

A Novel Preparation Method for Lean Duplex Steels

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Within many areas of the chemical, power and paper industry as well as in oil and petrol production high corrosion resistant steels are used. It is well known that chromium is the key element to enhance the resistance against corrosion attack. Additional alloying elements like nickel, molybdenum, manganese and/or nitrogen are used to change the lattice structure and to improve mechanical and/or chemical properties. During the last years the commodity price of nickel and molybdenum is significantly increased. Consequently, steels with low nickel and molybdenum content have been developed. The so-called lean duplex steels like LDX 2101 (X2CrMnNiN22-5-2) and SAF 2304 (X2CrNiN23-4) are a good substitute for high alloyed austenitic stainless steels.

In order to obtain information about the microstructural changes of lean duplex steels after a heat treatment at 475 °C and 700 °C, which has a great influence on mechanical and chemical properties [1], a new preparation method based on [2] has been developed. First attempts, however, have led to unsatisfying results as depicted in Fig 1. Austenite and ferrite are distinguishable, but grain boundaries within the individual phases are not clearly visible. Unfortunately, scanning electron microscope (SEM) observations show deformation pattern (Fig. 2). Such a surface condition does not allow for any electron back scatter diffraction (EBSD) investigations. The newly developed preparation method listed in Tab. 1, in combination with electrolytic etching, gives a very clear identification of the austenite and ferrite phases as well as their grain boundaries (Fig. 3a, b).

Furthermore, this method is also useful to investigate the microstructure after annealing. A heat treatment of these steels at 700 °C for 30 hours leads to precipitation of carbides and nitrides as well as of σ -phase. This can be seen from the inserts in Figs. 3a, b. Additionally, a fraction of ferrite is transformed to secondary austenite (γ_2). It should be mentioned that this preparation method (Tab. 1) is also suitable for EBSD investigations in order to clarify the different phases after heating (Fig. 4).

TABLE 1. Preparation method for lean duplex steels, “</>” rotating direction of specimen holder and grinding or polishing disk (denotations according to Struers)

grinding						
granularity	time [s]	force [N]	specimens	direction	cooling	rpm
500	540	70	6	</>	water	300
800	120	70	6	</>	water	300
1200	90	70	6	</>	water	300
2400	90	70	6	</>	water	300
4000	120	70	6	</>	water	300
comment: during grinding with granularity 500, the paper was changed every 3 minutes						
polishing						
surface	time [s]	force [N]	specimens	direction	polishing agent	rpm
MD Mol.	480	90	6	</>	DP-susp. 3 μ m	150
MD Chem.	600	60	6	>/<	OP-U + H ₂ O	150

References

- [1] K. S. Ragger et al., BHM 9 (2010)
- [2] Struers Ltd., Preparation Method of Pure Iron, Information report no. 1829

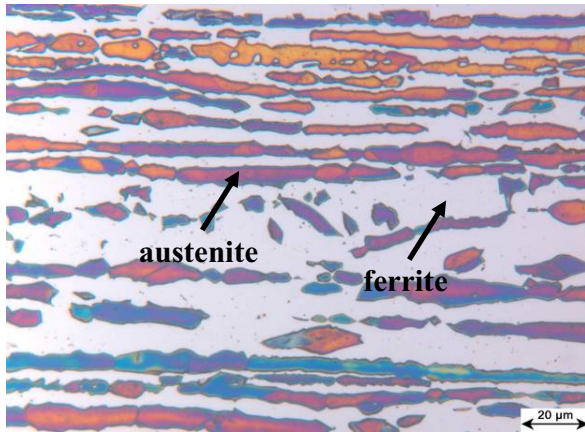


FIG. 1. SAF 2304 after solution annealing and preparation after [2], etching according to “Lichtenegger-Bloech”; light-optical microscopy

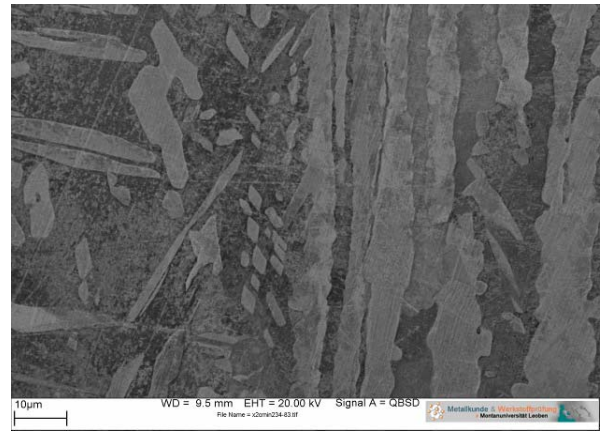


FIG. 2. SAF 2304 after solution annealing and preparation after [2], no etching, SEM investigation; deformation pattern are visible

