doi:10.1017/S1431927618004002
Microsc. Microanal. 24 (Suppl 1), 2018

Scanning Electron Microscope, an Essential Equipment for Failure Analysis

Michael Panzenböck[1]

[1.] Department of Physical Metallurgy and Materials Testing, Montanuniversität Leoben, Austria

After the damage of parts and components, the purchaser is interested in an efficient and quick clarification. Basic or fundamental solutions are not an option, because they are time-demanding, cost intensive and sometimes highly sophisticated equipment have to be used. The first results are obtained from observations with the naked eye. It is possible to distinguish between brittle and ductile fracture or damage due to fatigue, stress corrosion cracking, high temperatures, etc. Normally, the second step is to prove the first results of investigations with the help of a scanning electron microscope, simply equipped with EDX and at least with two detector systems (SE/secondary electron- and BSE/back scatter electron-detectors). Some experience in fracture mechanics and fractography is required for the interpretation. The following examples will give a short overview of SEM-investigations of failed parts.

Fig. 1 shows a picture of a ductile fracture. The formation and the orientation of the dimples give information of the material condition and loading direction. In this case a valve made of a machinable steel failed. Within the dimples -elongated in the longitudinal direction- MnS are visible (see yellow arrows) [1]. The same steel reveals a transgranular brittle fracture (Fig. 2) due to high strain rates caused by an explosion [1]. Steels reveal brittle intergranular fracture, too (Fig. 3). Such a phenomenon can be caused by precipitations at grain boundaries, intergranular corrosion or due to hydrogen in high strength steels [2]. A faceted fracture surface is visible due to stress corrosion cracking [3] or such features can be identified within the first stage of fatigue at austenitic stainless steels (Fig. 4). Another important feature is the presence of dendrites (Fig. 5), which reveals inadequate solidification of the material during casting or welding. The evidence of striations proves the damage due to fatigue (Fig. 6). Finally, a damage due to cyclic loading is caused by crack initiation. Sometimes the triggering event for crack initiation is a non-metallic inclusion (Fig. 7a), which can be identified with EDX (energy disperse x-ray) and BSE (Fig. 7b). In this case the non-metallic inclusion appears dark. Other examples will be given during the talk.

References:

[1] M. Panzenböck *et al*, to be published in Practical Metallography **3** (2016), p. 641.
[2] M. Pohl, Practical Metallography **54** (2017), p. 267.
[3] M. Panzenböck *et al*, Practical Metallography **51** (2014), p. 291.

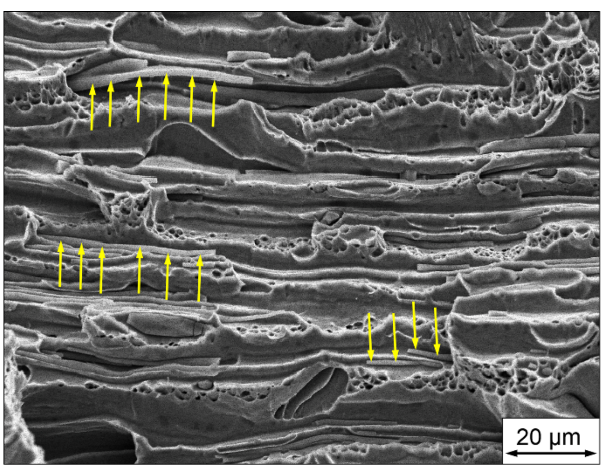

Figure 1. Typical ductile fracture of a machinable steel (11MnS5), which contains a high amount of MnS elongated in longitudinal direction (indicated by yellow arrows). Therefor elongated dimples are visible.

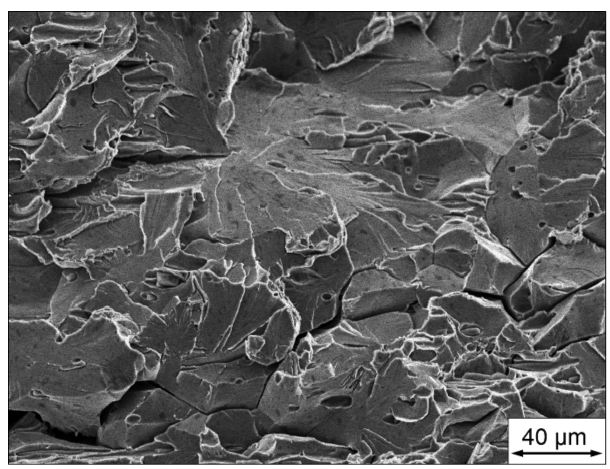

Figure 2. Typical transgranular brittle fracture of a machinable steel (11MnS5) caused by a very high strain rate. Terraces, smooth areas, river patterns and tongues are remarkable features of such a damage.

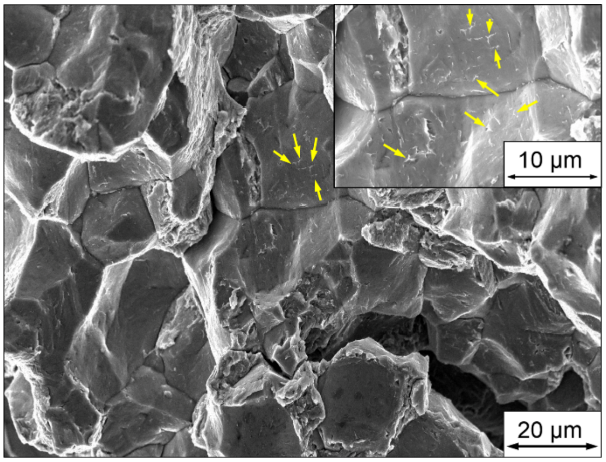

Figure 3. Intergranular fracture of a heat treatable steel (42CrMo4) due to hydrogen. Yellow arrows indicate “crow’s feet” (see insert).

