MICROSTRUCTURE AND DISLOCATION SUBSTRUCTURE IN DUAL-PHASE STEELS SUBMITTED TO FATIGUE TESTS.

*Antonio Jorge Abdalla, *Tomaz Manabu Hashimoto,
◆Waldemar Alfredo Monteiro

*UNESP - Guaratinguetá - Av. Ariberto Pereira da Cunha, 333 - 12500-000 Guaratinguetá - SP
e-mail - dmt@feg.unesp.br
◆ IPEN - Instituto de Pesquisas Energéticas e Nucleares, Divisão de Materiais Metálicos.
Cidade Universitária - São Paulo - Caixa Postal 11049 - CEP 05422-970 São Paulo - SP
e-mail - wamontei@net.ipen.br

The dual phase steels are an important kind of steels with great potential of application, mainly in automobilist industry [1]. Its microstructure has a martensitic hard phase and a ferritic ductile phase, and sometimes bainitic and austenite residual due to intercritical heat treatment. The phase's combination guarantee to dual-phase steels good ductility and high values of mechanical properties [2,3].

In the present work a USI - RW - 450 steel, containing 0,1% of carbon, niobium microalloyed, was submitted to intercritical quenching at 760 °C, obtaining a ferrite matrix with small island of martensite. The volumetric fraction of martensite was 13%. This treatment promotes an increase of yield strength and tensile strength, up to composing with the annealed steel and an increase of up to 20% comparing with the laminated steel.

Table 1 shows the yield strength, tensile strength and the elongation for the USI - RW - 500 with three different situations: annealed steel, laminated steel and dual-phase steel.

Table 1 - Mechanical Properties

	Yield Strength (MPa)	Tensile Strength (MPa)	Elongation (%)
Annealed Steel	269	350	41,7
Laminated steel	415	512	30,1
Dual-phase steel	483	661	13,4

After that was prepared fatigue tests samples with the aim of study the microstructure and the evolution of formed dislocations substructure.

Three different types of steel were studied and tested in a fatigue machine. The fatigue life of dual-phase steel was bigger compared with others two steels. The interrupted tests were realized by using to the dual-phase steel for several fatigue life material conditions percentage. For each fatigue life percentage was prepared specimens to be observed in Transmission Electron Microscope (Tip-Jeol / 200 kV – grinned and thinned in a Tenupol Machine).

The figure 1 shows the formation of martensic phase as small island (dark) in the ferritic matrix (white and gray). This is the general aspect of the microstructure of the material.

The figure 2 shows a martensitic phase (dark) and around it small bainitic phase. This grain is surrounded by ferritic grains.

The figure 3 shows some dislocations inside the ferritic grain. It can be showed that some present precipitates (carbides) acting like dislocations barrier. The low dislocation density is associated with the non-tested material.

The bainite increases the synergism between hard and ductile phases.

The figure 4 shows the aligned dislocations formed during fatigue tests. These dislocations are predominant and were developed in the ferritic phase.

The figure 5 shows several dislocations inside the ferritic grain. These dislocations were created during the fatigue tests.

The figure 6 shows the formation of some dislocation in the martensitic phase grain. In the martensitic phase appeared a small quantity of dislocations when in the ferritic phase for identical number of cycles was observed a complex arrangement of dislocation.

The figures 7 and 8 show intensive dislocation arrangements with appearance inside of the ferritic grain. These cellular arrangements are typical from 1% of life in fatigue and return well marked in a later stage.

The fatigue test showed that the hard phase, acted like a resistance wall to the pressure caus

ed by the dislocations and near the final rupture occurred the martensitic phase yield. The final dislocation substructure before the rupture was the cell formation in the ferritic phase with bigger concentration near martensitic phase.

REFERENCES

[1] Nolasco, C.A., Metalurgia, ABM, v. 39, nº 302, p.5-10, 1983.

[2] Dakkalöglu, A.; Prakt. Metallogr. 33, pg 146-153, 1996.

[3] Cribb, W.R. and Rigsbee, J.M., R.A.Kot. Morris, eds, TMS- AIME, Warrendale, p. 91- 114, 1979.