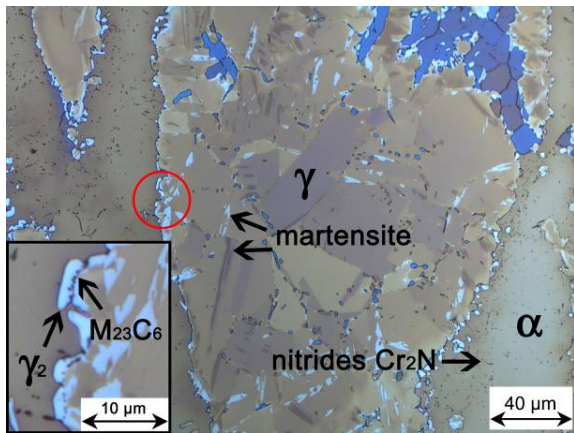


FIG. 3a. LDX 2101 after annealing at 700 °C for 30 hours, preparation method according to Tab. 1, etching 40 % NaOH/2V/43sec, light microscopy

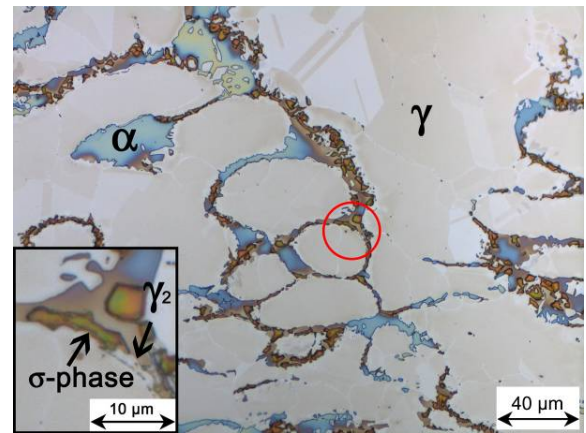


FIG. 3b. SAF 2304 after annealing at 700 °C for 30 hours, preparation method according to Tab. 1, etching 40 % NaOH/2V/43sec, light microscopy

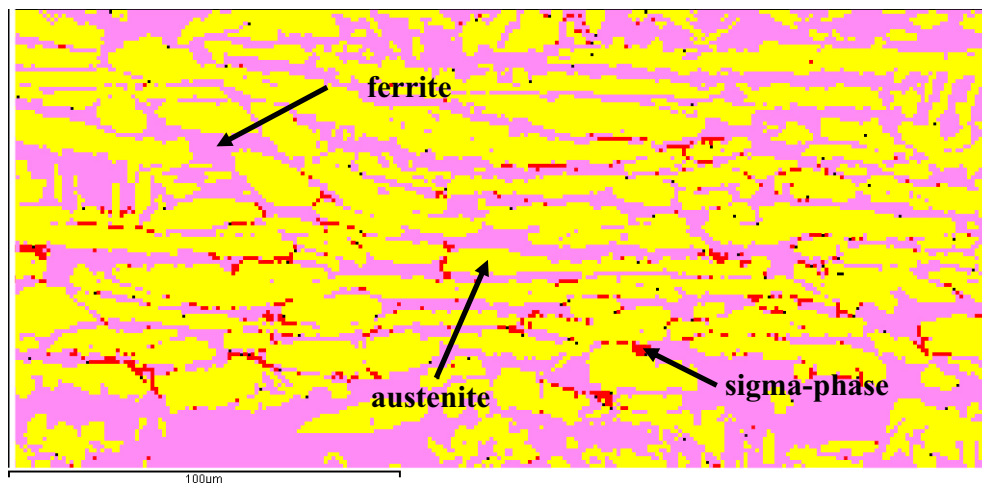


FIG. 4. SAF 2304 after annealing at 700°C for 30 hours, preparation method according to Tab. 1, no etching; SEM-EBSD image