Summary

This thesis deals with the investigation of grain boundary engineering processes in case of steels. The effects of the treatments for the modification of the grain boundary structure are demonstrated on the special grain boundaries in AISI 304 type austenitic stainless steel.

After the introduction of the general properties of the grain boundaries, the physical phenomena influenced by the grain boundaries are summarized and the special grain boundary types are characterized. The often used models for the description of the special, geometrically periodic grain boundaries are studied – especially the prevailing Concident Site Lattice (CSL) model which is also used during the investigations presented in the thesis. The optical, x-ray and electron microscopic methods and equipments are described which are capable for the examination of the grain boundary structure. The EBSD-equipment operating based on the phenomenon of electron back scattered diffraction (EBSD) is reviewed in detail. The thermo-mechanical treatment types applied in metal processing are summarized, highlighting the treatment generally used for the engineering of grain boundary structure. The published scientific results of the former researches for the modification of the grain boundary structure of austenitic steels are reviewed. The desirable further research areas in this field are mentioned.

In the chapter introducing the own experimental results, the effect of the thermo-mechanical treatment on the grain boundary character distribution of the body centered cubic Armco-iron is shown. The most effective sample preparation method for EBSD-measurements is worked out in case of the AISI 304 type steel and the effect of the sample preparation on the achievable image quality is shown. The fraction of the special grain boundaries is determined versus the deformation in cold rolled AISI 304 type austenitic steel. The effect of heating duration on the special grain boundaries is investigated in case of heat treated AISI 304 type steel. The effects of the parameter changes of thermo-mechanical treatment on the grain boundary structure are examined in case of AISI 304 type steel samples, varying the applied cycles of the treatment, the deformation ratio and the duration of the heat treatment. It is shown by experimental results, that the parameter settings of the evaluation method strongly influence the obtained results. The optimal parameter settings are defined in order to improve the measurement method.

New scientific results

This thesis deals with the engineering and electron back scattering investigation of grain boundaries in Armco-iron and AISI 304 type steels by treatments, which increase the fraction of the CSL-boundaries. Since the CSL-boundaries are resistant against intergranular degradation processes, materials owning enhanced properties can be developed due to these treatments. Based on the results of the investigations I draw the following conclusions:

1st thesis

The highest measured CSL-fraction in the thermo-mechanically treated (consisting of 0-53% cold rolling and recrystallization) body centered cubic structured Armco-iron is much lower (7.6%) than in case of face centered cubic structured austenitic stainless steels. The main cause for that is the absence of appearance of the recrystallization or annealing twins; however the difference exists even if we neglect the coherent twin boundaries of the austenitic steels induced during the heat treatment. **The fraction of special grain boundaries in Armco-iron is independent from the cold rolling rate and heat treatment type of the executed thermo-mechanical treatments.**

2nd thesis

The image quality maps produced by back scattered electron diffraction demonstrate that the mechanical grinding and polishing are deformation type not cutting type manufacturing. The Beilby-layer appearing on the sample surface during mechanical polishing blocks the identification of the diffraction patterns of the individual measurement points, lowering the image quality. This layer can be eliminated through several cycles of chemical etching and mechanical polishing. The image quality values show tendency according to the disappearance of the layer ($IQ_{average}$: 67.5; 105.2; 119.9). The best image quality values can be achieved through mechanical polishing followed by electro polishing ($IQ_{average}$: 175); while no satisfactory result can be obtained through mechanical polishing, not even with extreme long preparation time ($IQ_{average}$: 36.7).

3rd thesis

The method using the average grain orientation of the neighboring grains for the CSL-identification provides significantly more precise results than the algorithm considering the orientation of the adjacent points along the grain boundaries. The root cause is of that is the intensive lattice deformation in the near of the grain boundaries, which

has a negligible influence on the average grain orientation, but causes a significant error during the orientation measurement of the points along the grain boundaries. This distortional effect of the grain boundaries disappears at the third measurement points using 2 μm step size during scanning of the investigated samples.

4th thesis

The difference value between the fraction of CSL-boundaries and coherent twin boundaries represent more precisely the goodness of the grain boundary structure than the CSL-boundary fraction alone. This is verified by the discontinuity of the random grain boundary network, since the tendency of discontinuity rate follows the tendency of the difference values (not the values of CSL boundary fraction).

5th thesis

The fraction of CSL-boundaries in AISI 304 type steel is independent from the heat treatment duration of the executed thermo-mechanical treatments, containing two cycles of heat treatment (5-30 min; 1050 ºC; followed by water quenching) and cold rolling (25% total height reduction). The fraction of coherent twin boundaries increases in function of the duration of heat treatment; the fraction of random grain boundaries does not change significantly. **The difference value (35.2%) between the fraction of CSL-boundaries and coherent twin boundaries and the fraction (5.5%) of advantageous triple junctions (triple junctions, where the random grain boundary network is discontinued) have peak values in case of the thermo-mechanical treatment containing 5 min. long heat treatment periods.** If the aim is the evolution of grain boundary structure with high resistance against intergranular degradation processes, the most effective and economical thermo-mechanical treatment is found to be the one, containing short heat treatment.

Nyilatkozat nyilvánosságra hozatalról

Alulírott Gaál Zoltán hozzájárulok a doktori értekezésem interneten történő nyilvánosságra hozatalához az alábbi formában*:

- korlátozás nélkül
- elérhetőség csak magyarországi címről
- elérhetőség a fokozat odaítélését követően 2 év múlva, korlátozás nélkül
- elérhetőség a fokozat odaítélését követően 2 év múlva, csak magyarországi címről

Budapest, 2008. december 7.

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(aláírás)