Experimental report

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Proposal: **1-02-200**

Council: 4/2016

Title: Determination of elastic constantsin two-phase alloys by diffraction

Research area: Materials

This proposal is a new proposal

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Samples: Ti-6Al-2Sn-4Zr-6Mo
duplex steel AISI 318 LN
austempered ductile iron

Instrument	Requested days	Allocated days	From	To
SALSA	2	0		
D20	2	2	05/09/2016	07/09/2016

Abstract:

We propose to derive single crystal elastic constants on polycrystalline two-phase alloys by diffraction studies. Our main goal is to establish a method to determine elastic constants in technical multiphase alloys. In particular for materials which are not available as single crystals or in single phase forms this apprach would be highly beneficial.
The proposed method required diffraction studies under various orientations of the load axis with respect to the incident beam. This can be achieved by our tensile rigs allowing an orientation of the load axis in a Eulerian cradle like way. We propose to carry out the investigations on diffractometer D20 or alternatively SALSA. The data will be analysed using the software package MAUD and by our own software.

Experimental report Proposal No 1-02-200, Team: Hoelzel, Finkel, Heldmann

Local contact: Th. Hansen, Instrument: D20

The mechanical behavior of materials in the elastic regime is based on the single crystalline elastic constants. For materials development and modeling of polycrystalline multiphase alloys the elastic constants of the constituent phases are required as input parameters. However, for various technological interesting materials single crystals or even single phase polycrystalline materials do not exist. To derive the elastic constants from diffraction data several authors proposed methods which can be regarded as reverse way of classical stress analysis [1-4]. Here the strain is measured for the defined stress. In particular textured samples require measurements in all possible grain orientations. Thus, these methods require diffraction data over a wide range of reflections under mechanical load for a series of orientations of the load axis with respect to the incident beam.

We carried out diffraction studies on diffractometer D20 on different steel, austempered ductile iron as well as titanium alloys using a load frame which enables an orientation of the load axis in an Eulerian cradle like manner (FRM II design, Fig 1 [5]). One and two phase steel samples as well as austempered ductile iron were used as reference samples in which the elastic constants of the constituent phases are quite well known. The main focus of our investigation are the elastic constants in both phases (cubic + hexagonal) in the alloy Ti-6Al-2Sn-4Zr-6Mo which was supported by measurements of single phase alloys Ti-6Al-4V (hexagonal = α-phase) + Ti-3Al-8V-6Cr-4Mo-4Zr (cubic = β-phase). All titanium samples are of high technological importance. In particular the stiffnesses in the cubic β-phases differ due to alloying compositions.

After removal of the radial oscillating collimator the load frame has been placed at D20 at a fixed omega orientation of 45° with respect to the incident beam. All diffraction patterns were collected at a monochromator angle of 90° using Ge(115) to achieve a wavelength of 1.54 Angstroems. Measurements were carried out in the initial state and up to three different strain states in the elastic regime of the samples. At each strain state, diffraction patterns at different chi-orientations of the load axis with respect to the scattering plane (typically seven steps between 0° and 90°, depending on texture of the samples) were collected. For this purpose, the motor for chi tilting of the load frame had been implemented into the instrument control of D20. Reflections from the load frame were suppressed by cadmium shielding.

Due to the outstanding flux of diffractometer D20 excellent diffraction data are obtained even for weak scattering materials such as titanium alloys. The data are analyzed using our own software which includes the approach published by Gnäupel-Herold [2]. All peak positions are obtained by single peak profile fitting using Pseudo-Voigt functions. From the obtained d-values of the profile fit, the diffraction elastic constants are calculated. The single-crystalline elastic constants are determined by a least-squares fit (LMA) to the diffraction elastic constants using the models of Voigt, Reuss, Hill and DeWitt. In addition we use an approach which can be regarded as the reverse method of stress-strain analysis for highly textured materials outlined by Behnken [7]. The texture parameters are implemented based on previous pole figure measurements at instrument STRESS-SPEC (FRM II). The data analysis of the titanium alloys is still ongoing and results are very promising. In particular the calculated single crystalline elastic constants explain our measured macroscopic constants (e.g.Young modulus) very well.

