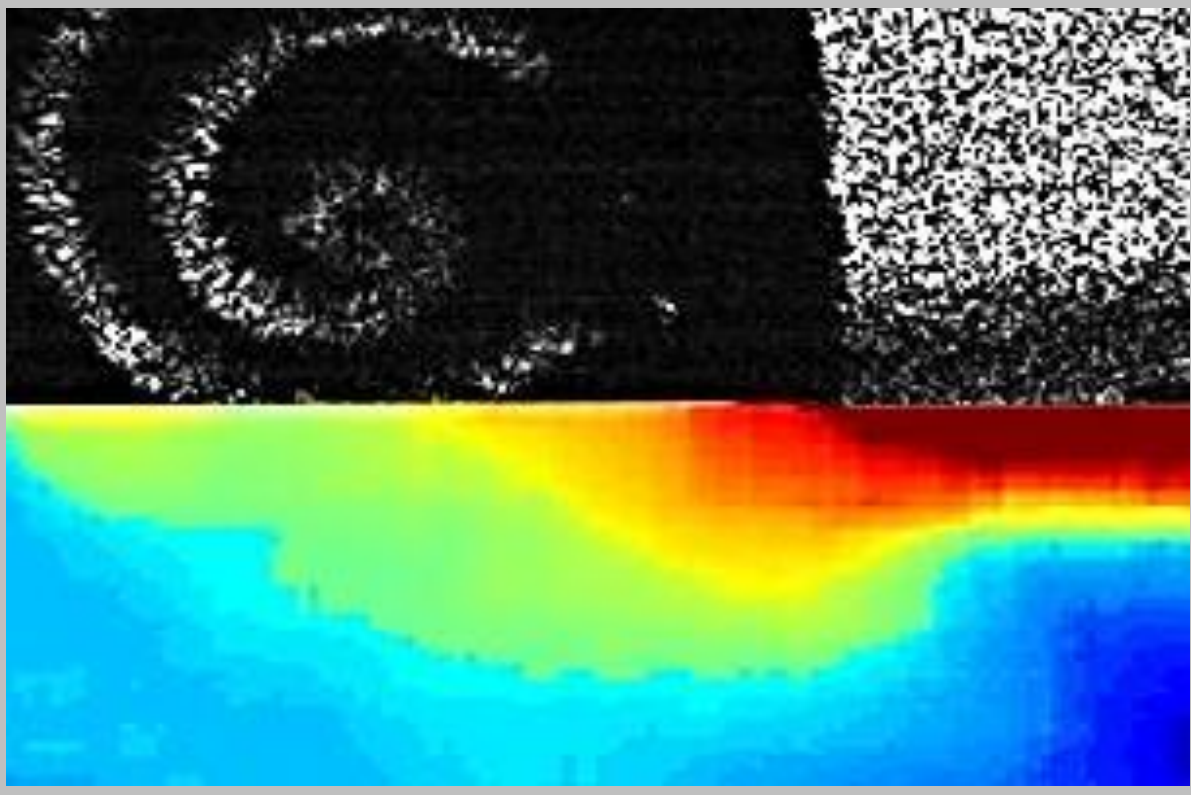
Annual Report

2016/2017



2007 - 2017 • 10 Years BIMAQ

BIMAQ

Bremer Institut für
Messtechnik, Automatisierung
und Qualitätswissenschaft

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Preface

Dear friends and partners of the institute!

10 years after its foundation, the Bremen Institute for Metrology, Automation and Quality Science (BIMAQ) is a core institute of the University of Bremen. In 2016 and 2017, numerous activities, events and achievements took place so far.

In 2016, the former BIMAQ director Prof. Goch handed the key of the institute over to the next generation, and I am very grateful to him for accompanying my introduction and his ongoing support for the institute. He established a new institute in the heart of the department Production engineering and the University of Bremen, which we will develop further.

Recently, several lectures and practical courses were revised to offer students fundamentals as well as state-of-the-art research topics during their study. Please learn more about our teaching activities in production engineering, system engineering and industrial engineering with the present report. Additional information can be found on our new website www.bimaq.de, which informs students and guest about our teaching and research activities.

Our research is focused on measurement system engineering, which includes aspects of automation and quality controls as well. For this reason, I am happy to be accepted as a new member of the association „Arbeitskreis der Hochschullehrer für Messtechnik e. V. (AHMT)“. With our ongoing research of in-process measurement techniques for production and material engineering (SFB 747 and SFB/TRR 136) I was also accepted as a principle investigator in the Center for Materials and Processes (MAPEX) in Bremen. Further research topics cover yet unsolved measurement tasks concerning wind energy systems, gear measuring technology and flow measurements. Here we continue the membership in the ForWind community, which is a Center for Wind Energy Research of the Universities of Oldenburg, Hannover and Bremen.

With a focus on model-based, dynamic measurement techniques, the BIMAQ is active in fundamental and applied research projects, in teaching as well as in cooperative research and measurement services for the industry. I would like to express many thanks to all members, students, partners and supporters of the institute that have contributed to the achievements during the last year, and hope for your continuous support for the future.

Bremen, June 2017

Prof. Dr.-Ing. habil. Andreas Fischer

BIMAQ - the Institute

Vision, topics and infrastructure

The research focus of the Bremen Institute for Metrology, Automation and Quality Science (BIMAQ) is the holistic investigation of optical measurement systems, which includes the design, realization, modelling, characterization and, finally, the application of novel measurement techniques. By applying a rigorous system-based analysis of the measurement systems, the limits of measurability and the respective uncertainty principles are investigated in order to determine and to surpass the limits of state-of-the-art approaches. Beyond pure measurement tasks, automation aspects and the application of quality controls is investigated as well. However, the core competence of BIMAQ is measurement system engineering, which is a key discipline for solving technical and overall social challenges.

A key challenge is to obtain information in-situ or in-process from highly unsteady or complex technical processes. For this purpose, model-based, dynamic measurement systems are a key topic of the BIMAQ research, which includes interdisciplinary fundamental and application-oriented research on the measurement methods and their applications. Current research topics cover task from production engineering, materials science, wind energy systems and fluid mechanics.

In addition to methodical innovations for instance based on multi-sensor-system approaches, one highlight at the BIMAQ is a unique laboratory for large gear metrology with a coordinate measurement device for gears up to a few meters. This illustrates the unique BIMAQ expertise regarding the metrology of large gears and overall geometrical measurements with a high dynamical range. Further laboratories and equipment exist in the BIMAQ main building and the BIMAQ technical center, for instance for the analysis of the surface topography and strain down to the nanometer scale, for thermographic flow analyses from long distances of several hundred meters and for laser-based flow measurements in optically non-cooperative fluids.

Research
Teaching
Knowledge

Metrology

Automation | Quality Control

Methods

Measuring System Theory

- Modelling and Simulation
- Uncertainty Relations
- Limits of Measurability

Measuring System Technology

- Optical High Speed Measuring Systems
- Multi-Sensor-Systems
- Coordinate Measuring Systems

➔ modelbased, dynamic Measuring Systems

Application

Produktion Engineering & Materials Science

- Geometrical and Roughness Metrology
- Optical In-Process-Metrology
- Thermography, Edge Zone Analyses

Wind Power Systems & Flow Processes

- Gear Measuring Technology
- Gear Metrology
- Flow Measurement Technology

BIMAQ competences

BIMAQ - the Institute

Laboratories

LAB

Laboratory for dimensional metrology

BIMAQ's infrastructure features a variety of modern high-precision measurement systems. The equipment ranges from tactile coordinate, gearing and roughness measuring devices via optical systems like stripe pattern projection and laser triangulation through testers for non-destructive analysis with thermal, magnetic and acoustic probe systems and sensors. This equipment is used for the calibration and validation of newly developed measurement and sensor systems, e. g. for optical gear measurements, but it is also the basis for measurements within research projects and for the regional industry.

BIMAQ conducts form, size and location tests on very small to very large components by dimensions of a few millimeters up to 3 meters and offers standardized measurement and evaluation procedures as well as customer-specific solutions, such as the evaluation of advanced features or the digitization of a component.

Services

- Development of measurement and evaluation strategies
- Acquisition and analysis of dimensional deviations - tactile or optical
- Characterizing surface quality - tactile or optical
- Gear inspection
- Surface integrity analysis - non-destructive and non-contact
- Order/reference measurements

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Tactile measurement of a 5-axis milled gear segment

LAB

Technikum:
Laboratory for large gears

Optimization of large gear measurements

To calibrate large gears currently no appropriate standards exist, that allow the traceability of the test processes to the SI unit "meter" with sufficient accuracy. In close cooperation with the National Metrology Institute of Germany (PTB), BIMAQ therefore is involved in developing large gear standards with a diameter of 2000 mm and more.

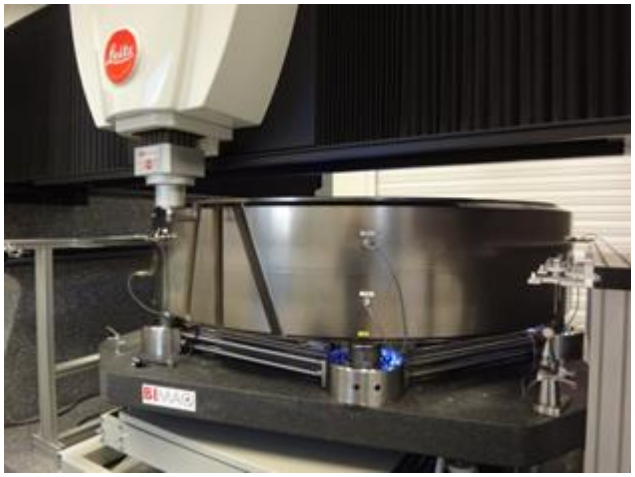
Furthermore, BIMAQ analyzes the cause-effect relationships between gear manufacturing, geometric deviations and occurring gearbox damages. In the field of quality inspection of gears, algorithms are being developed in order to evaluate dimensional measurement data.

Technical specifications

Portal coordinate measuring machine Leitz PMM-F 30.20.7:

- Measuring volume:
  3.0 x 2.0 x 0.7 m³

Tactile measurement of large cylindrical gearing



Measuring a 2 m gear standard
on BIMAQ‘ s large CMM

- Measuring uncertainty:
  $MPE_E = (1.3 + (L \text{ in mm})/400)\ \mu m$
- Workpiece mass:
  max. 6,000 kg
- Rotary table:
  For rotation-symmetric components up to 3.0 m diameter

Air conditioning
(maximum temperature gradients):

- 0.4 K/h, 0.8 K/d, 0.2 K/m

Services

- Order/reference measurements
- Calibration of reference standards
- Analysis and evaluation of geometric deviations
- Development of measurement and evaluation strategies
- Software development

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Laboratories

Laboratory for optical metrology

The laboratory for optical metrology includes the two main fields of research:

- In-process measuring methods and
- Surface integrity evaluation.

The focus "In-process measurement methods" concentrates on the surface assessment with scattered light and other methods as well as the determination of (primarily) mechanical workpiece loads during manufacture.

The used light scattering methods allow a quick, in-process determination of (statistical) surface characteristics, without detecting the actual topography of the component. The procedures can be applied to investigate fast moving component surfaces in the manufacturing process. In addition to assessing the mean roughness in the observed measurement spot, statements about structure heights and widths as well as individual defect classes of components are possible. This evaluation can be applied not only for structure areas with sizes above the optical wavelength, but also for structures in the nanometer range (below the optical wavelength) due to the use of the rigorous scattering theory based on Maxwell equations. The measurement methods are investigated with simulative and experimental approaches leading to results about measurement resolution and uncertainty for specific applications as well as general measurability limits.

Services

- Feasibility studies on the application of measurement principles, particularly in manufacturing and heat treatment processes,
- Development of measuring methods for industrial applications,
- Basic research for new measurement methods in the two fields of research,
- Simulation and measurement of light scattering on micro- and nano-structured workpieces to assess the structural quality,
- Destructive surface integrity/topography checking by comparison with reference samples.