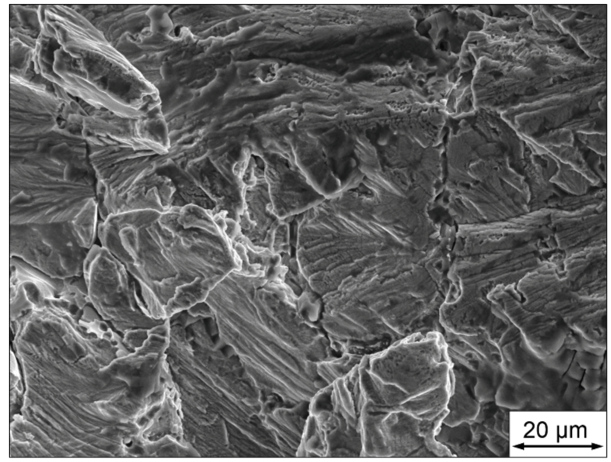

Figure 4. Transgranular fracture of a stainless steel (X5CrNi18-10) due to stress corrosion cracking.

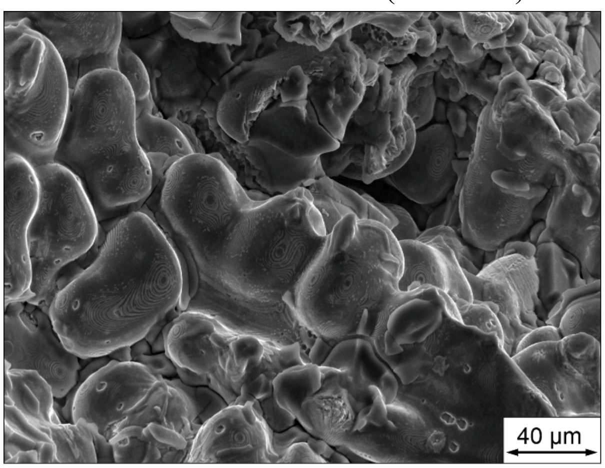

Figure 5. Hot cracks originating during solidification of a stainless steel (X5CrNi18-10). Dendrites and rounded structures are visible

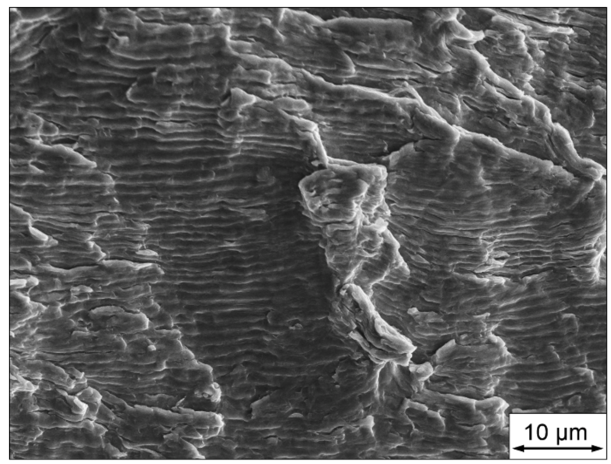

Figure 6. Typical fracture features of a martensitic steel (X5CrNiMo13-4) after fatigue. Striations are remarkable features.

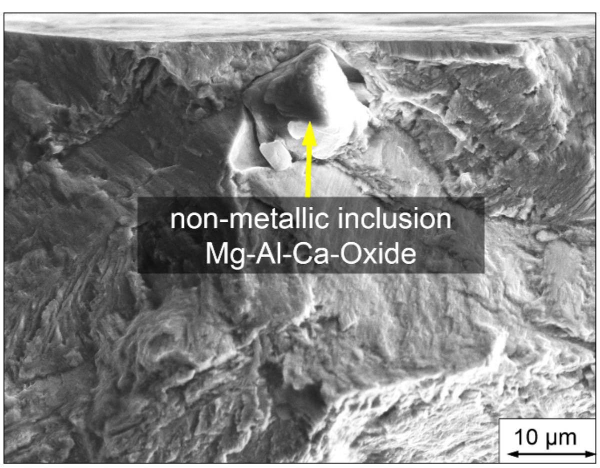

Figure 7a. Crack initiation during fatigue of a stainless steel (X5CrNiMo13-4) due to a non-metallic inclusion (topographical contrast)

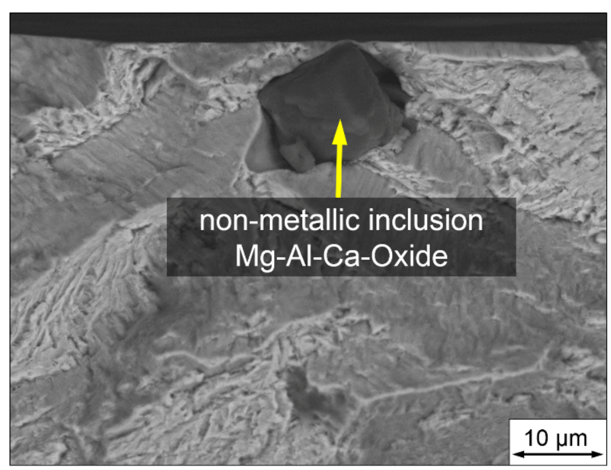

Figure 7b. Same position as in Figure 7a. The non-metallic inclusion appears dark (material contrast)

https://doi.org/10.1017/S1431927618004002 Published online by Cambridge University Press