Journal of large-scale research facilities

Journal of large-scale research facilities, 1, A6 (2015) http://dx.doi.org/10.17815/jlsrf-1-25

Published: 18.08.2015

STRESS-SPEC: Materials science diffractometer

Heinz Maier-Leibnitz Zentrum
Technische Universität München
Helmholtz-Zentrum Geesthacht, German Engineering Materials Science Centre
Technische Universität Clausthal, Institute of Materials Science and Engineering

Instrument Scientists:
- Michael Hofmann, Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Garching, Germany, phone: +49(0) 89 289 14744, email: michael.hofmann@frm2.tum.de
- Weimin Gan, German Engineering Materials Science Centre (GEMS) at Heinz Maier-Leibnitz Zentrum (MLZ), Helmholtz-Zentrum Geesthacht GmbH, Garching, Germany, phone: +49(0) 89 289 10766, email: weimin.gan@hzg.de
- Joana Rebelo-Kornmeier, Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Garching, Germany, phone: +49(0) 89 289 14710, email: joana.kornmeier@frm2.tum.de

Abstract: In response to the development of new materials and the application of materials and components in new technologies the direct measurement, calculation and evaluation of textures and residual stresses has gained worldwide significance in recent years. STRESS-SPEC, the materials science diffractometer, which is jointly operated by the Technische Universität München, the Institute of Materials Science and Engineering, Technische Universität Clausthal and by GEMS, Helmholtz-Zentrum Geesthacht, is located at the thermal beam port SR-3 of the FRM II and can easily be configured either for texture analysis or strain measurements.

1 Introduction

The set-up utilises three different monochromators: Ge (511), bent silicon Si (400) and pyrolitic graphite PG(002). This selection of monochromators and the possibility to vary automatically the take-off angles from $2\Theta_M = 35°$ to 110° allows to find a good compromise between resolution and intensity for each measuring problem.

The gauge volume defining optical system of primary and secondary slits is designed with regard to reproducibility of geometrical alignment and sturdiness. Both slit systems are linked to the sample table and the detector in such a way that the center of the beam remains the same under all conditions. Instead of the secondary slit a radial collimator can be used in front of the detector. Samples can be aligned using theodolites and a camera system. In addition, the possibility to scan surfaces of components offline using a CMM laser scanner is available at STRESS-SPEC.

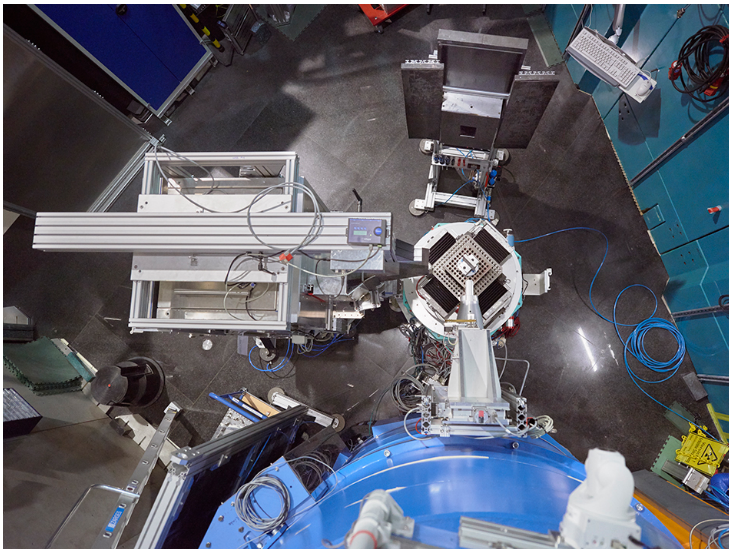

Figure 1: Instrument STRESS-SPEC (Copyright by W. Schürmann, TUM).

2 Typical Applications

Residual stress analysis (Hofmann et al., 2006)

- Industrial components
- Welds
- Superalloys
- Strain mapping
- Surface measurements from 150 μm possible (Šaroun et al., 2013)

Texture determination (Brokmeier et al., 2011)

- Global textures
- Local textures
- Strain pole figures
- FHWM pole figures

Structural applications

- Phase transformation dynamics
- Spatially resolved phase analysis (e.g. batteries)

3 Sample Environment

- XYZ-table
  capacity 300 kg, Travel xy = ±120 mm, z = 300 mm, accuracy $\sim$ 10 μm
- Load frame
  +/- 50 kN, heatable to 1000°C
- Full circle Eulerian cradle (max. load 5 kg)
- ¼ circle Eulerian cradle for heavy samples
- Standard sample environment (e.g. furnace, cryostat)

A positioning system consisting of a Stäubli-6-axes robotic arm for texture and strain measurements (payload up to 30 kg) can be mounted instead of the standard sample table (see Figure 2). It offers more flexibility than an Eulerian cradle and can be also used as automatic sample changer for texture measurements (Randau et al., 2015).