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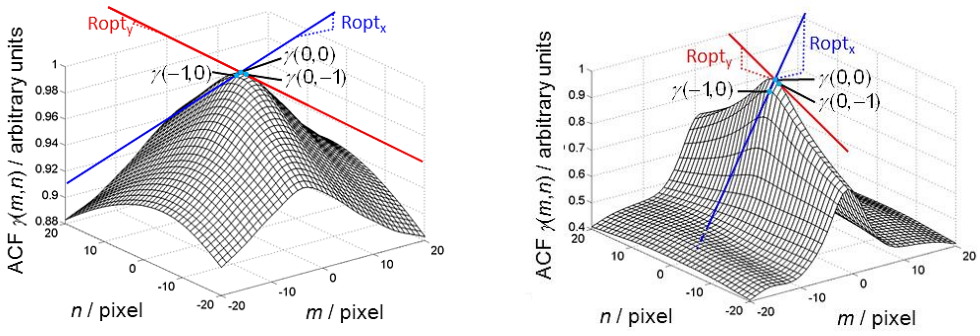


Roughness evaluation of two surfaces with speckle-autocorrelation function

LAB

Laboratory for thermography

Boundary layer visualization of running wind turbine rotor blades

The temperature distribution on the surface of a rotor blade can be detected by thermographic cameras. BIMAQ investigates thermographic measurements of rotor blades on wind turbines in operation. Measurements are taken in co-operation with the Deutsche WindGuard Engineering GmbH in Bremerhaven. Meaningful results can be achieved from a distance between 100 and 500 m.

Technical Data

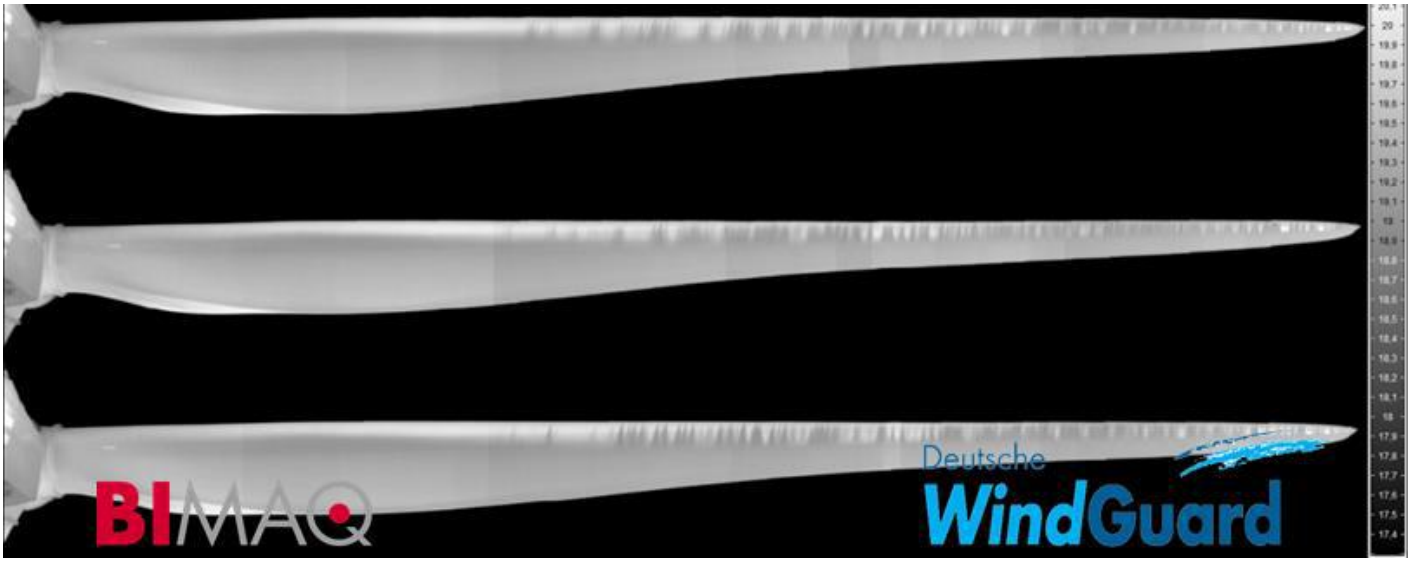
ImageIR thermographic imaging system:

- High speed system
- Detector format: 640 x 512 Infrared Pixel
- Spectral range: 2 - 5 µm
- Focal length incl. telephoto lens: 200 mm

ImageIR thermographic imaging system

Services

- Determination of the laminar/turbulent transition location
- Detection of early laminar-turbulent transition due to leading edge contamination, erosion, manufacturing irregularities or the effects of leading edge protection
- Inspection of vortex generators, zig-zag tapes and other flow control devices



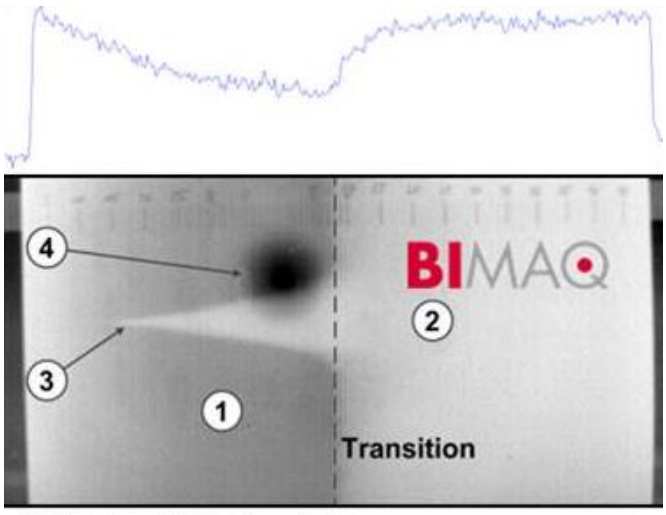
Thermographic images taken at the research wind turbine of the University of Bremen

BIMAQ - the Institute

Laboratories

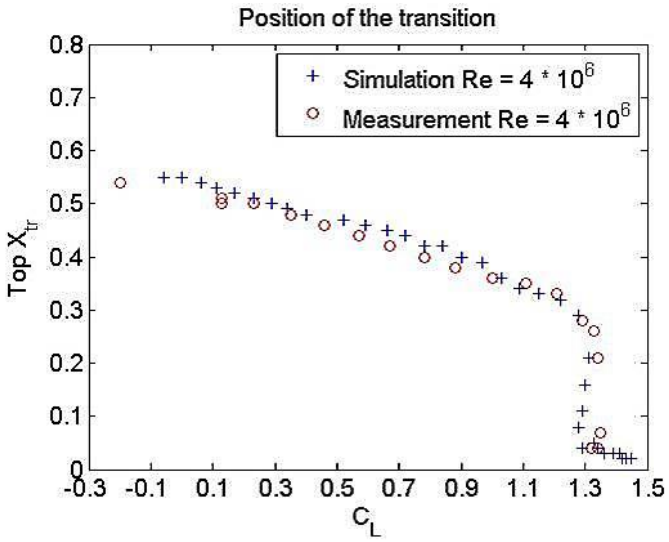
Boundary layer visualization of wind turbine airfoils

In order to investigate the boundary layer flow phenomena on airfoils, thermographic measurement approaches are developed and applied. The research focus are new image evaluation techniques based on the flow dynamics. The flow experiments with two different IR imaging systems are performed at the Deutsche WindGuard Aeroacoustic Wind Tunnel in Bremerhaven, where laminar air flows at speeds of up to 360 km/h and chord-Reynolds numbers of up to 6 million can be generated. Aerodynamic as well as aero-acoustic studies are conducted.



1: Laminar boundary layer
2: Turbulent boundary layer
3: Turbulence wedge due to a paint defect
4: Reflection of the cooled detector

Thermographic image for flow visualization on an airfoil in the wind tunnel



Position of the transition X_{tr} as a function of lift coefficient Cl

Technical Data

VarioCam hr:

- Detector format: 640 x 480 Infrared Pixel
- Spectral range: 7,5 - 14 µm
- Focal lengths: 12,5 mm and 30 mm

ImageIR:

- Detector format: 640 x 512 Infrared Pixel
- Spectral range: 2 - 5 µm
- Focal lengths: 12 mm, 25 mm, 100 mm and 200 mm

Services

- Determination of the laminar turbulent transition location
- Checking functionality of vortex generators and zig-zag tape
- Comparison to simulation data

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LAB

Laboratory for inside-sensoring

Wind turbine generators (WTG) are dynamically highly stressed, which can lead to bearing and gear damages. For targeted improvements in design, production and choice of material meaningful metrics are missing. The individual transmission components (gears, bearings, shafts) are metrologically not accessible during operation, so far. A few states can be observed from the outside, e. g., Temperature changes on the housing or noises or vibrations. But, the causes of problems are mostly inside the gear housing. These include mechanical stresses which may lead to undue distortion of the individual teeth and subsequently to wear of the tooth flanks.

Services

- Development of sensing prototypes
- Order and reference measurement
- Development of new measurement and evaluation strategies
- Software development

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Drivetrain inside the hub of a wind energy system

BIMAQ - the Institute

Laboratories

LAB

Technikum: Mechanical workshop

BIMAQ maintains a 400 m² Technikum to support the research work.

The Technikum contains the

- Laboratory for large gears
- Experimental field
- Mechanical workshop

Mechanical workshop

For the production of test rigs, test stands and prototypes, the mechanical workshop is equipped, for example, with a

- CNC milling machine
  Travel distance: 400 mm x 400 mm x 400 mm
- 3D printer
  Space: 203 mm x 203 mm x 152 mm
- Milling drill plotter
  Maximum material size:
  229 mm x 305 mm x 35 mm

Services

- Item and small-batch production
- Additive and cutting machining

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Staff

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Prof. Dr.-Ing. habil. Andreas ***Fischer***

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Thomas ***Eilts***
Michael ***Essert*** (until 07/2016)
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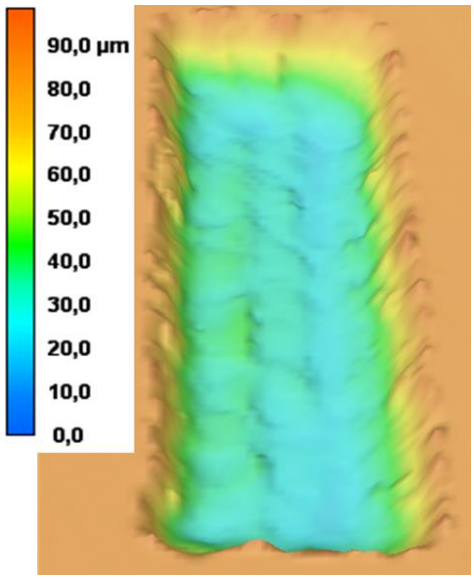
Dipl.-Ing. Frank ***Horn***
B. Sc.Robin ***Lipinski***
Uwe ***Reinhard***

SFB 747 Micro Cold Forming - Subproject A5

Controlled scalable laser removal procedure for the manufacturing of contoured micro forming tools

Funding organization: DFG/SFB
Funding ID: SFB 747 Mikrokaltumformen
Duration: 01 Jan 2007 - 31 Dec 2018
Project scientists: Peiran Zhang,
Merlin Mikulewitsch

Laser chemical machining (LCM) is a novel procedure used to manufacture micro forming tools from hard metals with relatively low cost compared to competing micro-machining processes such as micro-milling or micro electrical discharge machining. The material is removed by an etchant that is chemically activated by heat from a focused laser beam, localized at the area of incidence, to produce the desired geometry.



Rectangular micro die (500 µm x 200 µm) manufactured with laser chemical machining

The project aims to evaluate and improve the process capability of laser chemical machining in addition to reducing irregularities and dimensional deviations inherent in the etching process. In order to master a stable and reproducible production of micro forming tools without manual determination of the optimal process parameters, an adaptive control system is developed. Integrating the control system in the LCM process reduced the flatness deviation of a rectangular micro die (cf. figure) from about 33 µm to less than 5 µm. The design of a 3D path-planning for the path of removal is the focus of ongoing research.

