# Table of Contents

## Chapter 1 General introduction and scope of the thesis

1.1 Background information on the evolution of the ECCI imaging technique

## Chapter 2 Progress in the practical application of electron channeling contrast imaging (ECCI)

2.1 Background information on the evolution of the ECCI imaging technique

2.2 Theoretical fundamentals of ECCI imaging

2.2.1 Bragg diffraction and Bloch wave model

2.2.2 Intensity profiles of crystal defects

2.3 Experimental procedure

2.3.1 Sample preparation

2.3.2 Microscope setup for controlled electron channeling contrast imaging

2.3.3 Tools for orientation determination and crystallographic analysis

2.4 Results and discussion

2.4.1 Dislocation imaging by means of ECCI

2.4.2 Stacking fault imaging by means of ECCI

2.4.3 Coherent phases resolved by ECCI

2.4.4 Direct comparison of ECC images and TEM micrographs

2.5 Conclusion

## Chapter 3 Deformation of TWIP steels in experiments with strain path change

3.1 Theoretical background

3.1.1 High manganese steels

3.1.2 Deformation mechanisms in fcc structures

3.1.3 Work hardening

3.1.4 Cup drawing process

3.2 Experimental approach

3.2.1 Test material

3.2.2 Simulation of cup drawing test

3.2.2.1 Channel die - plane strain compression

3.2.2.2 Three point bending

3.2.2.3 Electron backscatter diffraction

3.3 Results

3.3.1 Methods for data analysis

3.3.2 Biaxial plane strain compression tests

3.3.2.1 Mechanical data

3.3.3 Microstructure evolution

3.3.4 Bending - Unbending

3.3.4.1 State 1: Bending and unbending of the non-pre-strained material

3.3.4.2 State 2: Bending and unbending of the -0.07 pre-strained material

3.3.4.3 State 3: Bending and unbending of the -0.2 pre-strained material

3.3.4.4 Bending – Unbending in X40MnAlSi20-1.5-1

Bibliografische Informationen
http://d-nb.info/114180901X
3.4 Discussion ......................................................................................................109
3.4.1 Deformation mechanisms of single grains in polycrystals .....................109
3.4.1.1 Microstructure evolution .........................................................................110
3.4.1.2 Orientation dependence .........................................................................112
3.4.1.3 Correlation of hardening behavior and twinning .................................115
3.4.2 Pre-strained grains (strain path change) ..................................................118
3.4.2.1 Deformation mechanisms .........................................................................119
3.4.2.2 Orientation dependence .........................................................................122
3.4.3 Recrystallized and pre-deformed grains in the reverse deformation .......126
3.4.3.1 Deformation mechanisms (Detwinning) ...................................................126
3.4.3.2 Grain orientation spread ..........................................................................132
3.4.4 Critical structures for hydrogen embrittlement ........................................136
3.5 Conclusion ......................................................................................................139

References ...........................................................................................................142

Summary ...............................................................................................................155

Zusammenfassung ..................................................................................................157