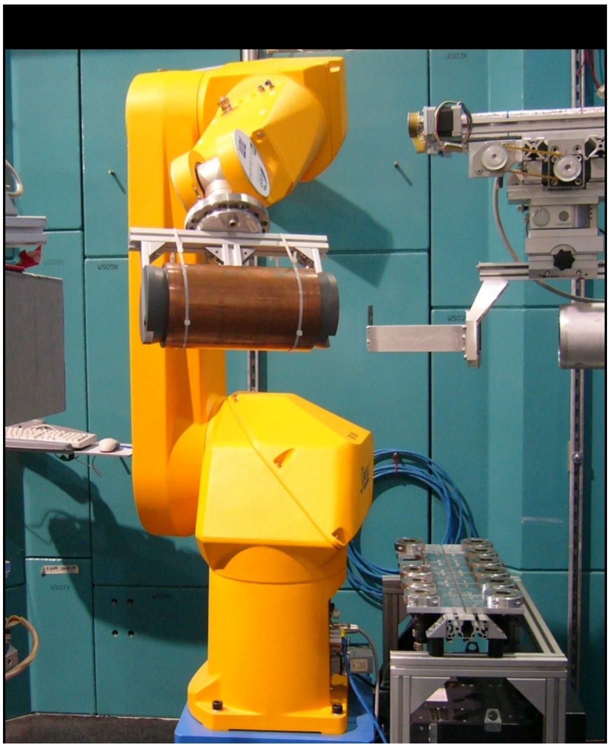

Figure 2: Robot at STRESS-SPEC holding a copper tube for combined texture and strain measurements.

4 Technical Data

4.1 Neutron beam

- SR-3 thermal neutrons
- Collimators (‘in-pile’) 15’, 25’, open

4.2 Monochromators

- Ge(511), Si(400), PG(002)
- $2\Theta_M$ 35° – 110° continuous
- Wavelength 1 Å – 2.4 Å; (2.5 $Å^{-1} < Q < 10.5$ $Å^{-1}$)

4.3 Possible slit size - Residual Stress

- Primary slit: automatic continously variable up to 7 x 17 mm^2 (W x H)
- Secondary slit: continuously variable up to 15 mm
- Radial collimators (FWHM = 1 mm, 2 mm, 5 mm, 10 mm)

4.4 Possible slit size – Textures

- Primary slit: max. 30 x 40 mm^2 (W x H)
- Secondary slit: continuously variable up to 15 mm or open

4.5 Detector

- ^{3}He-PSD, 25 x 25 cm^2; 256 x 256 pixel

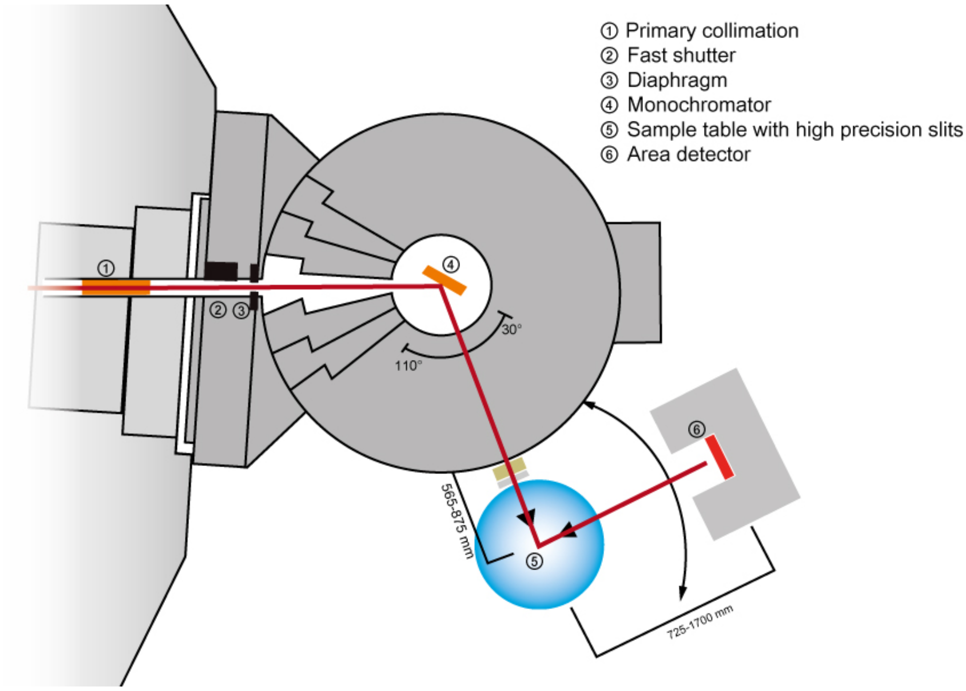

Figure 3: Schematic drawing of STRESS-SPEC.

References

Brokmeier, H.-G., Gan, W., Randau, C., Völler, M., Rebelo-Kornmeier, J., & Hofmann, M. (2011). Texture analysis at neutron diffractometer STRESS-SPEC. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, *642*(1), 87 - 92. http://dx.doi.org/10.1016/j.nima.2011.04.008

Hofmann, M., Schneider, R., Seidl, G., Rebelo-Kornmeier, J., Wimpory, R., Garbe, U., & Brokmeier, H.-G. (2006). The new materials science diffractometer STRESS-SPEC at FRM-II. *Physica B: Condensed Matter*, *385-386, Part 2*, 1035 - 1037. (Proceedings of the Eighth International Conference on Neutron Scattering) http://dx.doi.org/10.1016/j.physb.2006.05.331

Randau, C., Brokmeier, H., Gan, W., Hofmann, M., Voeller, M., Tekouo, W., … Schreyer, A. (2015). Improved sample manipulation at the STRESS-SPEC neutron diffractometer using an industrial 6-axis robot for texture and strain analyses . *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, *794*, 67-75. http://dx.doi.org/10.1016/j.nima.2015.05.014

Šaroun, J., Kornmeier, J. R., Hofmann, M., Mikula, P., & Vrána, M. (2013, Jun). Analytical model for neutron diffraction peak shifts due to the surface effect. *Journal of Applied Crystallography*, *46*(3), 628–638. http://dx.doi.org/10.1107/S0021889813008194