Literature

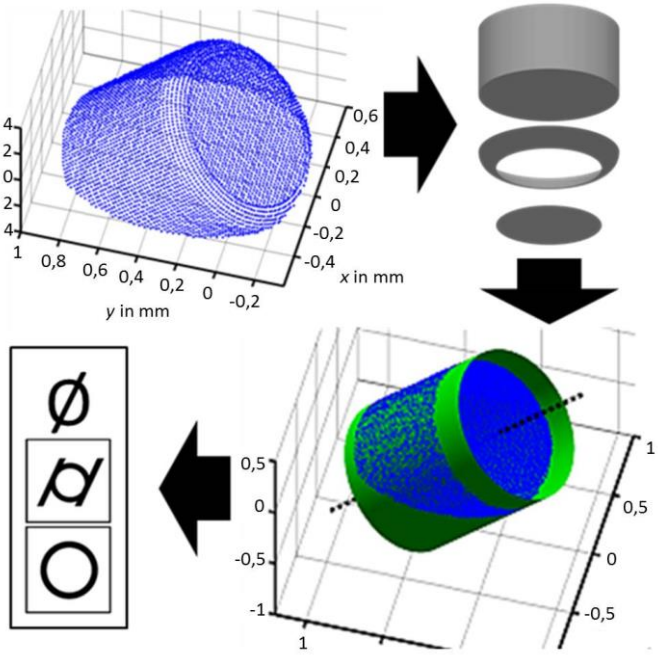
[1] P. Zhang, G. Goch: A quality controlled laser-chemical process for micro metal machining. Production Engineering 9:577-583, 2015.
[2] P. Zhang, S. Mehrafsun, G. Goch, F. Vollertsen: Automatisierung der laserchemischen Feinbearbeitung und Qualitätsprüfung mittels Interferometer. In: 6. Kolloquium Mikroproduktion, Braunschweig, 8 Oct 2013.
[3] P. Zhang, A. von Freyberg: A closed loop quality control system for laser chemical machining. In: euspen 2016, Nottingham/UK, 30 May - 3 Jun 2016, pp. 505-506.

SFB 747 Micro Cold Forming - Subproject B5

Quality inspection and logistic quality control for micro production processes

Funding organization: DFG/SFB
Funding ID: SFB 747 Mikrokaltumformen
Duration: 01 Jan 2007 - 31 Dec 2018
Project scientists: Axel von Freyberg, Matthias Auerswald

Micro cold forming poses two challenges for the quality inspection process: On the one hand, the parts and geometrical features to be tested have sub-millimeter dimensions and request high dynamic ranges of the measuring systems; on the other hand, the forming processes produce parts in a high clock rate, which limits the time available for measuring and evaluating the individual parts. To cope with these conditions, the collaborating institute BIAS is developing a digital holographic measuring system within this project to acquire geometric date of the part's surface.



Geometric decomposition and approximation

In contrast to conventional dimensional metrology, the optically acquired surface data represents a combination of geometric elements, which has to be separated into individual objects prior to the evaluation of geometric deviations and parameters. For this purpose, algorithms have been developed for an automated holistic approximation of the combined geometric elements, including the ideal decomposition of these elements (see figure). This new approach is currently being adapted to combinations of higher order geometric elements (e.g. ellipse, parable etc.) to address the increase of complexity within the SFB 747.

Literature

[1] K. Lübke, Z. Sun, G. Goch: Three-dimensional holistic approximation of measured points combined with an automatic separation algorithm. CIRP Annals 61(1):499-502, 2012.

[2] A. von Freyberg, P. Höweler, H. Flosky, H. Brüning, G. Goch: Analyse des Effektes der Mess-Strecke bei der Rauheitsmessung an gekrümmten Mikrobauteilen. In: 7. Kolloquium Mikroproduktion, Aachen, 2015.

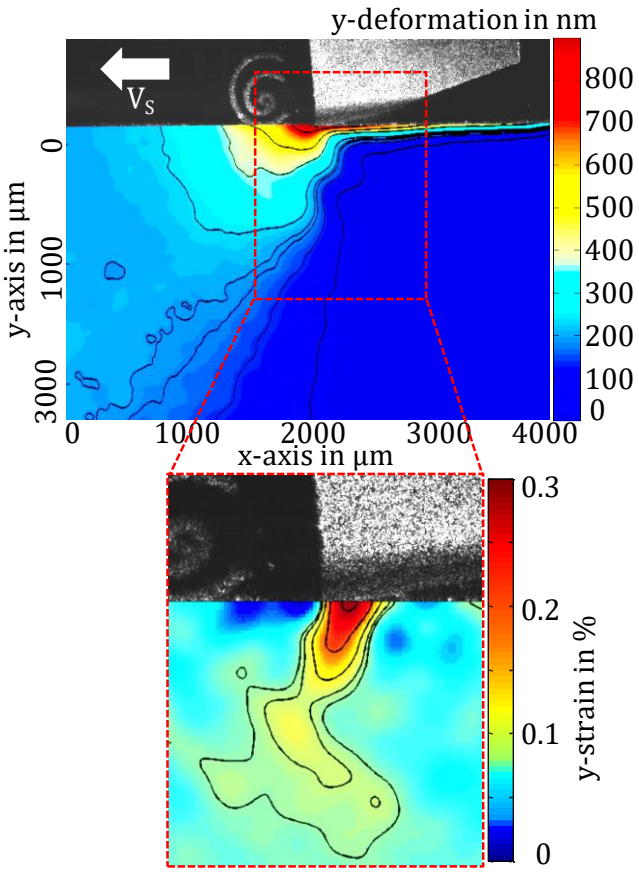
SFB/TRR 136 Process Signatures - Subproject C04

In-situ measurement of mechanical and thermal material loads

Funding organization: DFG/SFB
Funding ID: SFB Transregio 136
Duration: 01 Apr 2014 - 31 Jan 2017
Project scientist: Andreas Tausendfreund

Production processes, such as deep rolling or grind strengthening try to manipulate the specific surface layer properties of the workpiece in a deliberate manner. For this, a comprehensive knowledge of the physical stresses during the machining is necessary. The interesting properties, like hardness and elastic modulus, are strongly influenced by plastic and elastic deformation. However, the measurement of elastic deformations in a running production process is complicated. Speckle correlation methods in principle offer the potential to meet this challenge. The initial question was, whether speckle correlation methods are suitable to measure under the rough production conditions with sufficient measurement resolution.

Deformation measurements during tooling succeed with the aid of a high-speed camera and a laser short-pulse exposure. Evaluation algorithms, specially adapted to the various production processes, recognize and eliminate disturbing influences such as for example particle or spark flight. The resulting elastic and plastic deformations can be reconstructed with a local resolution of 20 nm. This makes it possible for the first time, to observe the dynamic material deformations and strains in a milling process.



Elastic deformation and strain in a single tooth milling process

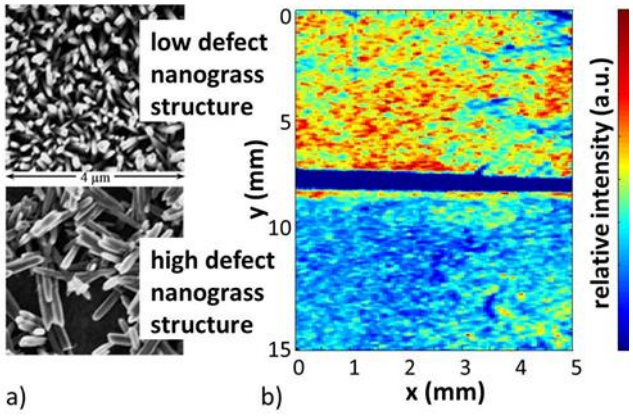
Literature

[1] A. Tausendfreund, D. Stöbener, S. Patzelt, G. Ströbel, A. Fischer: In-Prozess-Verformungsmessung auf Basis von Speckle-Korrelationsverfahren. In: AHMT 2016, Hannover, 15 - 16 Sep 2016, pp. 201-207.
[2] A. Tausendfreund, D. Stöbener, G. Ströbel: In-process measurements of strain fields during grinding. In: euspen 2016, Nottingham/UK, 30 May - 3 Jun 2016, pp. 85-86.
[3] A. Tausendfreund, D. Stöbener, G. Dumstorff, M. Sarma, C. Heinzel, W. Lang, G. Goch: Systems for locally resolved measurements of physical loads in manufacturing processes. CIRP Annals 64(1):495-498, 2015.

Method development for measuring procedures for the in-process-characterization of sub-100-nm-structures

Funding organization: DFG
Funding ID: GO 554/35-1
Duration: 01 Apr 2015 31 Mar 2018
Project scientist: Gabriela Alexe

More and more applications from nanotechnology are finding their way into mass production. One of the biggest challenges is the adequate process management, resulting in an increasing need for suitable in-process measuring methods for rapid quality testing and process control. Theoretical considerations show that scattered light distributions of illuminated surfaces also contain information about existing nanostructures. Due to their fast, integral and non-contact data acquisition, scattered light measurement methods are predestined for in-process measurements on nanostructured systems.



a) Examplary SEM images of intact and defective nanograss-structured surfaces.
b) Measured scattered intensities during a large area simultaneous scan over an intact and a defective nanograss structure.

The aim of this project is the realization of a simulation-assisted methodology for the design of in-process scattered light measuring methods for nanostructured surfaces, developed for several specific applications. Light scattering distributions for intact and defective surfaces are rigorously calculated and the scattering features connected to specific defects are determined with statistical relevance. Whether for stochastic or periodical structures, fast measuring methods to unambiguously distinguish the defective surfaces can be this way configured without a comprehensive experimental effort (see figure). Moreover, the methods are designed for structures with sub-wavelength dimensionality.

For the case of subwavelength sinusoidal gratings formed in a roll-to-roll procedure, an evaluation algorithm for the grating period and height was developed, able for inline application. Offline measurements resulted in measurement uncertainties for the grating period and height of 0.3 nm and ≤8 nm, respectively.

Literature

[1] G. Alexe, A. Tausendfreund, D. Stöbener, A. Fischer: In-process measuring method for nanostructures.
euspen Special Interest Group Meeting: Structured and Freeform Surfaces, Copenhagen/DK, 9 - 10 Nov 2016. (oral presentation)
[2] G. Alexe, A. Tausendfreund, D. Stöbener, G. Ströbel: In-process characterization of sub-wavelength structures. In: euspen 2016, Nottingham/UK, 30 May - 3 Jun 2016, pp. 183-184.

In-situ nitriding layer measurement

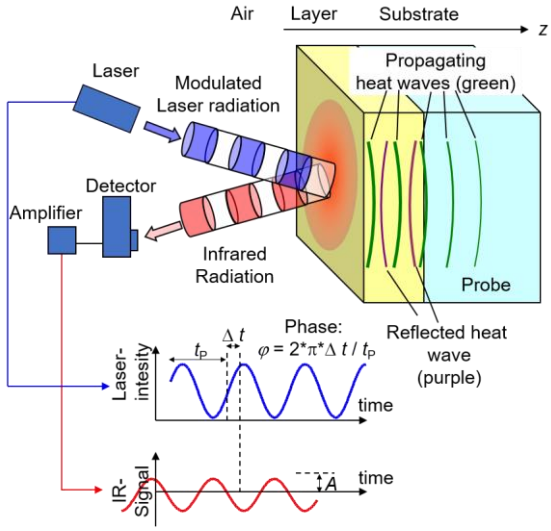
Online monitoring nitride layer formation during gas nitriding based on photothermic and X-ray in-situ measurement techniques

Funding organization: AIF
Funding ID: IGF N11787/13
Duration: 01 Aug 2014 - 31 Jan 2017
Project scientist: Helmut Prekel

In the case of gas nitriding of steels, faulty nitriding results frequently occur. This includes soft spots, a too thin nitride layer or a strongly porous connecting layer. The nitriding results are therefore to be examined conventionally after nitriding. Proven test methods, such as metallography, are destructive, cost-intensive and time-consuming so that, for example, batch effects are difficult to compensate. Therefore, a control of the nitriding process is needed, which requires an in-situ measuring method.

Although radiography permits an in-situ characterization of the nitride phase formation and the internal stress in the laboratory scale, it is not applicable in an industrial nitriding furnace. Photothermic methods are in principle suitable for in-situ testing, even in an industrial environment, but require a calibration which has to be carried out using X-ray diffraction (XRD) methods in the laboratory.

