MM 22: SYM Physics meets Industry

Time: Wednesday 14:45–19:55 Location: H16

MM 22.1 Wed 14:45 H16

Eine neue Bohr- und Auswertestrategie zur Bestimmung von Messunsicherheiten bei der Eigenspannungsermittlung nach dem inkrementellen Bohrlochverfahren — •Wulf Pfeiffer und Johannes Wenzel — Fraunhofer IWM, Wöhlerstr. 11, 79108 Freiburg

Das Bohrlochverfahren ist als ökonomische Methode zur teilzerstörenden Eigenspannungsermittlung bekannt. Es beruht auf der Bestimmung von Dehnungsänderungen an der Oberfläche des Bauteils durch definierten Eingriff in das Eigenspannungsgleichgewicht (Bohren eines Sackloches). Ein wesentlicher Nachteil des Verfahrens ist, dass die Angabe der Messunsicherheit nur durch (meist nicht machbare) Wiederholungsmessungen möglich ist.

Es wurde ein Verfahren erarbeitet, das die Berechnung von Messunsicherheiten ohne Wiederholungsmessungen ermöglicht. Dazu wird für jeden Tiefenschritt das Bohrloch zusätzlich lateral aufgeweitet. Damit werden zusätzliche Dehnungsauslösungen zur Verfügung gestellt, die zur Berechnung einer Messwertstreuung herangezogen werden können. Der funktionale Zusammenhang zwischen den Dehnungsumlagerungen an der Bauteiloberfläche und inkrementeller Elimination spannungsbehafteter Volumenelemente wird durch Finite Elemente Modellierung bestimmt. Diese Kalibrierfunktionen können dann zur Berechnung diskreter Eigenspannungswerte für verschiedene Tiefen und Aufweitungen nach den bekannten linear-elastischen Ansätzen differenzieller Verfahren herangezogen werden. Durch Bohrversuche an einer Zugprobe unter bekannten Lastspannungen wurden die Ergebnisse der FE-Berechnungen verifiziert.

MM 22.2 Wed 15:05 H16

New Possibilities for X-ray Diffractometry — •Jörg Wiesmann, Christian Hoffmann, Jürgen Graf, and Carsten Michaelsen — Incoatec GmbH, Max-Planck-Str. 2, 21502 Geesthacht

During the last years the instrumentation for X-ray metrology has remarkably improved. There are numerous solutions for all components such as sources, optics and detectors. We present a new development for X-ray beams which we deliver in modules custom-built: the IμS - Incoatec Microfocus Source - is a high-brilliance X-ray source incorporating a 30W microfocus sealed tube together with a high-performance Montel Multilayer X-ray Optic. The IμS has the brilliance of a conventional 5.4-kW rotating anode system, but offers numerous benefits for example no moving parts, long lifetime without maintenance, air-cooling to name but a few. It can be integrated into various X-ray analytical systems using Cu or Mo radiation. The optics shape parallel as well as focused beams with different spot sizes. Data quality and ease of operation are strongly improved in applications such as biological and chemical crystallography and Small Angle X-ray Scattering (SAXS). For SAXS there is a factor of five intensity gain compared to a conventional sealed-tube setup. Finally we will give an outlook on further improvements of IμS. We invite users to discuss their requirements and share their ideas with us.

MM 22.3 Wed 15:25 H16

Advanced Residual Stress Investigation Utilizing Laboratory X-Ray Diffraction Instrumentation — •Lutz Brügemann and Jens Brechbühl — Bruker AXS, Karlsruhe, Germany

Different methods for the determination of material properties like hardness, tensile strength, and Young*s modulus are limited in their ability to characterize the performance of a material or a work piece entirely. However, X-ray diffraction based methods enable a non-destructive approach to the internal stress state of a work piece after even after heat treatment/hardening and/or grinding. Additionally, due to X-rays capability to penetrate the material, those diffraction based residual stress investigations allow determining volume information from some microns below the sample surface. By utilizing those methods even a depth profile/stress gradient can be studied.

