Identification of phases in novel Co-Re-based high temperature materials

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In gas turbines, the thermal fficiency is limited by the maximum gas inlet temperature. Therefore modern blade materials have to withstand severe operating conditions. Today, Ni base superalloys are the most prominent high temperature materials in the hot sections of aero engines and gas turbines for energy production. At peak material temperatures up to 1100°C, these alloys operate close to their melting point at around 1300.C. In order to allow process temperatures, which exceed the capability of Ni base superalloys, material engineers are interested in new metallic systems with significantly higher melting points and improved high temperature strength. A promising new class of materials may be derived from the ternary Co-Re-Cr system, where henium has an extremely high melting point [1].

From the Co-Re-Cr system different alloys (Co-17Re-23Cr, Co-17Re-23Cr-2.6C, Co-17Re-23Cr-2.6C-1.2Ta, and Co-17Re-23Cr-15Ni, all compositions in at.%) were produced in an ingot metallurgical processing route, involving arc-melting under argon atmosphere and subsequent heat treatments. After the heat treatment the Co-17Re-23Cr alloy has a hexagonal matrix with few blocky sigma phase particles located on or close to grain boundaries. Addition of Carbon leads to the formation of plate-like precipitates of type M23C6 embedded in the hexagonal matrix. With further addition of Tantalum tiny globular TaC appear [2]. Fig. 1a shows a low magnification STEM image of the Co-17Re-23Cr-15Ni alloy obtained with the HAADF detector of a grain boundary region. Heterogeneous grain boundary precipitation could be detected. Diffraction analysis reveals that the grain interior has a hexagonal structure (Fig. 1b) whereas in the grain boundary an fcc matrix phase (Fig. 1c) is present together with sigma phase. In Fig. 1d an EDX line-scan crosses the three phases of the grain boundary. Focusing on the Re-content, a strong increase of this element in the sigma phase is observed. In agreement with this, previous investigations showed that the sigma phase has a tetragonal lattice of type Cr2Re3 [2]. Furthermore, the Ni-content in the fcc phase is slightly increased as compared to the hexagonal matrix.

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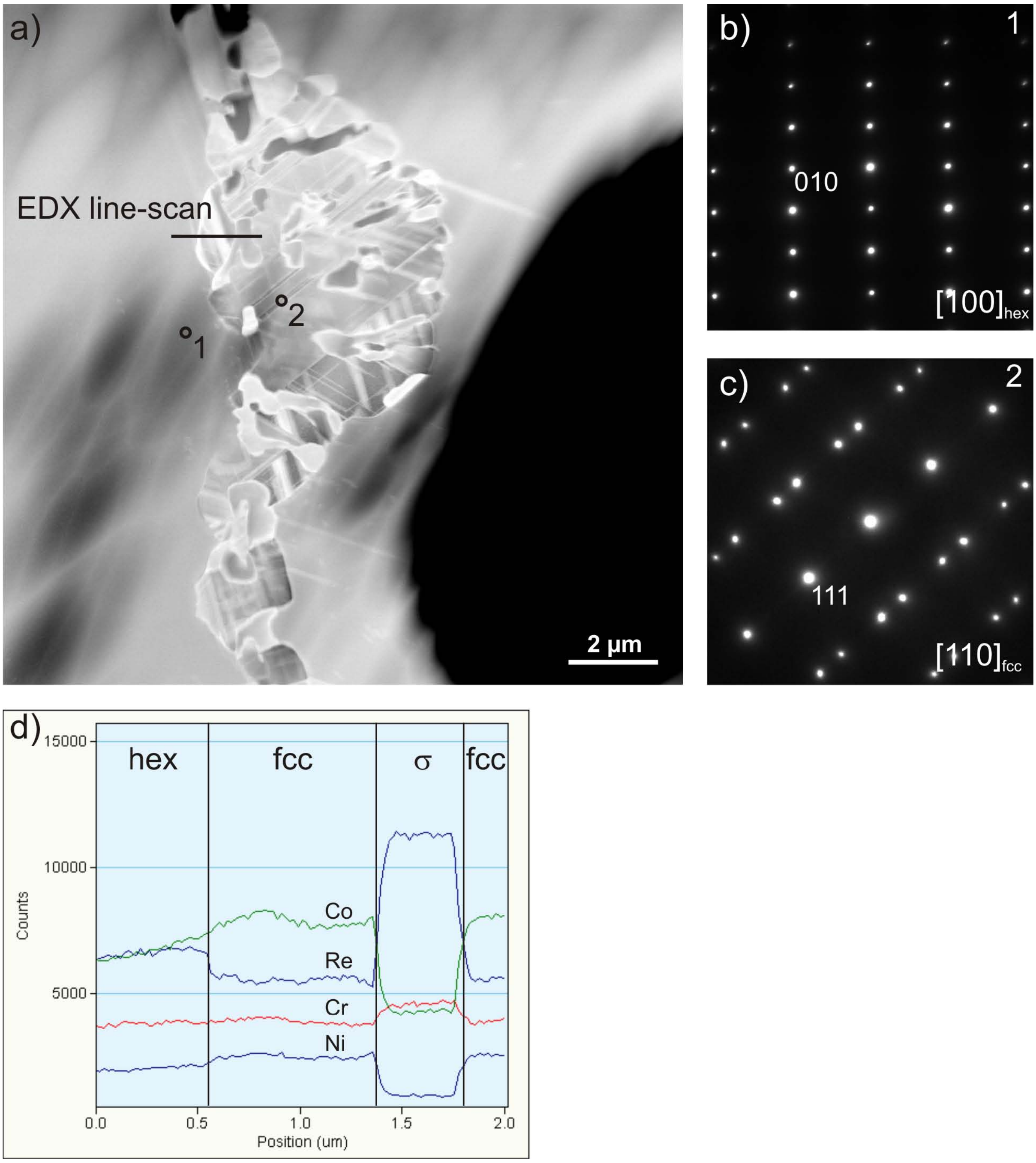

Figure 1. a) STEM image of a grain boundary region in a Co-17Re-23Cr-15Ni alloy after solution heat treatment. b) Selected area diffraction pattern for the hexagonal grain interior. c) Selected area diffraction pattern for the twinned fcc phase. d) EDX line-scan for the line marked in the STEM image.

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