Measurements during nitriding showed a strong correlation between nitride layer thickness and photothermic measurement signals which could be verified by XRD. Simulation tools using the finite element method (FEM) were used to extract the layer thickness information from the measurement signal. This signal can be used to develop strategies for controlling the nitriding process and detect the appearance of pores in the surface of the workpiece.



Principle of the photothermic measurement technique

Experimental setup using XRD and photothermal radiometry

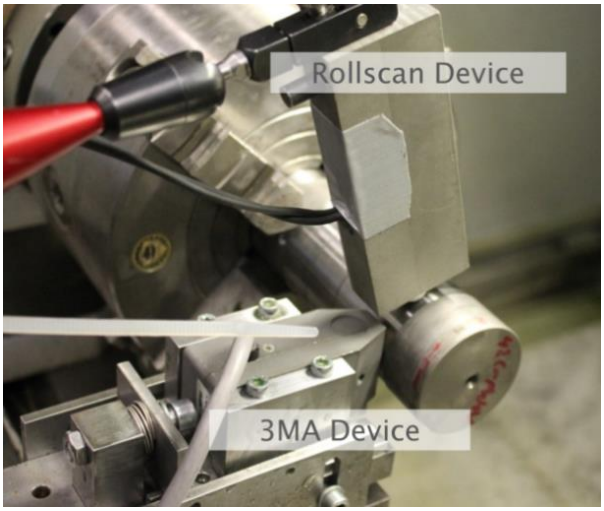
Literature

[1] J. Dong, H. Prekel, M. Dethlefs, J. Epp, A. Fischer: In-situ Untersuchung von Randschichten während des Gasnitrierens mittels Röntgendiffraktometrie und photothermischer Radiometrie. HTM Journal of Heat Treatment and Materials 72(3), 2017, pp. 154-167.

Adaptive grinding process

Funding organization: AIF (CORNET)
Funding ID: IGF 135 EBG
Duration: 01 Jan 2015 - 31 Dec 2016
Project scientist: Christoph Dollinger

Grinding as precision machining is usually realized at the end of the process chain. Up to this point, considerable cost and energy were invested in the previous manufacturing steps. According to the state-of-the-art, significant potentials of productivity and quality cannot be utilized due to the geometrically undefined cutting edge of the abrasive grain and the non-constant conditions of contact. Thus, the objective of the project is to significantly increase productivity while simultaneously increasing process reliability and quality by realizing a controlled adaptive grinding process. In addition to the parameters of grinding forces and spindle performance, thermal damage of the workpiece's peripheral zone is used for the first time as a parameter.



Different Barkhausen noise devices in the grinding machine at the Fraunhofer IWU in Chemnitz

The thermomechanical state of the peripheral zone is characterized by the Barkhausen noise [1]. In addition the in-process applicable laser optical surface roughness measurement for the characterization of the grinding-tool state is investigated. The identification of suitable measurement and control parameters is conducted in the laboratory and then transferred to grinding machines [2]. The developed control circuit, based on Barkhausen noise measurements in the grinding machine (see figure), is capable to reduce the grinding time, which causes an increase in productivity and to improve the process reliability, which causes a reduction of scrap and reworking, and an improvement in quality. Based on the first results it is intended to complement the adaptive grinding process with roughness parameters provided by a laser optical surface roughness measurements. By that the process can be controlled not only by the state of the peripheral zone, but also by surface roughness.

Literature

[1] P. Thiemann, C. Dollinger, G. Goch: Untersuchungen zum Phänomen Schleifbrand. HTM Journal of Heat Treatment and Materials 69(3):173-181, 2014.
[2] C. Dollinger, R. Lipinski, M. Sorg: In-Prozess-Detektion thermomechanischer Schädigungen für einen geregelten Schleifprozess. DFMRS Windenergietagung, Bremen, 16 Mar 2017. (poster)

MoQua

Model based quality control for zero-defect production in a thermo-forming process

Funding organization: AiF
Funding ID: 19336 N
Duration: 01 Feb 2017 - 31 Jan 2019
Project scientists: Axel von Freyberg, Johannes Stempin

The objective of this project is the development of a three level quality control with adaptive modules. In combination with suitable sensors and empirical values stored in databases, this quality control will enable a zero-defect thermo-forming production.

The innovation is to consider the workpiece quality as control variable. Thereby, the inner quality of the workpiece as well as its geometry is being controlled in-situ. The required technologies, in particular a deep understanding about the influences of workpiece heating, the press power and workpiece positioning, will be developed and implemented. Within this system, the quality control compensates quality deviations, which occur within the first production steps, by parameter adaptions in the subsequent sub-processes. Thus, the quality features of the workpieces finally meet the tolerances.

Fiber composite clips of aerospace industry
(source: Institut für Verbundwerkstoffe GmbH)

Sensors will acquire the process parameters and environmental effects in-process, and this data is being analyzed in parallel to realize a closed-loop control. Based on a reference variable generator, a quality controller and sensor data, the three level quality control will be implemented in one system. This control system leads to a reproducible and high workpiece quality, and, at the same time, reduces the reject rate while adapting the process to new workpieces or geometry variations. The functionality of the quality controller is the capability to predict how the process parameters affect the workpiece quality and to automatically adapt these parameters in case of imminent exceeding tolerances.

The implementation and demonstration of the project results are carried out in the frame of a thermo-forming process for the production of thermoplastic fiber composite workpieces, as their material behavior requests a strict compliance of the process parameters.

EVeQT

Increased availability and quality optimization of power train components and gears for wind energy systems

Funding organization: Federal Ministry for Economic Affairs and Energy
Funding ID: 0325490A
Duration: 01 Sep 2012 - 31 Jan 2017
Project scientists: Dirk Stöbener, Jan F. Westerkamp

Damages of the gear box in wind energy systems (WES) are one of the major reasons for WES downtimes. These damages are caused in part due to insufficiently manufactured gear box components (gears and bearings).

The quality inspection of these components lacks of fast geometry sensors and of adequate sensor systems for quality criteria of the surface integrity. Additionally, even if sufficient sensors are available, the traceability of the geometry measurements is not ensured due to a worldwide missing large gear standard.

Coordinate measuring machine measuring the large gear standard

Therefore, the goals of the project focus on the development of:

- a gear-like large gear standard
- optical sensors for coordinate measuring machines (CMM) to acquire gear geometries
- CMM-mountable sensors for surface integrity measurements (roughness, surface damages due to heat treatment)
- new strategies and evaluation methods for areal gear measurements.

These goals were mostly achieved: A large gear standard was manufactured and calibrated by the Physikalisch Technische Bundesanstalt (PTB). Measurements of the BIMAQ during a national measurement intercomparison resulted in small deviations (<1 µm) from the calibrated values. Additionally, interferometric probes for CMMs and a new strategy for the areal gear measurement were developed and successfully tested by the project partners.

Literature

[1] A. Günther, F. Balzer, I. Lindner, D. Stöbener, J. F. Westerkamp, G. Goch: Einsatz von Koordinatenmessgeräten (KMG) an Großverzahnungen. In: VDI-Berichte, Bd. 2243, 2014, pp. 139-154.
[2] F. Balzer, M. Schäfer, I. Lindner, A. Günther, D. Stöbener, J. F. Westerkamp: Recent advances in optical gear measurements. In: International Conference on Gears, Garching, 5 - 7 Oct 2015, pp. 655-666.
[3] A. Günther, D. Stöbener, G. Goch: Self-Calibration method for a ball plate artefact on a CMM. CIRP Annals 65(1):503-506, 2016.

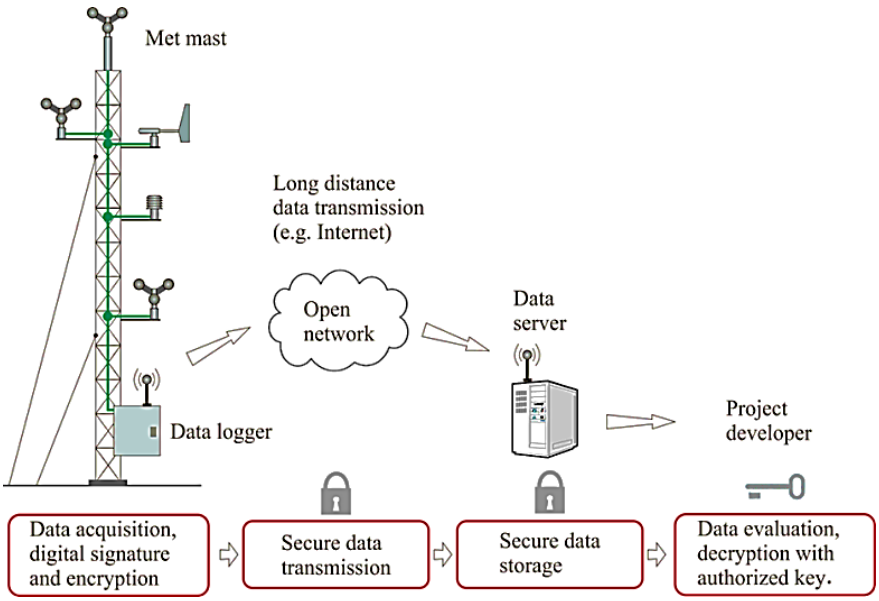
RealMe

Traceable acquisition of meteorological data

Funding organization: Federal Ministry BMWi
Funding ID: 0325468A
Duration: 01 Nov 2012 - 30 Apr 2016
Project scientist: Michael Sorg

Anemometers and tail vanes are wind sensors, which are sensitive measuring instruments installed to acquire meteorological data to calculate the energy yield of wind turbines and wind farms. Various factors affect the acquisition and transmission of measurement data. Among them are the usual influences due to weather conditions but also incidents distort the measurement results. Thus, research partners from Ammonit Measurement, Adolf Thies, Deutsche Windguard and efm together with scientists of the University of Bremen initiated the research project in order to improve both the reliability and the accuracy of measured meteorological values.

Goal of the co-operative research project is to develop and enhance measuring systems for meteorological data. The results will increase reliability, security and traceability of the measured data for evaluation by developers, operators of wind turbines and service providers. For compliance with enhanced quality-parameters, the sets of measurement-data in comprehension of all components of the measuring chain must be upgraded with digital signatures. This also prevents the manipulation of measured data which is required to ensure a correct assessment of the site's wind energy potential. Furthermore, for reasons of confidentiality the measured data must be encrypted. The partners evaluate appropriate methods to digitize, digitally sign, and encrypt measurement values directly in the sensor. Microelectronic circuits will be developed for the integration in meteorological sensors which are connected by digital bus-systems for secure data transfer (see figure). The development of data plausibility checks requires additional sensors which will be added to the meteorological systems for detecting influences on data quality.



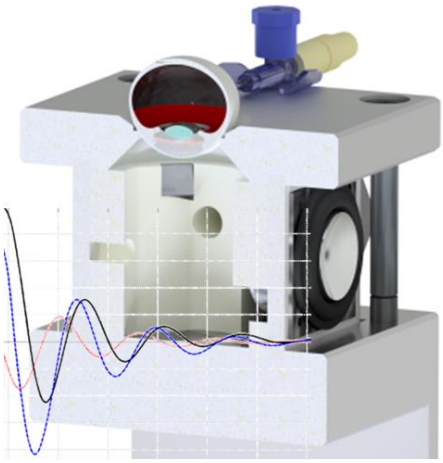
Acquisition of meteorological data with an extension of the data record with encryption and signature, and including all components of the measurement chain

SelTon

Selftonometer for the determination of intraocular pressure with acoustic vibration excitation - evaluation algorithms and system integration

Funding organization: Federal Ministry BMBF
Funding ID: 13GW0054C
Duration: 01 Aug 2014 - 31 Jul 2017
Project scientists: Jan Osmers,
Axel von Freyberg, Michael Sorg

Although glaucoma is the world's second most common cause of blindness, there is no curative therapy available to date. Therefore early diagnosis is essential with the goal of preserving vision. The major risk factor that can be influenced in order to stop disease progression is the eye pressure (IOP). A novel IOP measurement principle for a handheld non-contact self-tonometer shall be validated.