Residual stress investigations are also of very high interest for wafer manufacturing. Thin Cu films or damascene Cu lines on Si-wafers need to be investigated with high lateral resolution (micro-diffraction). XRD2 using a 2-D photon counting detector is the right method allowing fast measurements although the signals are weak due to the small illuminated volume. Additionally, the commonly strong texture of the thin Cu lines can be recorded and considered simultaneously, and hence will not impede the stress measurements and data evaluation.

The goal of the presentation is to give a wider view of the principles of the residual stress investigations by using X-rays. By means of case studies the capabilities of laboratory instrumentation is presented.

MM 22.4 Wed 15:45 H16

The Deposition Process of Nanoscaled Multilayer Coatings for X-ray Optics — •Frank Hertlein, Jörg Wiesmann, Alexandra Oehr, Steffen Kroth, and Carsten Michaelsen — Incoatec GmbH, Max-Planck-Str. 2, 21502 Geesthacht

Incoatec develops, produces and sells X-ray optics with optimized properties. The optics consist of bent substrates with shape tolerances below 100nm, upon which multilayers are deposited with single layer thicknesses in the nanometer range and up to several hundreds of layer pairs. Additionally these multilayers were designed with lateral thickness gradients within +-1% deviation of the ideal shape. This means that a deposition precision in the picometer range is needed.

The talk will highlight how Incoatec designs, produces and characterizes these optics. We use sputtering methods for deposition, optical profilometry in order to characterize the shape and X-ray reflectometry to characterize the multilayers. The talk will emphasize the possibilities and limits of different in-situ and ex-situ metrology methods when manufacturing X-ray optics. Finally, ideas for new high precision metrology methods will be outlined.

15 min break

MM 22.5 Wed 16:20 H16

On the Application of SIMS for the Determination of Carbon Depth Profiles — •Peter-Joachim Wilbrandt[1], Jürgen Gegner[2], and Reiner Kirchheim[1] — [1]Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]SKF GmbH, Department of Material Physics, Ernst-Sachs-Str. 5, 97424 Schweinfurt, Germany

An industrially well-established method for the optimization of edge zone properties of steel components is carbon enrichment before hardening. Due to unreliable state-of-the-art process prediction, quality control and improvement of carburizing case hardening operations is essential. Additionally, detailed information on carbon distribution in edge zones is needed to assess decarburization during steel heat treatments and for computer simulations of carbon diffusion processes.

The standard methods for carbon concentration determination, like electron microprobe, glow discharge spectroscopy or hardness measurements, are limited regarding accuracy or spatial resolution. This motivated attempts to apply secondary ion mass spectroscopy (SIMS) as microchemical analysis technique for the determination of carbon profiles in ferrous materials.

The method is applied to metallographically prepared cross sections. After a detailed description of the measuring procedure, some representative applications to heat treatment technology, failure analysis and material science are discussed. A new method for the determination of carbon diffusivities in the austenitic phase of low-alloyed steels is presented.

MM 22.6 Wed 16:40 H16

High-temperature corrosion in waste incineration plants — •Barbara Waldmann, Bernhard Stöcker, Ferdinand Haider, and Siegfried Horn — Universität Augsburg

The corrosion of steels in heat exchangers of power plants is still not understood in all details. Especially in waste incineration plants the corrosion is a substantial technical and also economic problem. A corrosion probe was developed, which allowed to detect corrosion in real-time by performing potentiostatic analysis. The measurements were performed with three electrodes, two of which consisted of the steel (15Mo3) employed in the respective facility. Additionally the probe head was kept at the same temperature as the heat exchanger pipes to allow for a conclusion about the corrosion on the heat exchanger pipes in the facility. The measured corrosion rates agree well with those observed in the facility. In addition to these measurements, the influence of parameters like temperature, exhaust gas composition, or flow rate on the corrosion behaviour and the deposit composition were investigated by changing these parameters locally at the probe head.