Figure 1 - The general aspect of the microstructure (TEM)

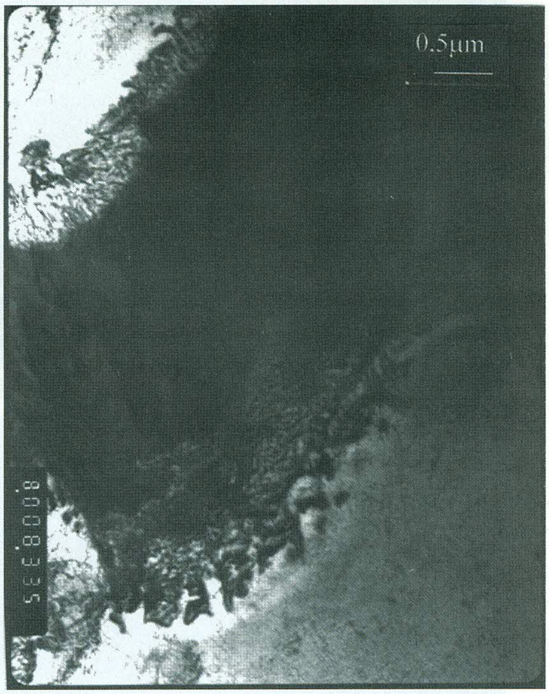

Figure 2 - The martensitic phase (dark) and around at small bainitic phase (ramified) between ferrite grains (white and gray) (TEM)

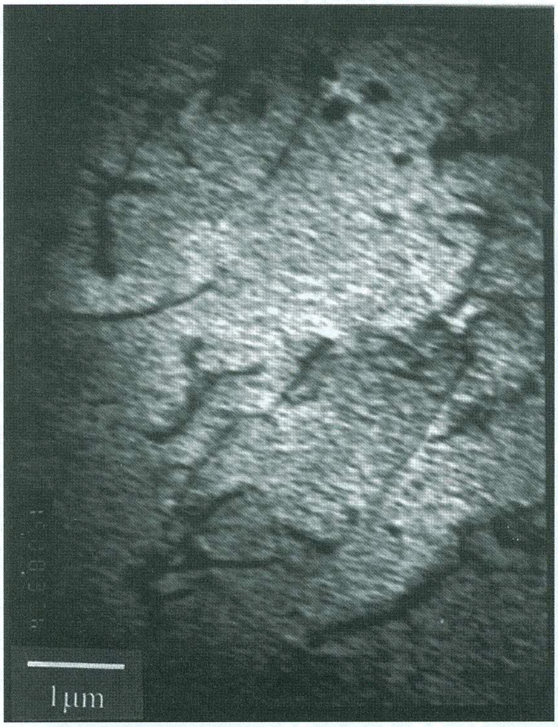

Figure 3 – Dislocation inside the ferrite grain (specimens no tested (TEM)

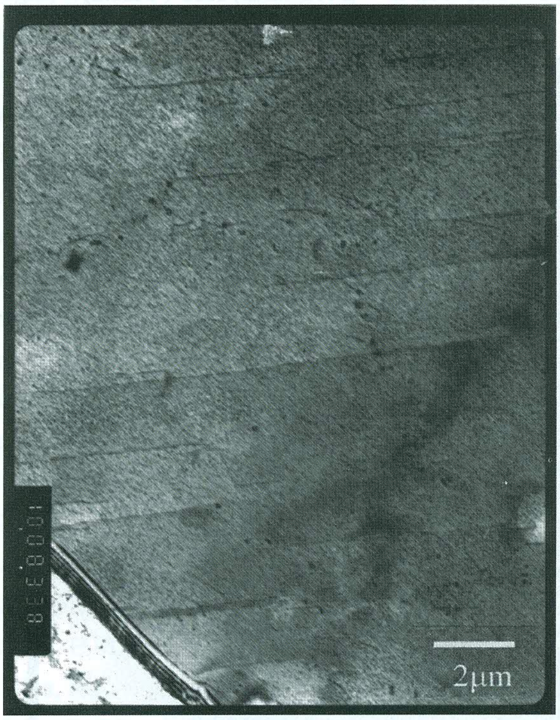

Figure 4 – Aligned dislocations formed during fatigue test. (Tested in fatigue - 3% of life - 615 MPa - 2.013 cycles)