Half cut of the measurement setup (CAD Illustration) with the inside of the pressure chamber, a 30 mm loudspeaker and a model of a porcine eye connected by a cannula for IOP adjustment

A pressure pulse generated by a loudspeaker causes the eye to vibrate. A closed pressure chamber is placed on the human orbit in order to reach the required sound pressure. With a microphone and a displacement sensor the dynamic behavior of the entire system is detected. The above mentioned principle was first analyzed on porcine eyes under laboratory conditions.

The combination of the loudspeaker, the pressure chamber, and the eye to be measured can be described as a coupled spring-mass-damper system. It was demonstrated for enucleated porcine eyes that a defined IOP variation leads to a change in the system's damping ratio. The derived measurement uncertainty due to random errors amounts to < 2 mmHg in the physiological range.

The laboratory results provide a basis for a gentle non-contact tonometry method with great applicational prospects. Data is currently being collected on human subjects in a clinical trial, to corroborate the measurement principle in-vivo. If the clinical validation proves to be successful, the prerequisite for a measuring instrument for an autonomous IOP inspection in home environment is fulfilled.

Literature

[1] J. Osmers, Á. Patzkó, M. Sorg, A. von Freyberg: The influence of intraocular pressure on a coupled spring-mass-damper system – Validation of a non-contact self-tonometer. In: 114. DOG-Kongress 2016 Augenheilkunde – ein großes Fach, Berlin, 29 Sep - 02 Oct 2016.

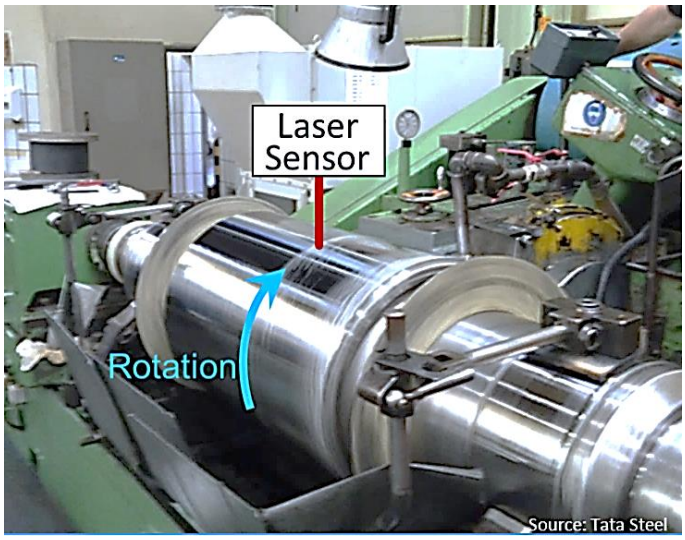
OptOCHar

Optical in-process surface characterization with hardware acceleration

Funding organization: Federal Ministry BMBF
Funding ID: 13N13535
Duration: 01 Mar 2015 - 28 Feb 2018
Project scientist: Stefan Patzelt

The quality of technical surfaces is a key factor for the overall quality of a product in many domains. According to DIN, roughness is defined by tactile measurement with a mechanical or an optical probe tip, which is time-consuming and requires laboratory conditions.

The research project develops a demonstrator measurement system for complete real time roughness measurement of specular reflecting surfaces in running production processes at velocities up to 1200 m/min (see figure). The measurement process generates and analyses scattered laser light patterns. The combination of an optimized measuring setup, adapted image processing algorithms and high performance Field Programmable Gate Array (FPGA) hardware enables for the first time a field of view diameter of 10 mm and a measuring rate up to 1.2 kHz. This results in a complete measured surface area of 4 m²/min.



Work roll recycling and complete real time roughness measurement with a FPGA based laser sensor system

Future applications of the sensor device are targeted on multiple domains, e.g. semiconductor industries, photovoltaic systems, medical systems, steel production and metal processing.

Literature

[1] S. Patzelt, Ch. Stehno, A. Tausendfreund, G. Ströbel: Optimierter specklebasierter Rauheitsmessprozess für bewegte, spiegelnde Oberflächen. tm - Technisches Messen 83(9):484–493, 2016.

[2] S. Patzelt, M. Quinten, Ch. Stehno, A. Tausendfreund, F. Houta, T. Eilts, G. Ströbel: Optimized parametric optical surface characterization process for smooth engineered surfaces. In: DGaO 117th Annual Meeting, Hannover, 17 - 21 May 2016, No. B15. (2 pages)

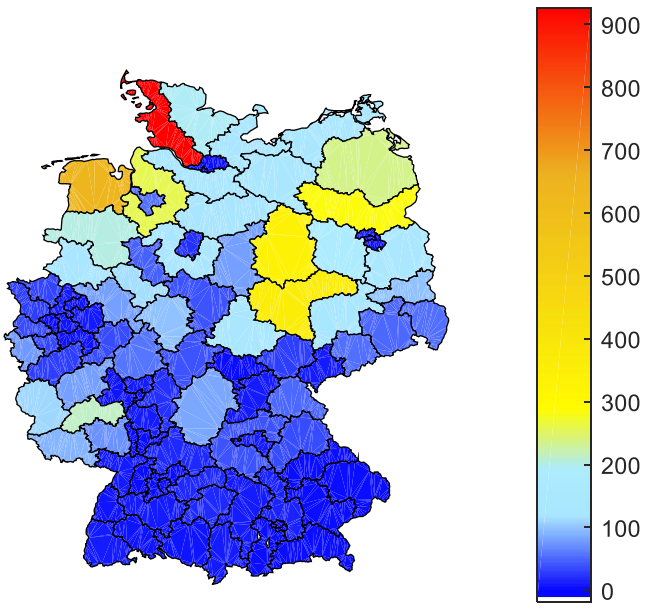
[3] S. Patzelt, Ch. Stehno, D. Stöbener, G. Ströbel, A. Fischer: In-Prozess-Charakterisierung spiegelnder Oberflächen mit Laserstreulicht und leistungsfähiger Hardware. tm - Technisches Messen, 2017. (accepted for publication).

GEOWISOL

Effects of the geographical distribution and temporal correlation of wind and solar input on the power supply system

Funding organization: Federal Ministry BMWi
Funding ID: 0325695B
Duration: 01 Sep 2015 - 30 Jun 2017
Project scientists: Volker Renken, Michael Sorg

The rising penetration of renewable energies became an important issue in the German electricity sector within the past years. For some regions the renewable generation is already surpassing the power demand. Because of the geographically and temporal varying distribution of the generation of renewable energy, a geographical distribution of the energy is inevitable. In order to plan the required infrastructure for the energy distribution, a detailed knowledge about the geographical and temporal power generation is crucial. However, the data availability for the distribution of the renewable power generation in Germany is insufficient due to the complexity of the energy system there are only simulation based studies available.



Mean wind energy generation in MW 2014 of 95 zip code regions

For this reason, a real measuring data based comparison between the renewable power generation and the electricity demand is conducted within GEOWISOL [1]. The data is given as time series of 15 minutes average values for each zip code region for wind, solar and demand quantities. For enhancing the still incomplete data, model-based data filling algorithms are introduced and compared to conventional interpolation techniques [2]. As a result, the data filling algorithms are validated and the power generation is shown to be very heterogeneous over space and time. Due to the generated measurement based data set, infrastructure questions regarding the energy system can be answered with higher reliability.

Literature

[1] V. Renken: Auswirkung der geographischen Verteilung und zeitlichen Korrelation von Wind- und solarer Einspeisung auf die Stromversorgung (GEOWISOL). Konferenz „Zukunftsfähige Stromnetze“, Berlin, 22 - 23 Sep 2016. (oral presentation)
[2] V. Renken, M. Sorg, A. Fischer: Regionale Bewertung der Einspeisung erneuerbarer Energien auf Basis von Messdaten und einer modellbasierten Datenergänzung. DFMRS Windenergietagung, Bremen, 16 Mar 2017. (oral presentation)

BiSWind

Component integrated sensor system for wind energy systems

Funding organization: Federal Ministry BMWi
Funding ID: 0325891D
Duration: 01 Dec 2015 - 30 Nov 2018
Project scientist: Jan F. Westerkamp

Drive trains of wind energy systems experience a broad range of dynamic loads. Transient torque reversals originate in power loss and emergency stops, start cycles and in sheer winds and turbulence. The subsequent failure of bearings and gearboxes result in over 50 % of wind energy. To improve the design of drive train components with precise load cycles, precise and long-term measurements are required.

Research wind energy system of the University of Bremen

Torque sensors are currently used only sporadically and not in volume production. Direct measurements of loads are not available for most parts of the drive train, especially from the inside of the gearbox. Data over the lifetime are scarce and correlations to failure events are thus limited to a few cases.

The co-operative research project develops a component-integrated measuring system. The key design aspects are measurement of torque, temperature, vibration and rotational speed with a sensor that is resistant to aging and aggressive media, and is self-sufficient.

The scientific and technical objectives cover a broad range beginning with the process development for direct coating and structuring of resistance structures and electrodes directly on shafts for the durable sensor itself. To be self-sufficient newly developed AlN and AlScN based piezoelectric structures have to provide the energy for the sensor module which in turn will be assembled on a cylindrical low temperature co-fired ceramics. This sub-project investigates both the suitability and the performance of the measuring system for application in wind turbines.

Literature

[1] K. Tracht, G. Goch, P. Schuh, M. Sorg, J. F. Westerkamp: Failure probability prediction based on condition monitoring data of wind energy systems for spare parts supply. CIRP Annals 62(1):127-130, 2013.

In-process sensors and adaptive control systems for additive manufacturing

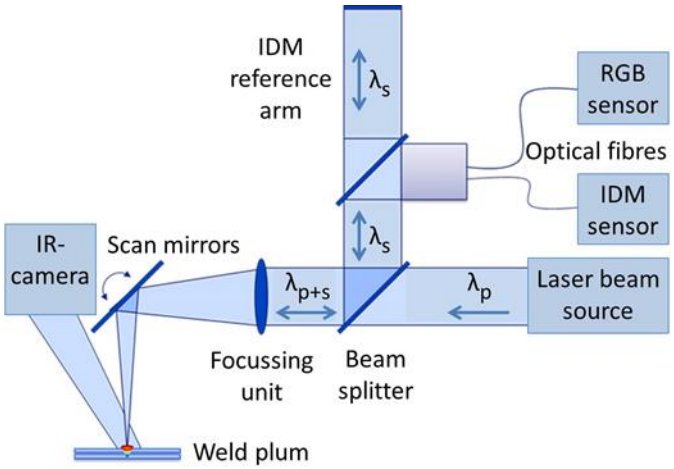
Funding organization: Federal Ministry BMBF
Funding ID: 02P15B076
Duration: 01 May 2017 – 30 Apr 2020
Project scientists: Volker Renken,
Axel von Freyberg

Selective laser melting (SLM) becomes an important factor for manufacturing different construction parts. The technology offers variances and functionalities going beyond conventional possibilities.

However, the SLM machines possess seldom sensors to detect actual process states and have limited reaction on disturbances. That leads either to part errors and unnecessary follow-up costs or to a not optimised manufacturing procedure regarding resources and efficiency.

Aim of the project is the integration of additional sensor and control technology into the machines. Different sensors measuring intensity in visible (RGB) and infrared range (IR) as well as topography (in-process depth meter - IDM) shall be included (see figure). Therefore, the process parameters as melt pool size and temperature will be reasoned and controlled by adaptive model-based control strategies [1]. For that purpose, techniques from machine learning are included in the control hardware. Current PLC (programmable logic controller) hardware offers these potentials [2]. The process speed is a high challenge for the control hardware and software. In order to be able to react on measurable changes fast models and fast hardware are needed.

As result from the project, a reduction of erroneous parts of 80 % and a decrease of throughput times of 30 % is aimed. Therefore eight industrial and scientific partners across the process chain are involved to solve the problems and transfer the solution to their products.



Sensor integration concept [3]

Literature

[1] V. Renken: Modellbasierte Regelung eines Lasergenerierprozesses. In: 49. Regelungstechnisches Kolloquium, Boppard, 4 - 6 Mar 2015, pp. 12-13.

[2] V. Renken; A. von Freyberg; G. Goch: Potenziale in der Automatisierungstechnik durch Verbindung von speicherprogrammierbaren Steuerungen mit Methoden der künstlichen Intelligenz. In: Angewandte Automatisierungstechnik in Lehre und Entwicklung an Hochschulen (AALE), Stralsund, 2013, pp. 157-170.