MM 22.7 Wed 17:00 H16

Surface analysis of technological relevant samples — •Andreas Thissen — Voltastr. 5, 13355 Berlin, Germany

Electronic devices have revolutionized everyday life in industrial countries over the last decades. Recently two main tasks for research and development are dominant: miniaturization for sophisticated applications targetting at the nanoscale, and designing low cost large scale devices. In both fields the device performance is strongly determined by materials* quality, composition, combination and last but not least by processes at materials* interfaces. Nanostructures, minimization of material consumption and the need to improve device efficiencies consequently leads to the widespread focussing on thin film preparation. For thin film devices surface and interface analysis like photoelectron spectroscopy is an important tool for material and device characterization. Classical well defined model experiments already reveal important insights using highly integrated vacuum systems for analysis and preparation. But analysis of materials and devices under near environmental conditions and even in situ during operation is an inevitable future development to improve the significance of data for development and quality management. In this respect techniques like high pressure XPS, XPS from liquids and hard x-ray PES (HAXPS) are some of the challenging tasks for manufacturing companies for surface analytical equipment.

MM 22.8 Wed 17:20 H16

Fabrication and Mechanical Properties of Metal Thin Films — •Thomas Wübben[1], Gunther Richter[1], and Eduard Arzt[1,2] — [1]Max-Planck-Institut für Metallforschung, Heisenberg-Str. 3, 70569 Stuttgart — [2]Universität Stuttgart, Institut für Metallkunde, Heisenberg-Str. 3, 70569 Stuttgart

Nanoscale metallic materials and structures exhibit size-dependent mechanical properties, which deviate substantially from bulk values. Our research aims to understand and quantify this so-called size effect. Various experimental techniques have been established in our group over the last years. These include the classical substrate curvature technique as well as the newly developed in situ tensile tests with stress measurement by XRD methods. To retain control on quality and properties, all samples are produced in house by the thin film laboratory. This central scientific facility inside our institute offers different physical vapour deposition techniques, including magnetron sputtering and molecular beam epitaxy. An extensive data base of the mechanical properties of the technologically important metals Cu, Al and Ag could be built up this way. The presentation will give an overview about the production and testing possibilities in our group. It will finally highlight the major technical challenges for future research and what we request from industry.

MM 22.9 Wed 17:40 H16

Flap Simulation and Testing System for the A400M Airbus — •Klaus Metzger[1] and Peter Scholz[2] — [1]imc Meßsysteme GmbH, Voltastr. 5, 13355 Berlin — [2]ADDITIVE GmbH, Max-Planck-Str. 22b, 61381 Friedrichsdorf

The measurement system consists of an actual Airbus A400M wing, combined with a virtual simulated wing. It is designed to measure the electrical and mechanical systems of the entire wing flap system. In addition to the hundreds of analog signals (including force, temperature, and voltage), it is important to record additional information, including the safety critical data on the ARNIC bus and other modern industrial serial data buses.

In summary, the whole system can handle and store a data volume of several mega words per second, from the various different data sources. The control and response of the missing wing is simulated such that the airplane systems behave as if it works with a complete system. This makes it possible to simulate and analyze all flight relevant situations. For data storage, PC systems with terra-byte capacities are used. A user friendly configuration and analysis interface, allowing operations simultaneously on six systems completes the system.

15 min break

MM 22.10 Wed 18:15 H16

Quantitative elastic modulus measurement at the nanoscale using atomic force microscope — •Udo Volz[3], Sergey Belikov[1], Sergei Magonov[1], Natalia Erina[1], Lin Huang[1], Craig Prater[1], Valeriy Ginzburg[2], Gregory Meyers[2], Robert McIntyre[2], and Hamed Lakrout[2] — [1]Veeco Instruments Inc., 112 Robin Hill Road, Santa Barbara, CA 93117, USA — [2]Dow Chemical Company, Analytical Sciences 1897E Building, Midland, MI 48667, USA — [3]Veeco Instruments GmbH, Dynamostrasse 19, D-68165 Mannheim, Germany

Quantitative studies of the elastic modulus of homogeneous polymer materials in a wide modulus range and recognition of the individual components and the interphases in heterogeneous systems with the AFM-based cantilever nanoindentation method will be presented.