The excellent support from Thomas Hansen and his colleagues at the ILL regarding the implementation of the load frame and the diffraction experiments is gratefully acknowledged.

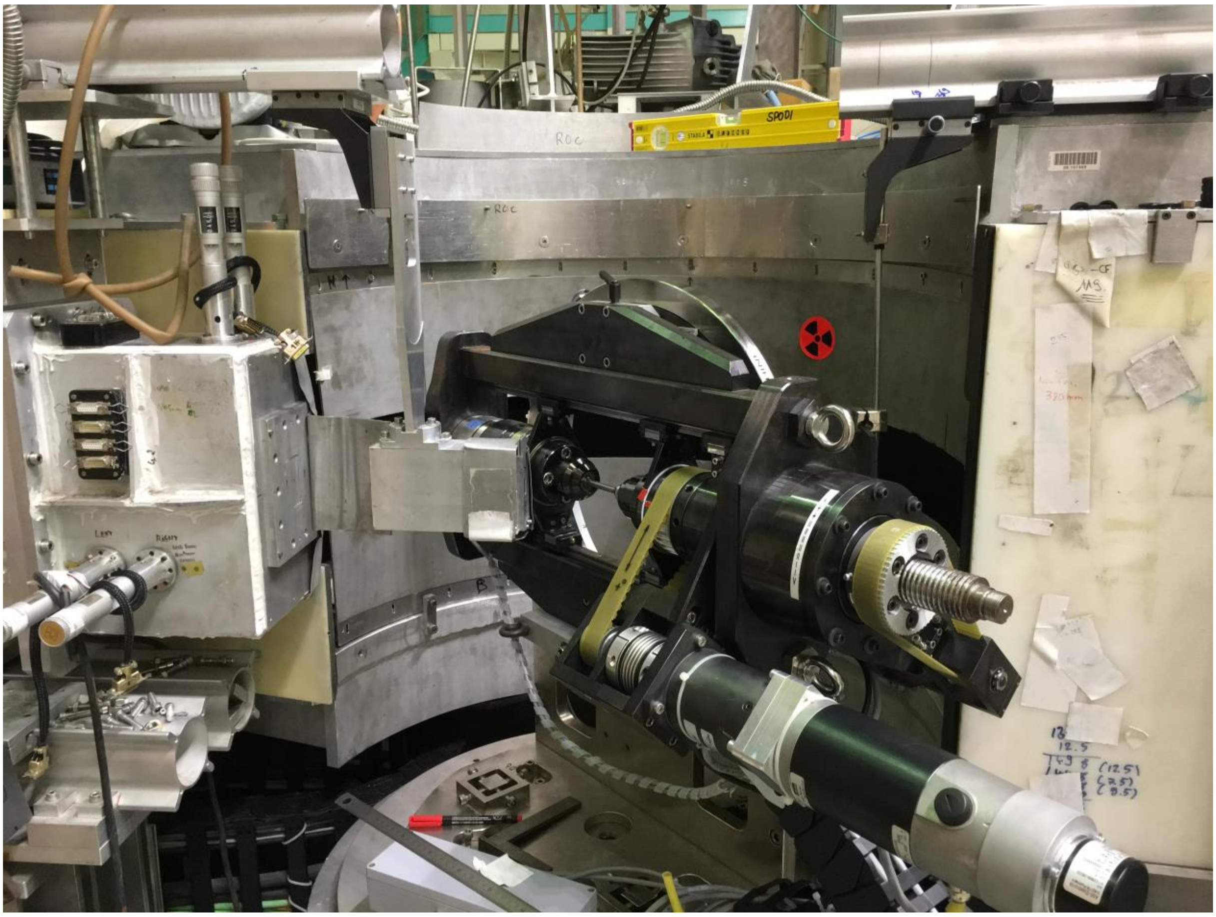

Fig 1: The rotatable load frame on diffractometer D20

References
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