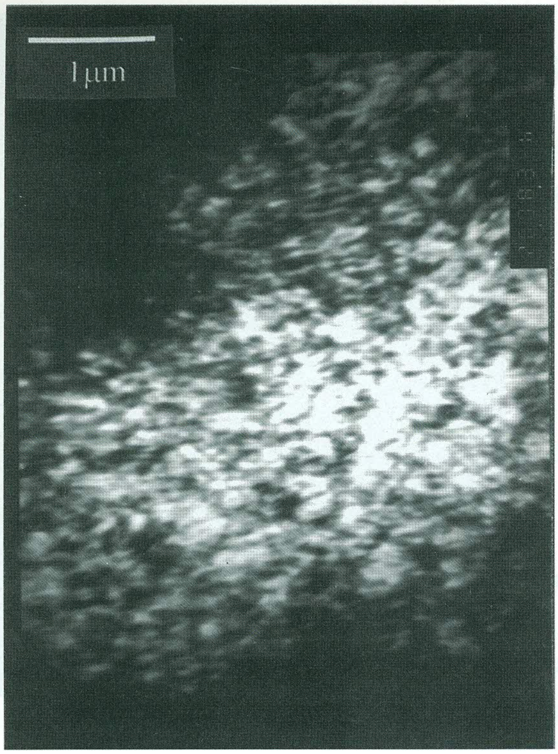

Figure 5 - Arrangement of dislocations inside ferritic grain (tested in fatigue - 40% of life - 615 MPa - 26.842 cycles (TEM)

Figure 6 - Dislocations inside the martensitic grain (tested in fatigue - 40% of life - 615 MPa - 26.842 cycles) (TEM)

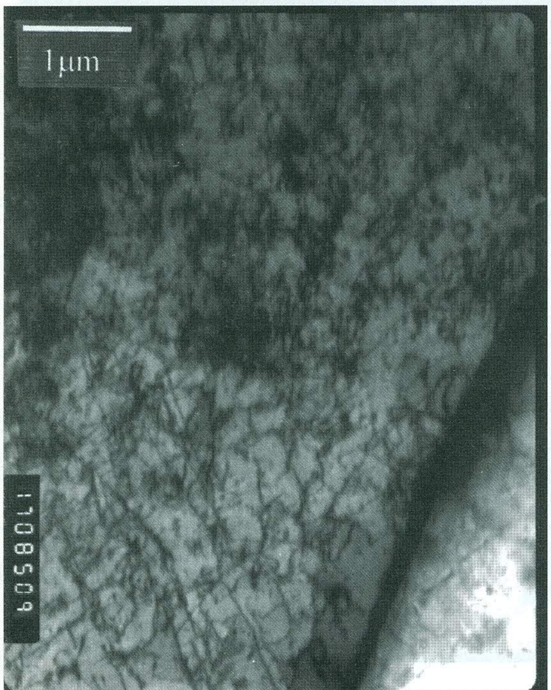

Figure 7 – Dislocation inside the ferric grain, near of grain boundaries (tested in fatigue – 6% of life – 615 MPa - 4.026 cycles) (TEM)

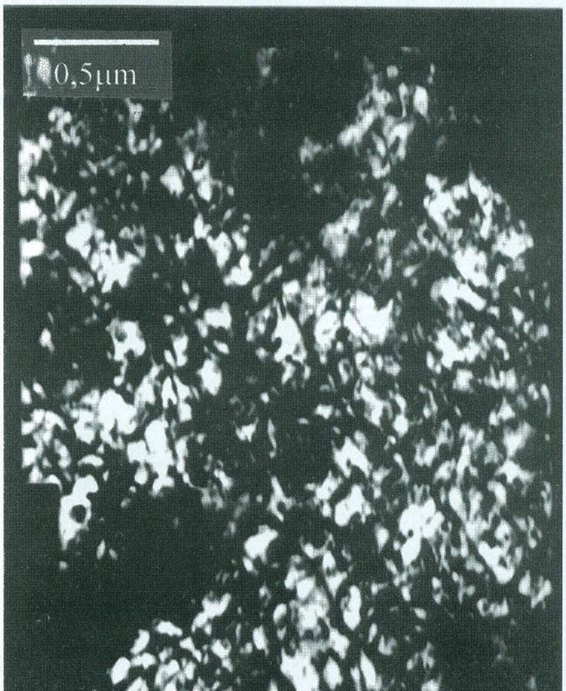

Figure 8 - Dislocations cells formed inside ferritic grain (tested in fatigue - 80% of life - 615 MPa - 53.684 cycles)