[3] V. Renken, S. Albinger, G. Goch, A. Neef, C. Emmelmann: Development of an adaptive, self-learning control concept for an additive manufacturing process. CIRP Journal of Manufacturing Science and technology 422, 2017. (accepted for publication)

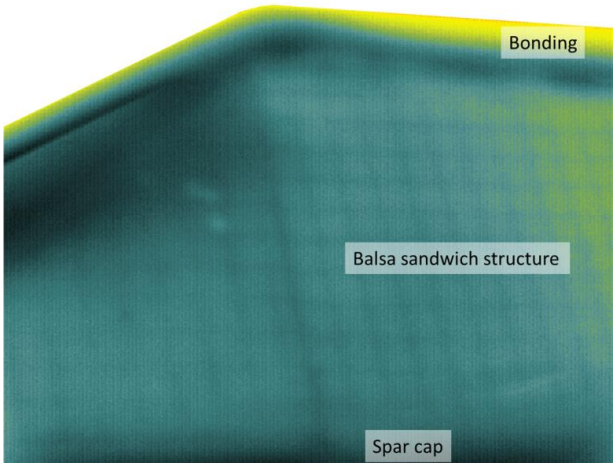
ThermoFlight

Concept for the development of an optimized maintenance and inspection method for offshore wind turbines using thermography and SHM as non-destructive testing technologies in combination with unmanned aerial vehicles

Funding organization: BIS
Funding ID: 59203/4-ZB
Duration: 01 Jan 2017 - 31 Aug 2018
Project scientist: Christoph Dollinger

The planned expansion of offshore wind energy in Germany requires the maintenance and operation to be efficiently organized both economically and ecologically for at least 25 years for a growing number of wind energy turbines. The maintenance and testing teams are confronted with new challenges offshore. This is due to short time windows as a result of difficult weather conditions as well as high safety requirements and regulations.

Especially the rotor blade tests by industrial climbers are difficult to plan under these harsh conditions. With the objective of minimizing the use of personnel for inspections and the resulting downtimes of the offshore wind turbines, the use of non-destructive testing methods and structural health monitoring is investigated. Especially in combination with unmanned aerial vehicles, these technologies can contribute to an efficient, safe, energy and material-optimized rotor blade inspection process.



Thermographic image of the inner structure of a rotor blade

For the nondestructive testing of the inner structure of offshore wind turbine rotor blades the potential of thermographic images taken from unmanned aerial vehicles is investigated. The resulting requirements in terms of weight and power supply limit the variety of suitable thermographic cameras and due to that affect the available spatial and thermal resolution.

In order to characterize the method, thermographic measurements, both with high-end and light-weight thermographic systems, in standstill for deep structural (see figure) and on the running wind turbine for surface near defects are performed [1]. The objective is to compensate the observed technical limitations by the use of image processing in terms of a contrast enhancement.

Literature

[1] C. Dollinger, N. Balaresque, M. Sorg, G. Goch: Thermographic measurement method for turbulence boundary layer analysis on wind turbine airfoils. In: AWEA Wind Power 2014 Conference and Exhibition, Las Vegas, 5 - 8 May 2014.

DBU Rotor blade

Investigations for the improvement of energy yield of wind energy turbines already in operation, by modifications of the rotor blades (phase 2)

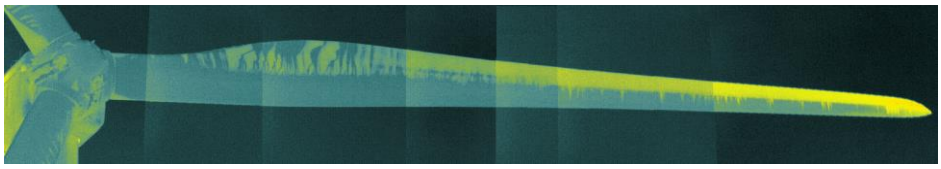
Funding organization: DBU

Funding ID: 27118/02

Duration: 01 Sep 2014 - 31 Mar 2017

Project scientist: Christoph Dollinger

During the first boom of wind energy in Germany around the year 2000 about 20 thousand wind turbines from the first Megawatt class were installed. Knowing that these types of turbines still have a considerable remaining life time, investigations for the potential of possible enhancement of energy yield by improving the aerodynamic performance are a reasonable approach for the enhancement of renewable energy to the overall fuel mix.



Thermographic flow visualization of a wind turbine blade in operation

Within this project a 37 m rotor blade from the Danish manufacturer LM is investigated. The geometry of a dismantled rotor blade was locally measured. The resulting 5 airfoil geometries were used in extensive wind tunnel measurements and CFD simulations. The wind tunnel measurements implicated thermographic flow visualization [1] and acoustic measurements with a microphone array in addition to the conventional aerodynamic testing. Detailed information regarding the measurements can be found in [2]. Several aerodynamic devices are known to be easily mounted and have been proven to increase the performance. Therefore several devices were considered for the improvement of the aerodynamic and acoustic properties of the rotor blade and the development of an optimization kit that can be installed on wind turbines already in operation.

Beside the development of the optimization kit, the first-time derivation and implementation of a structured and transferable methodology including the comparison of thermographic wind tunnel and in field measurements (see figure) is a novel achievement of the project. The modifications indicate an annual increase in energy yield by 5 % without effecting the acoustic emissions negatively. With unchanged performance a reduction of acoustic emissions of 2 dB is expected.

Literature

[1] C. Dollinger, N. Balaresque, A. P. Schaffarczyk, A. Fischer: Thermographic detection of separated flow. Journal of Physics: Conference Series 753(7):072006, 2016. (10 pages)

[2] N. Balaresque, S. Bicker, C. Dollinger, A. Fandrich, S. Gatz, M. Hölling, K. Irschik, T. Reichstein, A. P. Schaffarczyk, C. von Zengen: Investigations for improvement of energy yield of rotor-blades from the 1.5 MW Class. Journal of Physics: Conference Series 753(7):072012, 2016.

Teaching

Teaching activities, student projects, graduation works

Teaching activities

Lecture	PT	SE	Wing	BB	Sem. BSc	Sem. MSc	CP	Students WiSe 16/17 and SoSe 2017
Messtechnik	●	●	○	○	3rd		3	116
Übung Messtechnik	●		○	○	3rd		1	111
Labor Messtechnik	●		○	○	3rd		1	69
Regelungstechnik	●		○		5th		3	112
Übung Regelungstechnik	●		○		5th		1	107
Labor Regelungstechnik	●		○		5th		1	80
Grundlagen der Qualitätswissenschaft	●	●	●		5th	1st	3	167
Regenerative Energien	●	○	○	○	4th 6th	1st	3	37
Prozessnahe und In-Prozess-Messtechnik	●	●	●		4th 6th	1st 2nd 3rd	3	30
Geometrische Messtechnik mit Labor* AUKOM	●	●	○		5th	1st	3	35
Methoden der Messtechnik - Signal- und Bildverarbeitung	●	●	●		5th	1st 2nd	3	21
Einführung in die Automatisierungstechnik mit Labor	●	●	○		5th	1st 2nd	3	33
Produktion von Verzahnungen (held by several chairs)	●	○				1st 2nd	6	9
Labor Produktion von Verzahnungen (held by several chairs)	●	○				1st 2nd	3	7
Grundlagenlabor Produktionstechnik		●			4th		2	34

Legend:

● - Pflicht-/Wahlpflicht-/Wahlfach, ○ - fakultativ

PT - Produktionstechnik, **SE** - Systems Engineering, **Wing** - Wirtschaftsingenieurwesen Produktionstechnik, **BB** - Berufliche Bildung

* - AUKOM Certificate: AUKOM is a manufacturer-independent association for training in the field of geometric measurement technology. AUKOM offers the students to earn the level 1 basic certificate at cost (in total, there are 3 levels of training: 1 basic, 2 advanced, 3 expert).

Student projects

Kind of project	Title	Semester	Course of studies*
Bachelor-Projekt	Konfokale Topographieerfassung metallischer Mikrostrukturen unter Verwendung eines Fluorophors	SoSe 2017	BSc PT BSc WING
Projekt Systemtechnik	Langzeiterfassung schneller Prozesse mit einer Hochgeschwindigkeitskamera	SoSe 2017	BSc SE MSc SE
Softwaretechnik-Projekt	Entwicklung einer Softwarelösung zur Korrektur von Verzeichnungen und Verzerrungen in Thermografiebildern	SoSe 2017	BSc SE
Projektarbeit	Entwicklung eines medizinischen Bohrverfahrens mit gleichzeitiger Bestimmung der Länge des Bohrkanals	WiSe 2016/2017 SoSe 2017	MSc PT I/II
Informatik-Projekt	Automated data exchange between QUINDOS and EXCEL	SoSe 2016	BSc PT
Informatik-Projekt	Control of a MatLab-based image evaluation software with QUINDOS	SoSe 2016	BSc PT

*SE - Systems Engineering, PT - Produktionstechnik

Graduation works

Bachelor theses

- Torben ***Bührmann***:
  The transient FE analysis of the vibration of human eyes with Ansys Workbench and its validation on empirical data.
  Colloquium: 4 May 2017
- Marie ***Dethlefs****:*
  Detection of icing on cup anemometers.
  Colloquium: 7 Jul 2016
- Daniel ***Gleichauf****:*
  Extension of the system limits of a laser line scanner by integrating a linear axis and implementation of adapted evaluation algorithms.
  Colloquium: 18 Mar 2016
- Nicolai ***Haupt****:*
  Vibration dynamic analysis of the human eye as a function of the intraocular pressure with Ansys Workbench.
  Colloquium: 26 Oct 2016
- Ivan ***Hermann****:*
  Installation of a wind measuring system for the evaluation of potential energy sources at urban locations for a mobile charging station supply with wind energy.
  Colloquium: 19 Oct 2016
- Levin ***Kowalzik****:*
  Development of an evaluation algorithm for thermographic measurement data to

Teaching activities, student projects, graduation works

characterize the flow state of wind turbine rotor blades.
Colloquium: 14 Jan 2016

- Nils Marten ***Niemann**:*
  CAD design of a parametric human eye in Auto-desk Inventor as preparation for FEM analysis.
  Colloquium: 20 Sep 2016
- Marc ***Pillarz**:*
  Concept for an optical sensor for contactless detection of vibrations on the eye.
  Colloquium: 14 Apr 2016
- Jannik ***Schrage**:*
  Advanced visualisation for the geographical distribution of renewable energy generation with regard to general energy requirements and integration of new data.
  Colloquium: 23 May 2017

Master theses

- Felix ***Harmsen**:*
  Implementation of algorithms to mesh and merge individual measurements of a laser scanner.
  Colloquium: 24 Nov 2016
- Dirk ***Rode**:*
  Development of a fast, adaptive strategy on a programmable logic controller for selective laser melting.
  Colloquium: 22 Dec 2016
- Oliver ***Schultze**:*
  Development and analysis of a position determination device for a LED using the shadow cast principle.
  Colloquium: 28 Sep 2016
- Mary ***Schwarz**:*
  Concept for the accreditation of a laboratory for large gear measurements according to DIN EN ISO/IEC 17025.
  Colloquium: 16 Jun 2016
- Moritz ***Ulmer**:*
  Data, model and experiment management on an automotive test bed as hardware-in-the-loop with MATLAB, Simulink and dSPACE.
  Colloquium: 6 Apr 2016
- Janka *N.* ***Wöbbekind**:*
  Development of an algorithm for the geometrical characterization of the human petrous bone.
  Colloquium: 28 Sep 2016

Cooperations with industry and measurement services

Cooperation partners

A
- Aconity3D GmbH, ***Herzogenrath***
- Adolf Thies GmbH & Co. KG, ***Göttingen***
- Ammonit Measurement GmbH, ***Berlin***
- ASENTEC GmbH, ***Heilbronn***
- AUKOM e. V., ***Braunschweig***

B
- BIAS Bremer Institut für angewandte Strahltechnik, ***Bremen***
- BIBA Bremer Institut für Produktion und Logistik an der Universität ***Bremen***

C
- C.F.K. CNC-Fertigungstechnik Kriftel GmbH, ***Kriftel***
- CoSynth GmbH & Co. KG, ***Oldenburg***

