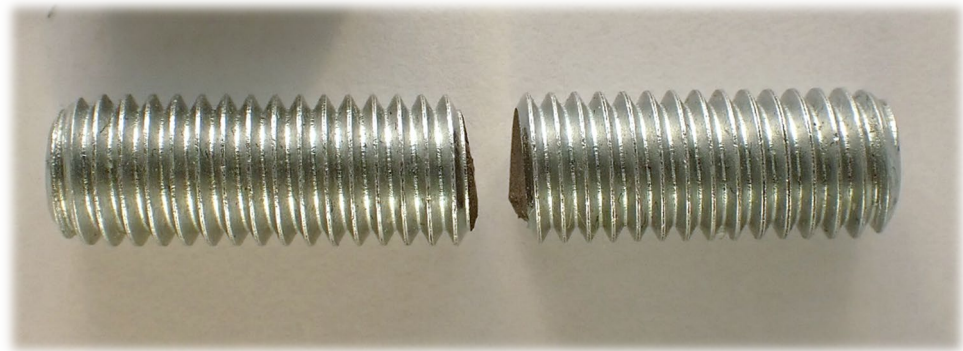


MATERIEX CASE STUDY

M8 SCREW FRACTURE



BACKGROUND

A fractured M8x40 hexagon socket set screw was received for failure investigation. According to the given information, the fracture was observed some time after the screw had been tightened. The screw material was specified to conform with zinc electroplated steel with the property class 45H (minimum hardness 450 HV). *This is only a shortened version/summary of the original report.*

INVESTIGATION

The investigation included the following:

- Visual examination
- Metallographic preparation and microstructural studies (LOM)
- Fractography (SEM)
- Chemical characterisation (EDX)
- Hardness measurements using micro-Vickers (HV₁)

LOM - Light optical microscopy

SEM - Scanning electron microscopy

EDX - Energy dispersive X-ray spectroscopy

FINDINGS

- The hardness was measured to ~505 HV which met the criteria for property class 45H.
- The macroscopic appearance of the fracture suggests that the fracture has been initiated in the thread root, along the circumference (indicated by red arrows in Figure 1) and rapidly propagated inwards/downwards towards the final fracture (yellow marked area in Figure 1).
- Investigation in SEM confirmed that the fracture had been initiated in the thread root. The fracture surface in this area had an intergranular brittle mode of fracture along the prior austenite grain boundaries (Figure 2a). The grain facets exhibited so-called “crow’s feet” (Figure 2b) which is a microscopic feature typically associated with hydrogen embrittlement. The intergranular fracture covered approximately 30-40 % of the total area fraction whereas the rest of the fracture surface (the final fractures) had a mixed ductile and brittle cleavage mode of fracture (Figure 2c).

CONCLUSION

Multiple factors strongly indicate that the fracture is caused by hydrogen embrittlement;

1. The character of the fracture surface; intergranular and with the presence of so-called “crow’s feet”.
2. Material properties; The screw is made of high strength steel with a hardness of ~505 HV. High strength materials (>~1000 MPa yield stress) are more susceptible to hydrogen embrittlement.
3. The timing of the fracture; the fracture did not occur immediately upon tightening but after some time.
4. The location of the fracture; The fracture was initiated in an area where high stresses are expected (e.g. thread roots).
5. Manufacturing process; The screw was zinc coated by electroplating which is known to be a process where hydrogen can enter and get trapped in the material.

Table 1. Measured hardness [HV].

