Electrochemical investigations regarding the influence of deformation-induced martensite on the corrosion behaviour of austenitic stainless steels

BAM
Bundesanstalt für Materialforschung und -prüfung

Martin Babutzka, Steffi Reinemann
Division 6.1 Corrosion and Corrosion Protection

Motivation and sample preparation

- type of electrochemical testing influences obtained results regarding corrosion resistance in a wide range
- as a starting point for further investigations and discussion different standard test methods were performed
- AISI 304 from a consistent heat with different deformation rates was used (fig.1)
- thus, identical chemical composition for each sample is guaranteed

fig. 1: microstructure of stainless steel AISI 304 with different cold deformation rates, etched with Beraha I

Passivation and sensitization behaviour

- investigated with Electrochemical Potentiokinetic Reactivation test (fig.2)
- double loop technique
- classical three electrode setup in a surface attachment cell (A_{WE} = 1.54 cm²)
- electrolyte: 0.5 M H_2SO_4 + 0.01 M KSCN
- sweep rate: 1.67 mV/s
- potential range: -500 ... 300 mV vs. GKE
- surface freshly ground with P 600 silicon carbide paper before measurement

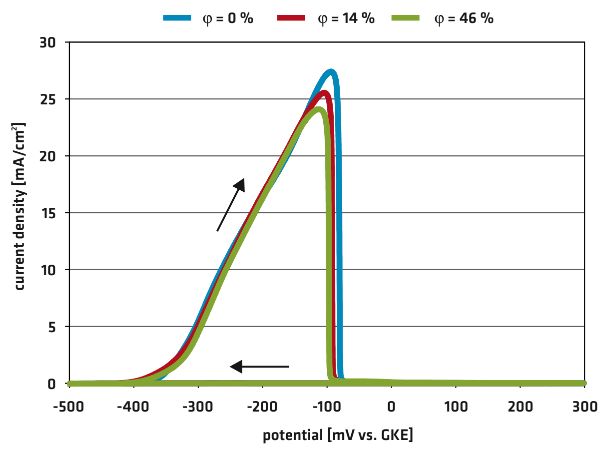

fig. 2: EPR-test, different deformation rates

Determination of critical potential values

- investigation of pitting corrosion behaviour with dynamic polarization (fig.3)
- classical three electrode setup in a surface attachment cell (A_{WE} = 1.54 cm²)
- electrolyte: borate buffer solution + 0.1 M NaCl, pH = 6.4
- sweep rate: 0.2 mV/s
- surface ground with P 600 silicon carbide paper, afterwards exposed to 96 % r. H. for one hour

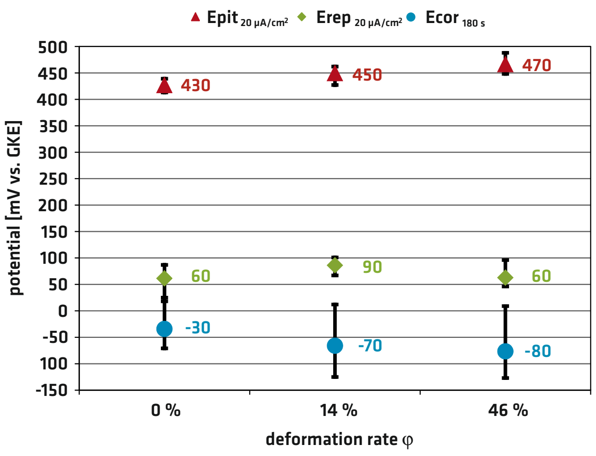

fig. 3: critical potential values

Results and outlook

- cold-rolling led to different amounts of magnetic contents in the microstructure:
  - φ = 0 % → 0.9 %
  - φ = 14 % → 1.8 %
  - φ = 46 % → 11.4 %
- indication for increasing amount of martensite in lattice structure

EPR:
- no differences in anodic dissolution range
- with increasing deformation rate passivation peak decreases
- no sensitization

critical potentials:
- no significant differences regarding E_{cor}
- pitting potential E_{pit} slightly increases with increasing deformation rate
- no significant differences regarding E_{rep}

ECN:
- decreasing amounts of transients with increasing deformation rate indicating less surface activity

→ further investigations correlating electrochemical results with microstructure

Electrochemical noise measurement

- potentiostatic polarization with constant potential of 300 mV vs. GKE (fig.4)
- electrolyte: borate buffer solution + 0.1 M NaCl, pH = 6.4
- current: filter 0 ... 1 Hz, 10 x amplification
- current noise: filter 0.1 ... 10 Hz, 100 x amplification
- surface ground with P 600 silicon carbide paper, afterwards long time exposure to 96 % r. H. for 48 h

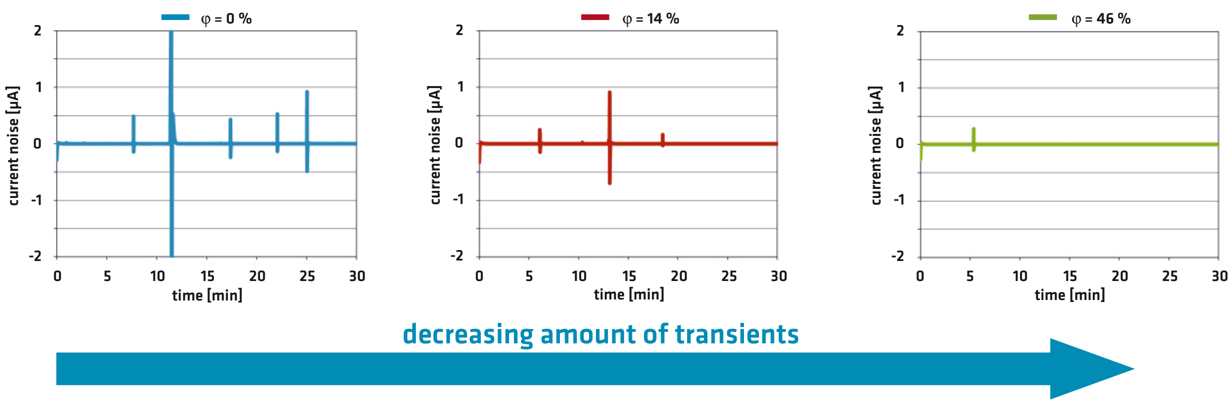

fig. 4: potentiostatic ECN measurements at a constant potential of 300 mV vs. GKE

References for further Reading
Babutzka, Reinemann, Heyn:
„Nachweis von Verarbeitungsfehlern bei nichtrostenden Stählen durch elektrochemische Korrosionsuntersuchungen"
15. Sommerkurs Werkstoffe und Fügen am Institut für Werkstoff- und Fügetechnik, Otto von Guericke University Magdeburg, 2014, ISBN 978-3-940961-85-3
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PO box 4120
D - 39106 Magdeburg