Phase Identification of Carbide Precipitates

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Introduction

Heat resisting alloys are strengthened by a number of different precipitate phases such as carbide and intermetallic phases, and their stability at high temperatures is essential to alloy design.

Fe_3Al-based alloys are a new class of heat resisting materials, distinguished by excellent high-temperature oxidation and sulfidisation resistance, good strength, low materials costs and a relatively low weight. Nevertheless, the strength and creep resistance at high temperatures is not satisfactory and requires the addition of stable precipitates. The addition of carbon and molybdenum leads to the formation of a number of different mixed carbides because the base material also contains some Chromium for enhanced room-temperature ductility. In order to better understand the formation of these carbides, EBSD and EDS are used together to identify the phases of these carbides.

Phase Identification

EBSD pattern analysis combined with EDS measurements of the approximate composition allows a highly efficient phase identification and phase characterization. An example is given in the figure below. It shows a backscattered electron image of an Fe-26Al-5Cr-1.5Mo-1.0C (at%) alloy heat-treated at 800°C for 1000 hours after a homogenization annealing at 1200°C in α(B2) single phase region.

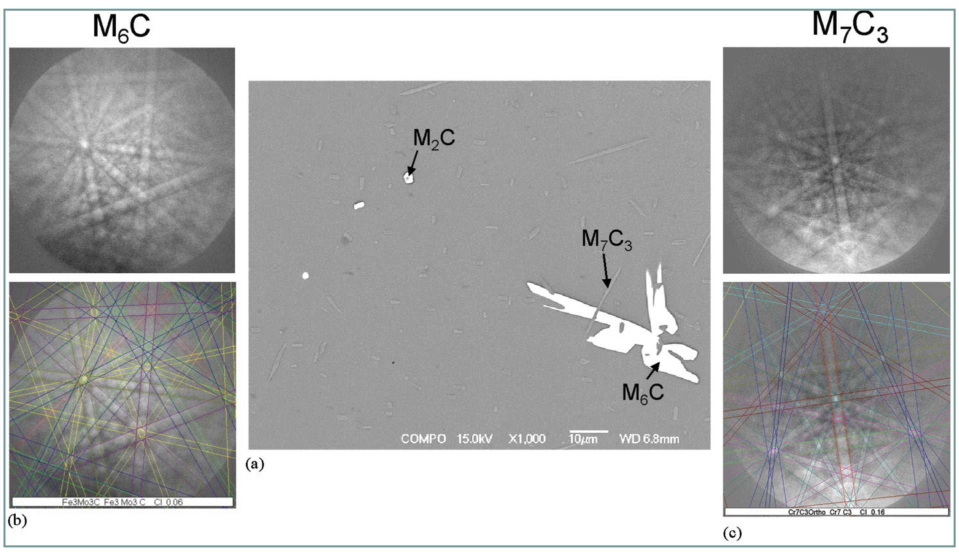

Figure 1 - a) BSE image of the microstructure of a heat treated Fe_3Al-based alloy with precipitations. b) and c) EBSD patterns of selected precipitations and the recalculated patterns for 2 different carbides.

Three kinds of carbide phases were identified, M_6C (bright and coarse), M_7C_3 (grey and needle shaped) and M_2C (bright and fine). M identifies a phase-dependent mix of Cr, Mo and Fe. The phase identification was done by fitting experimentally obtained EBSD patterns with simulated patterns. The simulated patterns were obtained by calculating structure factors for electron diffraction from the known atom positions in these carbides using the EDAX software Delphi and an in-house computer program - *TOCA*. Examples of pattern fitting for M_6C and M_7C_3 phases are shown in the figure. It can be seen that the M_6C carbide grows faster than M_2C and M_7C_3 phases, which indicates that this phase should be avoided in forming alloys for high temperature applications. The latter can be reached by changing the M/C ratio.

Conclusions

EBSD is an excellent tool to aid the materials scientist in identifying different carbide phases in steel. It is particularly useful in analyzing small carbides. As the carbides tend to be small, it can be difficult to get accurate EDS measurements due to resolution. In addition, EDS is not well suited to measuring subtle differences in carbon content in such materials. Coupling the EDS data with the EBSD data allows the researcher to make a more reliable determination. EBSD provides crystal structure information which can help resolve any ambiguities.

Bibliography

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