Sample	HV ₁
Screw	~505
Property class 45H	Minimum 450 HV

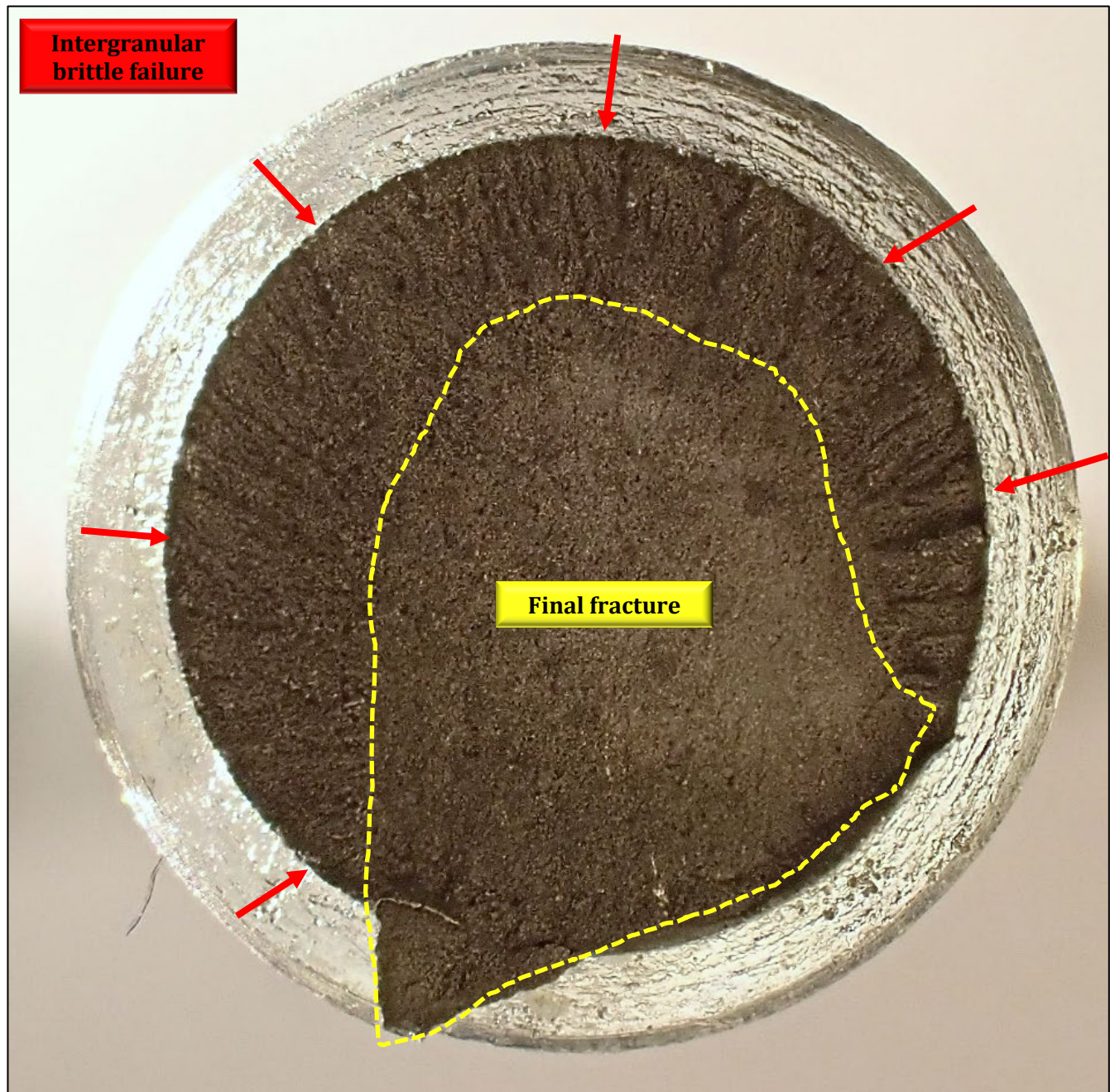
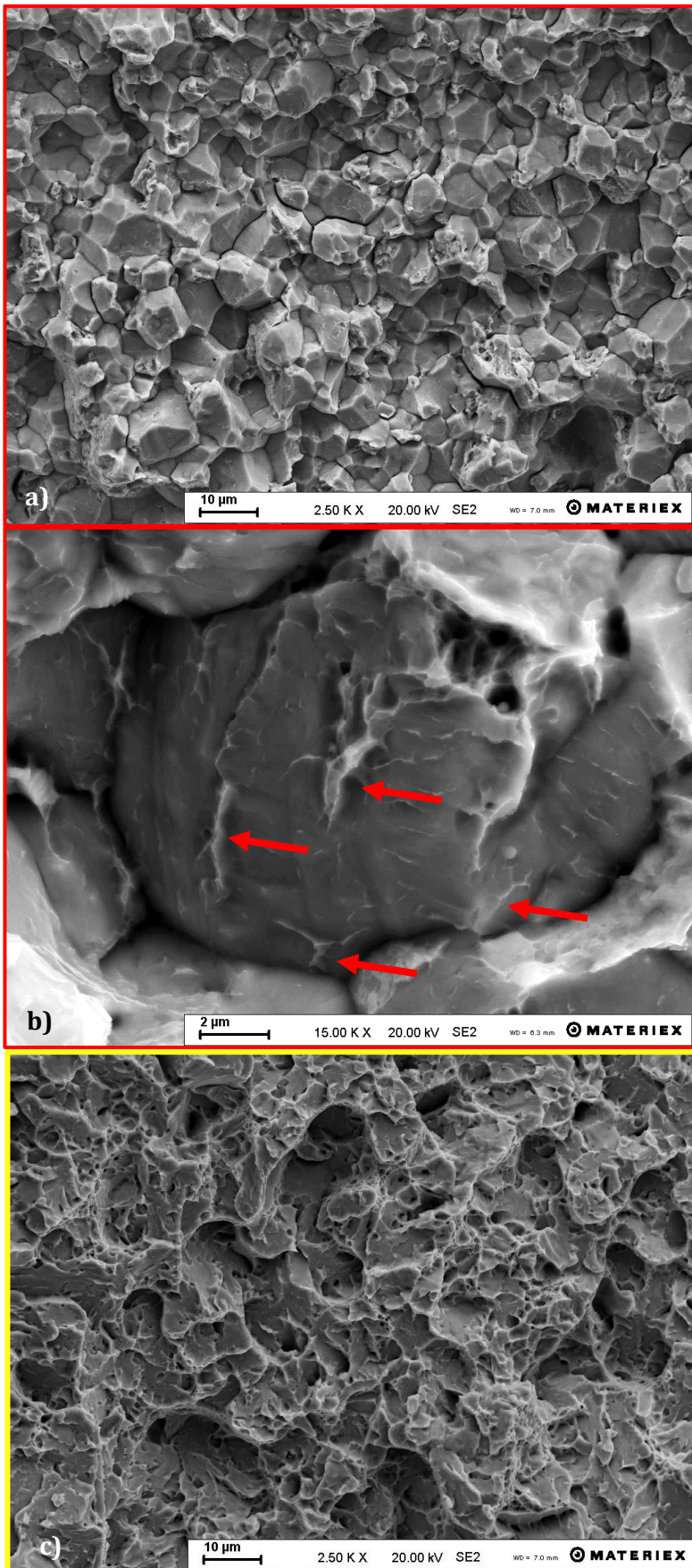


Figure 1. Fracture surface, red arrows indicate crack initiation sites with an intergranular brittle mode of fracture. The yellow marked area shows the final fracture.



**Figure 2. a) Intergranular brittle mode of fracture revealing austenite grain boundaries.
 b) High magnification image of a), showing the so-called crow's feet (red arrows).
 c) Final fracture showing a mixed ductile and brittle cleavage mode of fracture.**