MM 22.11 Wed 18:35 H16

Some new application aspects of scanning electron microscopy — •Hans-Georg Braun and Evelyn Meyer — Leibnitz Institute of Polymer Research Dresden, Max Bergmann Center of Biomaterials, D-01069 Dresden, Hohe Strasse 6

Scanning electron microscopy is a well established tool for the material scientist. Recent developments in SEM instrumentation allow the SEM operation at low (E<1 KeV) electron energies which overs remarkable possibilities in imaging ultrathin (t<10 nm) layers, especially polymer layers with high image contrast. In addition low operation voltage allows imaging of non-conducting materials such as polymer, ceramics or glass without electrical charging. The integration of tiny manipulation tools into the SEM makes the SEM a nano- or microlaboratory. The manipulation tools inside the SEM allow an interaction with the sample under direct observation at high magnifications. Tiny things can be moved, particles be separated and tools for measuring purpose can be adjusted under visual control.

MM 22.12 Wed 18:55 H16

Modulation of stress-GBD curves of a polycristalline fibre mat using a micromechanic model — •Florian Wolferseder[1], Ferdinand Haider[2], and Uwe Tröger[3] — [1]Universität Augsburg, Institut für Physik — [2]Universität Augsburg, Institut für Physik, Experimentalphysik I — [3]Firma ArvinMeritor, Augsburg, Deutschland

Polycrystalline fibre mats are used to support ceramic substrates in catalytic converters and diesel particulate filters. Under compressive loading the fibre mats show a non-linear stress-strain behaviour. The stress-GBD (gap bulk density) curves follow a power-law relationship in accordance with several models. The models predict an exponent of the power law higher 3, depending on the architecture of the fibre network. In-situ-deformation in a SEM on the fibre mat were conducted in order to verify the assumptions of the model and the results of the compression tests. Another aim has been to find an empirical formula of the stress-time behaviour for long time relaxation experiments.

MM 22.13 Wed 19:15 H16

On the Feasibility of Nitrogen Concentration Measurements in Steels by SIMS — Nicolas Bontems[1], •Peter-Joachim Wilbrandt[1], Jürgen Gegner[2], and Reiner Kirchheim[1] — [1]Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]SKF GmbH, Department of Material Physics, Ernst-Sachs-Str. 5, 97424 Schweinfurt, Germany

Besides the carbon distribution, which permits adjusting constant or varying hardness and microstructure across the wall thickness, nitrogen enrichment represents an effective method to improve the edge zone properties of steel components. More stable martensite is formed and higher retained austenite contents can be achieved. Since recent developments turned SIMS into a powerful technique for industrial routine carbon profile determination, the attempt was made to trace nitrogen parallel to carbon concentrations. Such a combined microanalytical measuring tool is most useful for quality control and process improvement of upcoming carbonitriding heat treatment technologies.

Five specimens with different carbon and nitrogen contents were analyzed. First tests yield good reproducibility of the counting rates and, thus, the general usability of the method. A systematic analysis of the mass spectra shows that nitrogen atoms can best be detected as negatively ionized molecule CN. As the amount of detected CN molecules is proportional to the carbon content, it was concluded that the CN/C ratio is representative of the nitrogen concentration. Comparison of such ratios with nitrogen content data proved this to be valid.

MM 22.14 Wed 19:35 H16

Measurement of Nano ordered structure in Biological macromolecules using SAXS technique — •Dillip Kumar Bisoyi — Department of physics, National Institute of Technology Rourkela, Rourkela-769008(INDIA)

Biological macromolecules play an important role in the living world. So to know the macromolecules and to characterize them from nano

ordered structure available in them is an important problem before the scientific community. There are various techniques available to solve such problems. One such informative tool is the Small Angle X-ray Scattering (SAXS), where nano ordered structure can be well resolved and hence informative solutions can be extracted and utilized to solve various problems related to biological macromolecules. Out of many biological macromolecules of importance to study, I have emphasized here human bone, because it has very complex structure, which was studied at nono order and discussed to some depth in this article. The nano ordered structure evaluated are in good agreement with the findings referred else where.