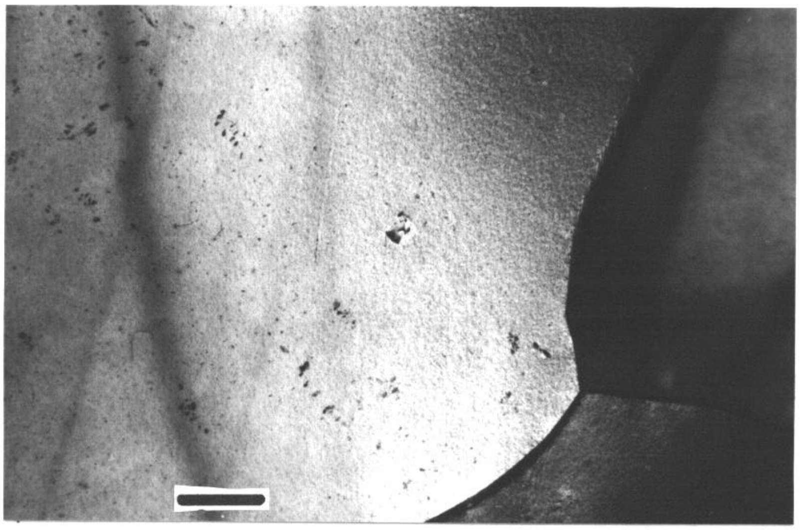

FIG. 1 - Inner grain (region 1) with interaction between fine precipitates and dislocations. Zone axis = (111). Bar = 2μm

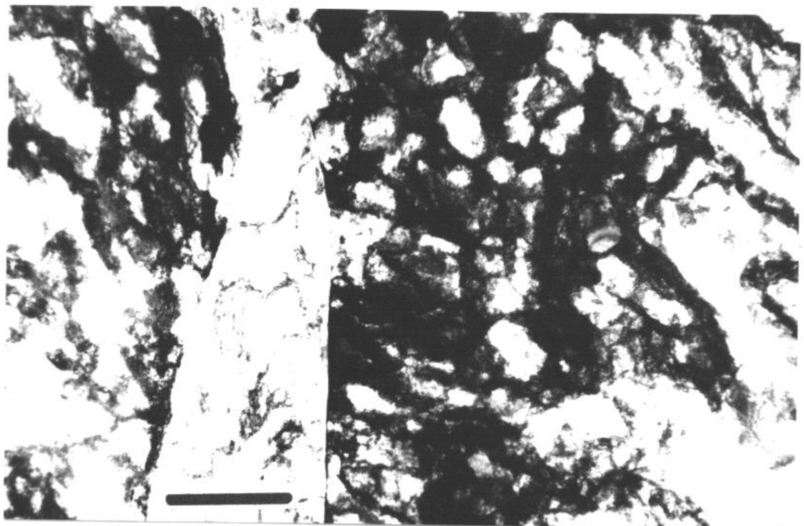

FIG. 2 - Inner grain (crater wall) with formation of small sub-grain and microbands due to deep-drawing. Zone axis = (111). Bar = 2μm.

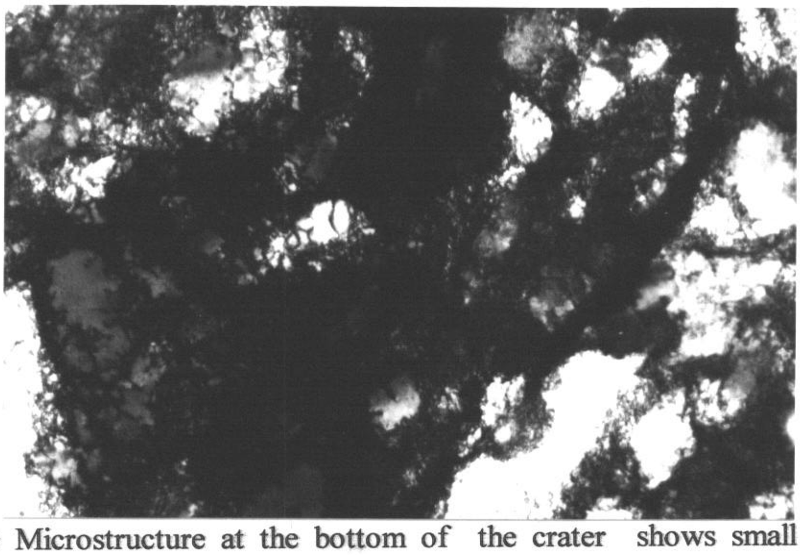

FIG. 3 - The Microstructure at the bottom of the crater shows small sub-grain and dense dislocation structure with creation of cell. Zone axis = (111). Bar = 2μm.