PHASE TRANSFORMATION AND DEFORMATION BEHAVIOUR OF STEELS WITH DIFFERENT CONTENT OF METASTABLE AUSTENITE

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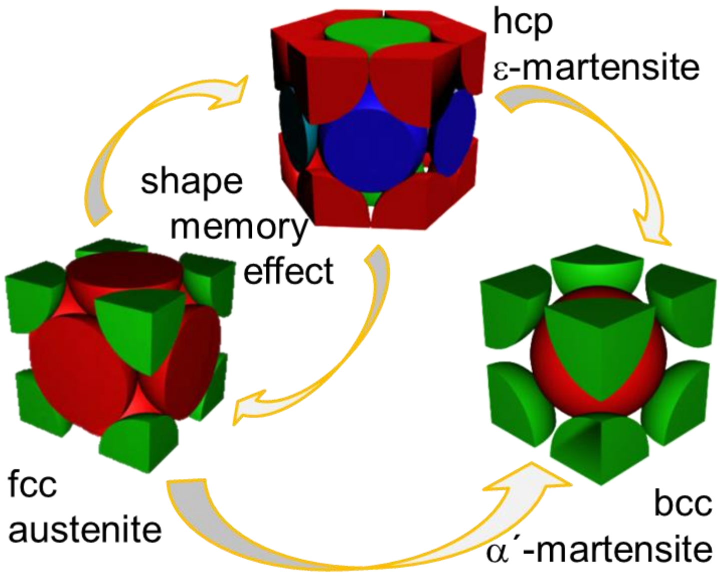
1. General

Existing of metastable austenitic microstructures at ambient temperature can be achieved in steels due to alloying chemical elements like Cr, Ni, Mn, Si and Al. Dependent on the amount of these elements and special heat treatments, advanced steels with a low content of retained metastable austenite (< 15 vol.-%) - so called low alloyed TRIP steels, or fully austenitic steels - so called high alloyed TRansformation Induced Plasticity / TWinning Induced Plasticity (TRIP/TWIP) steels can be produced. Some of low alloyed TRIP steels were included in the new German/European standard DIN-EN 10346. The initial microstructure of theses steels after heat treatment is mainly a ferritic-bainitic matrix with dispersed retained metastable austenite islands. The fully austenitic TRIP/TWIP steels are produced generally based on two alloying concepts: 1st: Cr-Ni-concept for corrosion resistant stainless steels (18 % Cr / 10 % Ni) and 2nd: Mn-Si-Al-concept for new, advanced austenitic steels, where a large variance in chemical composition exists and sometimes an addition of Cr and Ni is used. Depending on the chemical composition and consequently varying stacking fault energy in the metastable fully austenitic steels the TWIP-effect occurs along or instead of the TRIP-effect. Furthermore, due to alloying by Mn, Cr, Si and V, steels with shape memory effect (SME) and fully metastable austenitic microstructure have been developed in the last years.



Due to alloying of above mentioned chemical composition a paramagnetic metastable fcc austenitic microstructure can be achieved at ambient temperature, which transforms by mechanical deformation into paramagnetic hcp-martensite and/or ferromagnetic bcc-martensite, respectively (see. Fig. 1).

Figure 1. Nature of deformation induced phase transformation of metastable austenite

2. Investigated materials and methods

In this contribution microstructure as well as mechanical properties of four types of metastable austenitic steels: (1) low alloyed TRIP, (2) Cr-Ni stainless steel, (3) Mn-Al-Si (TRIP/TWIP) and (4) with shape memory effect are presented and discussed. The chemical composition is given in Table 1.

Type	Name	C	V	Cr	Ni	Mn	Si	Al
(1) Low alloyed TRIP	HCT780	0.25	-	-	-	2.0	2.0 (Si+Al)	
(2) Cr-Ni (stainless steel)	AISI 347	0.02	-	17.3	9.3	1.6	0.6	-
(3) Mn-Al-Si (TRIP/TWIP)	HSD 600®	0.24	-	-	-	14.2	2.8	1.4
(4) Mn-Cr-Si-V (SME)	no name	1.0 (C+V)		10.0	4.2	17.2	5.1	-

Table 1. Chemical composition of investigated steels

Figure 2 shows microstructure of investigated steels in initial state before mechanical loading. Depends of chemical composition retained austenite (Fig. 2a) or fully austenitic microstructure (Fig. 2b-d) occurs. During monotonic tensile tests phase transformations take place.

(a) (b) (c) (d)

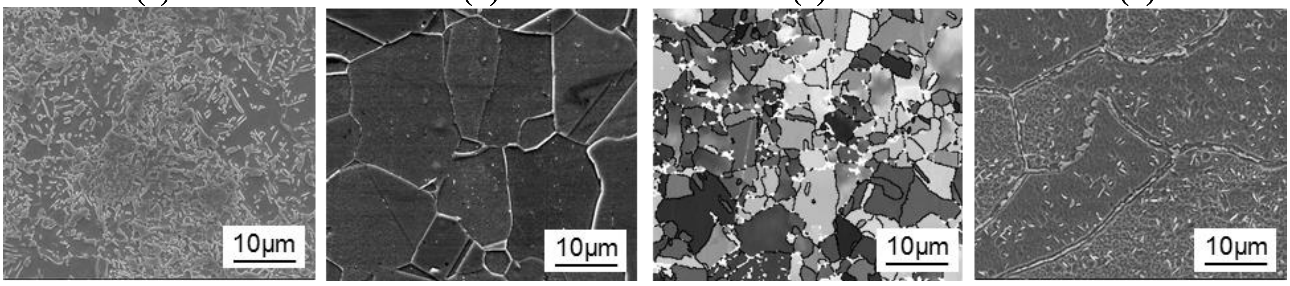


Figure 2: Microstructure of initial state: (a) low alloyed TRIP, (b) Cr-Ni (stainless steel), (c) Mn-Al-Si (TRIP/TWIP), (d) Mn-Cr-Si-V (SME)

The phase transformation and deformation behavior of four steel was investigated at ambient temperature during monotonic tensile tests by in situ measurement of stress-strain, temperature, electrical resistance and magnetic properties. After specimen failure optical and electron microscopy incl. EBSD as well as x-ray investigations were completed for the detail characterization of microstructure changes.

Acknowledgments

The authors thank the German Research Foundation (DFG) for the financial support within the CRC 926 ‘‘Microscale Morphology of Component Surfaces’’.