D
- Deutsche Wind Guard GmbH, ***Varel***
- Deutsche WindGuard Engineering GmbH, ***Bremerhaven***
- Deutsche WindGuard Systems, ***Berlin***
- Deutsche WindGuard Wind Tunnel Service GmbH, ***Varel***
- DFMRS Deutsche Forschungsvereinigung für Meß-, Regelungs- und Systemtechnik e. V., ***Bremen***

F
- Fachhochschule ***Kiel***
- Faserinstitut Bremen e. V. FIBRE, ***Bremen***
- Formtech GmbH, ***Weyhe***
- Fraunhofer Institut für Werkzeugmaschinen und Umformtechnik IWU, ***Chemnitz***
- Fraunhofer Institut für Windenergie und Energiesystemtechnik IWES, ***Bremerhaven***
- Fraunhofer-Institut für Keramische Technologien und Systeme IKTS, ***Dresden***
- Fraunhofer-Institut für Organische Elektronik, Elektronenstrahl- und Plasmatechnik FEP, ***Dresden***
- FRT GmbH, ***Bergisch Gladbach***
- FWBI Friedrich Wilhelm Bessel Institut Forschungsgesellschaft mbH, ***Bremen***
- Gottwald Hydraulik, ***Bremen***

H
- Hexagon Manufacturing Intelligence, ***Wetzlar***

I
- IMSAS Institut für Mikrosensoren, -aktoren und -systeme, Universität ***Bremen***
- ISRA VISION AG, ***Darmstadt***
- IWT Stiftung Institut für Werkstofftechnik, ***Bremen***

K
- K & R enatec GmbH, ***Schwanewede***

L
- Lloyd Dynamo Werke GmbH, ***Bremen***

M
- Materialise GmbH, ***Bremen***
- Meridian Lightweight Technologies United Kingdom (MLTUK), Sutton-In-Ashfield, ***Nottingham/UK***
- Micro Systems Engineering GmbH, ***Berg***

Cooperations with industry and measurement services

Cooperation partners

O
- OptoPrecision GmbH, ***Bremen***
- Optris GmbH, ***Berlin***

P
- Physikalisch-Technische Bundesanstalt PTB, ***Braunschweig***
- Pöppelmann GmbH & Co. KG, ***Lohne***
- Precitec GmbH & Co. KG, ***Gaggenau***

S
- Sachverständigenbüro Otto Lutz, ***Bundorf***
- Schaeffler Technologies AG & Co. KG, ***Herzogenaurach***
- Siegert Thinfilm Technology GmbH, ***Hermsdorf***
- Siemens AG, ***Bremen***
- SINUS Messtechnik GmbH, ***Leipzig***
- *Stiftung OFFSHORE-WINDENERGIE,* ***Varel***

T
- Tata Steel Plating, Hille & Müller GmbH, ***Düsseldorf***
- Technische Universität Dresden, Institut für Festkörperelektronik, ***Dresden***
- Technische Universität ***Graz***
- Technische Universität ***Hamburg***
- Technische Universität Ilmenau, Fachgebiet Elektroniktechnologie, ***Ilmenau***
- Technische Universität Ilmenau, Fachgebiet Mikromechanische Systeme, ***Ilmenau***
- Toho Tenax Europe GmbH, ***Wuppertal***
- Trecolan GmbH, ***Bremen***

U
- Universitätsklinikum ***Würzburg***

V
- VEW Vereinigte Elektronikwerstätten GmbH, ***Bremen***
- VTD Vakuumtechnik Dresden GmbH, ***Dresden***

W
- Weiss Umformwerkzeuge GmbH, ***Rednitzhembach***
- WindGuard Certification GmbH, ***Varel***
- WindMW Service GmbH, ***Bremerhaven***

Measurement services

Dimensional measurement service

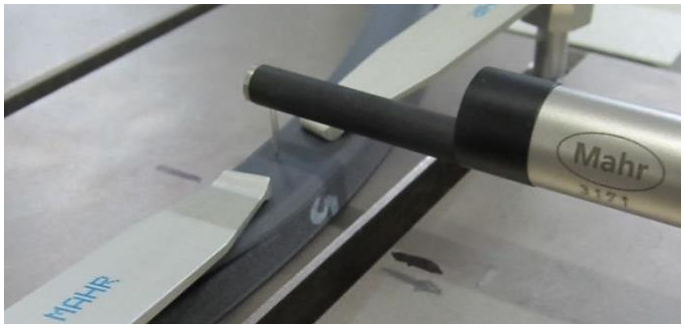
Duration: continously

Contact: a.freyberg@bimaq.de

With its extensive measurement equipment, BIMAQ offers measurement services for the local industry.

The measurement tasks range from dimensional measurements on metallic and fiber composite materials for the automotive, energy, aerospace and space industry to roughness measurements on flexible sealing elements. Depending on the application, geometrical features are acquired on coordinate measuring machines with tactile or optical probes and dimensional, shape and position deviations are evaluated. Other applications require the optical acquisition of free-form surfaces by means of stripe pattern projection systems.

Roughness measurements are performed either with a stationary measuring device or with a mobile device, e. g. on bearing rings with diameters up to 2 m.



Roughness measurement on a flexible sealing element

Thermographic flow visualization

Duration: year-long

Contact: c.dollinger@bimaq.de

In a close cooperation with Deutsche WindGuard Engineering GmbH, thermographic measurements for flow visualization in wind tunnel experiments and on the rotor blades of wind turbines in operation are performed. The thermographic method for flow visualization is non-invasive and provides the location of different flow regions including the laminar-turbulent transition. The flow regions can be distinguished by differences in heat flux and temperature fluctuations in time. In wind tunnel experiments, the acquisition, the automated processing and the evaluation of the results are part of the offered services.

Combined with a telephoto lens, the high-performance IR-camera is capable to detect small temperature differences on the rotor blade surface for a visualization of the flow conditions on wind turbines in operation. The information can be determined without the expensive instrumentation of conventional methods for flow visualization. The measurements are carried out at a distance of several hundred meters and enable an overall evaluation of the flow conditions at the rotor blade as well as the study of influences by contamination and erosion of the rotor blade on the flow.

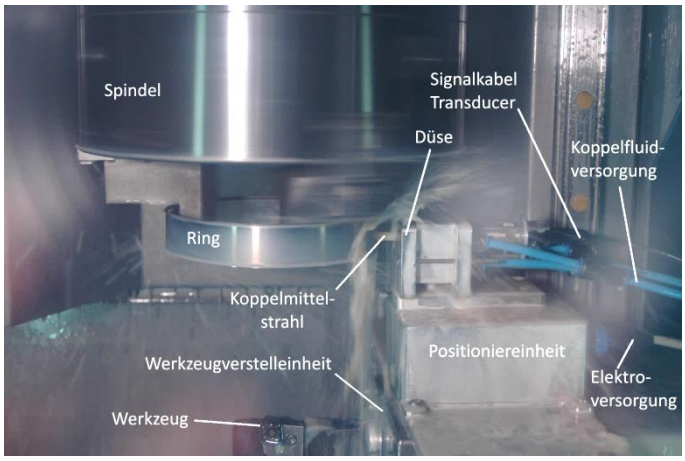
Publications and qualification of young academics

PhD theses

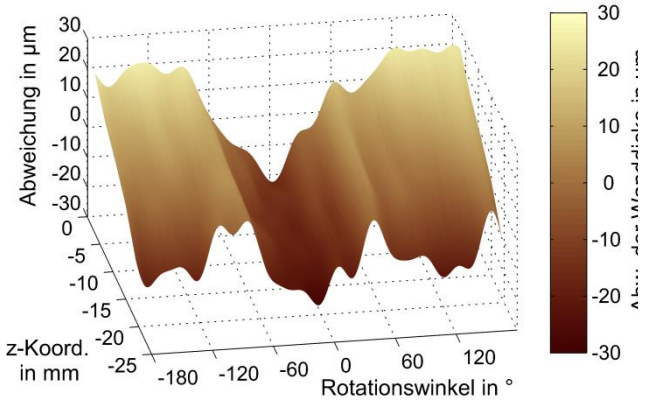
Ultraschallbasiertes in situ Geometrie-Messsystem für dünnwandige Stahlringe

Dipl.-Phys. Dirk Stöbener
Date of thesis defense: 20 July 2016
Supervisor: Prof. Dr.-Ing. G. Goch

The thesis presents a new ultrasound based in situ measuring system, which is able to determine the wall thickness variations of thin-walled steel rings from signal phase measurements. It is applied in the workspace of a horizontal turning center and delivers information about the ring behavior for different turning operations and clamping conditions. Additionally, it can be used to determine the set-values for a control system, which establishes a constant wall thickness by fast movements of a turning tool servo for clamping-distorted rings. The measuring system consists of a signal generator, control electronics, a 15 MHz transducer and a PC system for data acquisition and evaluation. It is operated in the impulse-echo mode with a burst signal of 20 sine periods and uses the metal working fluid of the turning center as the coupling fluid for the sound propagation between transducer and ring. The wall thickness measuring range is 0 to 600 µm with an estimated uncertainty of 6 µm.



Measuring system mounted in the workspace of the turning centre



Measured wall thickness variations of a ring, clamped with segmented jaws.

Literature

[1] D. Stöbener, B. Beekhuis: Application of an in situ measuring system for the compensation of wall thickness variations during turning of thin-walled rings. CIRP Annals 62(1):511-514, 2013.

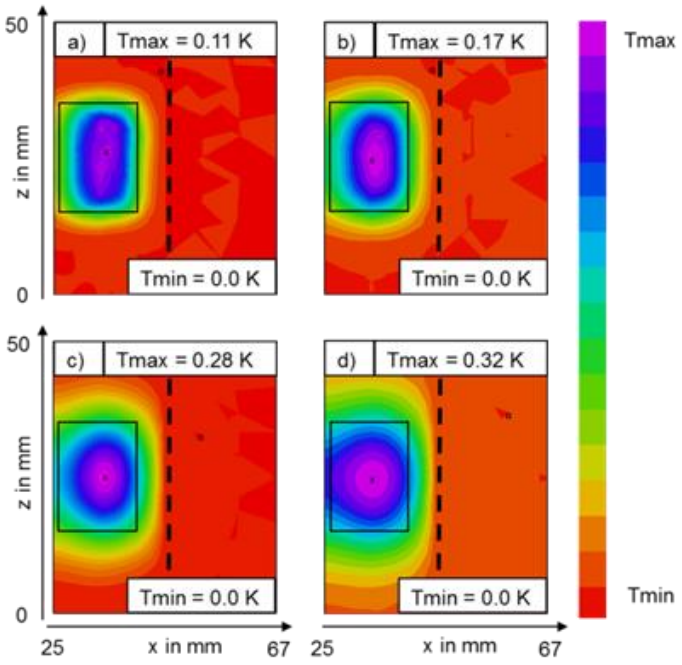
Simulation und Anwendung photothermischer Verfahren im Labor und unter prozessnahen Bedingungen

Dipl.-Phys. Helmut Prekel

Date of thesis defense: 19 July 2016
Supervisor: Prof. Dr.-Ing. G. Goch

This thesis examines new approaches to the photothermal characterization of thermal properties and to the detection of near-surface damages.

Photothermal measuring methods enable to analyze near surface zones non-destructively. The methods generally require to heat up a specimen and to measure its temporal variation of temperature. The thermal excitation is often performed by absorption of intensity modulated laser radiation, which generates thermal waves that propagate into the specimen. These thermal waves are reflected by thermal inhomogeneities like pores, cracks and layer boundaries. Interference effects cause modified amplitudes and phases (with respect to the exciting radiation) of the specimen´s surface temperature oscillation, which can be measured using infrared sensors.



Calculated temperature increase on a gearwheel tooth due to heat transferred during meshing from another, laser heated tooth

One chapter describes the heat propagation if there is a local phase shift within the thermal excitation radiation. The calculations revealed new approaches to detect vertical cracks and thermal properties. Furthermore, FEM-calculations were used to evaluate the feasibility of a laser induced contact pattern analysis of gears. In this concept, teeth of one gearwheel are heated up by intense radiation energy. During meshing, heat is transferred to the teeth of the second involved gearwheel. Areas with increased temperatures on the teeth of the second gearwheel (see figure) then indicate the contact pattern. Under certain conditions the local temperature increase is detectable with modern infrared cameras.

Literature

[1] H. Prekel, G. Goch, R. Lipinski, P. Thiemann: Modellierung einer lasergestützten Tragbildanalyse. In: 5. Fachtagung Verzahnungsmesstechnik 2014, Nürtingen. VDI-Berichte 2236, Düsseldorf, 2014, pp. 123-135.

Publications and qualification of young academics

Publications in journals and conference contributions

Journals

- N. ***Balaresque***, S. Bicker, C. Dollinger, A. Fandrich, S. Gatz, M. Hölling, K. Irschik, T. Reichstein, A. P. Schaffarczyk, C. von Zengen:
  Investigations for improvement of energy yield of rotor-blades from the 1.5 MW Class.
  Journal of Physics: Conference Series 753(7):072012, 2016.
- C. ***Dollinger***, N. Balaresque, A. P. Schaffarczyk, A. Fischer:
  Thermographic detection of separated flow.
  Journal of Physics: Conference Series 753(7):072006, 2016.
- J. ***Dong***, H. Prekel, M. Dethlefs, J. Epp, A. Fischer:
  In-situ Untersuchung von Randschichten während des Gasnitrierens mittels Röntgendiffraktometrie und photo-thermischer Radiometrie.
  HTM Journal of Heat Treatment and Materials 72(3), 2017, pp. 154-167.
- A. ***Fischer***:
  Model-based review of Doppler global velocimetry techniques with laser frequency modulation.
  Optics and Lasers in Engineering 93:19-35, 2017.
- A. ***Fischer***, C. Kupsch, J. Gürtler, J. Czarske:
  Volumetrische Strömungsmessungen mittels plenoptischer Hochgeschwindigkeitskamera.
  tm - Technisches Messen 83(1):9-15, 2016.
- A. ***Fischer***:
  Fundamental uncertainty limit of optical flow velocimetry according to Heisenberg's uncertainty principle.
  Applied Optics 55(31):8787-8795, 2016.
- J. ***Gürtler***, R. Schlüßler, A. Fischer, J. Czarske:
  High-speed non-intrusive measurements of fuel velocity fields at high-pressure injectors.
  Optics and Lasers in Engineering 90:91-100, 2016.
- J. ***Gürtler***, D. Haufe, A. Schulz, F. Bake, L. Enghardt, J. Czarske, A. Fischer:
  Camera based high-speed measurement system for aeroacoustic investigations.
  Journal of Sensors and Sensor Systems 5:125-136, 2016.
- A. ***Günther***, D. Stöbener, G. Goch:
  Self-calibration method for a ball plate artefact on a CMM.
  CIRP Annals 65(1):503-506, 2016.
- R. ***Kuschmierz***, A. Davids, S. Metschke, F. Löffler, H. Bosse, J. Czarske, A. Fischer:
  Optical, in-situ, three dimensional, absolute shape measurements in CNC metal working lathes.
  International Journal for Advanced Manufacturing Technology 84(9):2739-2749, 2016.
- S. ***Patzelt***, Ch. Stehno, A. Tausendfreund, G. Ströbel:
  Optimierter specklebasierter Rauheitsmessprozess für bewegte, spiegelnde Oberflächen.
  tm - Technisches Messen 83(9):484–493, 2016.

- S. ***Patzelt***, C. Stehno, D. Stöbener, G. Ströbel, A. Fischer:
  In-Prozess-Charakterisierung spiegelnder Oberflächen mit Laserstreulicht und leistungs-fähiger Hardware.
  tm – Technisches Messen 2017. (accepted for publication)
- H. ***Prekel***, G. Stroebel, R. Lipinski, G. Goch:
  Contact pattern analysis: Simulation of a laser assisted thermographic approach.
  International Journal of Thermophysics 37:82, 2016.
- K. ***Philipp***, A. Smolarski, N. Koukourakis, A. Fischer, M. Stürmer, U. Wallrabe, J. Czarske:
  Volumetric HiLo microscopy employing an electrically tunable lens.
  Optics Express 24(13):15029-14041, 2016.
- K. ***Philipp***, A. Filippatos, R. Kuschmierz, A. Langkamp, M. Gude, A. Fischer, J. Czarske:
  Multi-sensor system for in-situ shape monitoring and damage identification of high-speed composite rotors.
  Mechanical Systems and Signal Processing 76-77:187-200, 2016.
- V. ***Renken***, S. Albinger, G. Goch, A. Neef, C. Emmelmann:
  Development of an adaptive, self-learning control concept for an additive manu-facturing process.
  CIRP Journal of Manufacturing Science and technology 422, 2017. (accepted for publ.)
- H. ***Zhang***, R. Kuschmierz, J. Czarske, A. Fischer:
  Camera-based speckle noise reduction for 3-D absolute shape measurements.
  Optics Express 24(11): 12130-12141, 2016.
- P. ***Zhang***, A. von Freyberg, A. Fischer:
  Closed-loop quality control system for laser chemical machining in metal micro production.
  International Journal of Advanced Manufacturing Technology. (accepted for publication)

Conference contributions with proceedings

- G. ***Alexe***, A. Tausendfreund, D. Stöbener, G. Ströbel:
  In-process characterization of sub-wave-length structures.
  In: 16th International Conference & Exhibition of the European Society for Precision Engineering and Nanotechnology (euspen), Nottingham/UK, 30 May - 3 Jun 2016, pp. 183-184.
- G. ***Alexe***, A. Tausendfreund, D. Stöbener, A. Fischer:
  In-line measuring method for periodical sub-wavelength nanostructures.
  In: SPIE Optical Metrology, Munich, 25 - 29 Jun 2017, No. 10330-21.
- M. ***Auerswald***, A. von Freyberg, A. Fischer:
  Optical sensor system for 3D measurements on large gears.
  In: AMA Conferences 2017 - SENSOR 2017

Publications and qualification of young academics

Publications in journals and conference contributions

and IRS² 2017, Nuremberg, 31 May - 1 Jun 2017, pp. 227-232.

- N. ***Balaresque***, S. Bicker, C. Dollinger, A. Fandrich, S. Gatz, M. Hölling, K. Irschik, T. Reichstein, A. P. Schaffarczyk, C. von Zengen:
  Investigations for improvement of energy yield of rotor-blades from the 1.5 MW Class.
  The Science of Making Torque from Wind - TORQUE 2016, Munich, 5 - 7 Oct 2016.
  In: Journal of Physics: Conference Series 753(7):072012, 2016.
- C. ***Dollinger***, N. Balaresque, A. P. Schaffarczyk, A. Fischer:
  Thermographic detection of separated flow.
  The Science of Making Torque from Wind - TORQUE 2016, Munich, 5 - 7 Oct 2016.
  In: Journal of Physics: Conference Series 753(7):072006, 2016.
- J. ***Dong***, H. Prekel et al.:
  In-situ Untersuchung von Randschichten während des Gasnitrierens mittels Röntgen-diffraktometrie und photothermischer Radiometrie.
  72. Härterei Kongress, Cologne, 26 - 28 Oct 2016.
  In: HTM Journal of Heat Treatment and Materials 72(3), 2017, pp. 154-167.
- J. ***Gürtler***, F. Greiffenhagen, J. Peterleithner, J. Woisetschläger, D. Haufe, A. Fischer, J. Czarske:
  Seedinglose Messung der Wärmefreisetzungsrate und Geschwindigkeit in drallstabilisierten Flammen mittels kamerabasierter Laser-Vibrometrie.
  In: 24. GALA-Fachtagung "Experimentelle Strömungsmechanik", Cottbus, 6 - 8 Sep 2016, pp. 7-1 - 7-8.
- J. ***Gürtler***, D. Haufe, A. Schulz, F. Bake, L. Enghardt, J. Czarske, A. Fischer:
  Investigation of sound-flow interaction at a bias flow liner using 3D/3C velocity measurements and Helmholtz-Hodge decomposition.
  In: 18th International Symposium on the Application of Laser and Imaging Techniques to Fluid Mechanics, Lisbon/P, 4 - 7 Jul 2016, No. 2.3.3. (9 pages)
- D. ***Haufe***, J. Gürtler, A. Schulz, F. Bake, L. Enghardt, J. Czarske, A. Fischer:
  Aeroakustische Analyse mittels natürlicher Helmholtz-Hodge-Zerlegung.
  In: 24. GALA-Fachtagung "Experimentelle Strömungsmechanik", Cottbus, 6 - 8 Sep 2016, pp. 2-1 - 2-7.
- R. ***Kuschmierz***, H. Zhang, A. Fischer, J. Czarske:
  Beating the speckle limit of interferometric sensors.
  In: European Optical Society Bi-Annual Meeting (EOSAM) 2016, Berlin, 26 - 30 Sep 2016, TOM6 S05-2. (2 pages)
- R. ***Kuschmierz***, A. Fischer, J. Czarske:
  Absolute Formmessung in CNC-Drehmaschinen mit einem optischen Sensor.

In: VDI-Berichte 2285, Optische Messung von Funktionsflächen, Form- und Konturmesstechnik 2016, Nürtingen, 28 - 29 Jun 2016, pp. 147-157.

- S. ***Patzelt***, M. Quinten, Ch. Stehno, A. Tausendfreund, F. Houta, T. Eilts, G. Ströbel: *Optimized parametric optical surface characterization process for smooth engineered surfaces.* In: DGaO 117th Annual Meeting, Hannover, 17 - 21 May 2016, No. B15. (2 pages)
- S. ***Patzelt***, Ch. Stehno, A. Tausendfreund, G. Ströbel: *Speckle-basierte Oberflächen-Charakterisierung im laufenden Fertigungsprozess mit leistungsfähiger Hardware.* In: XXX. Messtechnisches Symposium 2016 des Arbeitskreises der Hochschullehrer für Messtechnik e. V. (AHMT), Hannover, 15 - 16 Sep 2016, pp. 167-174.
- S. ***Patzelt***, D. Stöbener, G. Ströbel, A. Fischer: *Uncertainty of scattered light roughness measurements based on speckle correlation methods*. In: SPIE Optical Metrology, Munich, 25 - 29 Jun 2017, No. 10329-55.
- J. ***Peterleithner***, R. Basso, F. Heitmeir, J. Woisetschläger, R. Schlüßler, J. Czarske, A. Fischer: *Comparison of flame transfer functions acquired by chemiluminescence and density fluctuation.* In: ASME Turbo Expo 2016: Turbomachinery Technical Conference and Exposition, Volume 4B: Combustion, Fuels and Emissions, Seoul, South Korea, 13 - 17 Jun 2016, Paper GT2016-57485.
- K. ***Philipp***, A. Smolarski, A. Fischer, N. Koukourakis, M. Stürmer, U. Wallrabe, J. Czarske: *High-contrast 3D image acquisition using HiLo microscopy with an electrically tunable lens.* In: SPIE Proceedings Vol. 9890: Optical Micro- and Nanometrology VI, pp. 98900A-98900A-6.
- R. ***Schlüßler***, J. Gürtler, J. Czarske, A. Fischer: *Planar fuel velocity measurements in the near-nozzle region of a high pressure Diesel injection nozzle.* In: 18th International Symposium on the Application of Laser and Imaging Techniques to Fluid Mechanics, Lisbon/ P, 4 - 7 Jul 2016, No. 4.3.1. (11 pages)
- M. ***Schuster***, R. Kuschmierz, A. Fischer, J. Czarske: *Messunsicherheitsuntersuchungen zur nichtinkrementellen Formmessung von rotierenden Objekten.* In: 18. GMA/ITG-Fachtagung Sensoren und Messsysteme 2016, Nuremberg, 10 - 11 May 2016, pp. 235-241.
- D. ***Schwensow***, N. Koukourakis, K. Philipp, A. Fischer, J. Czarske:

Publications and qualification of young academics

Publications in journals and conference contributions

Application of adaptive lenses in confocal microscopy.
In: DGaO 117th Annual Meeting, Hannover, 17 - 21 May 2016, No. P15. (poster)

- A. ***Smolarski***, N. Koukourakis, K. Philipp, A. Fischer, J. Czarske:
  Volumetric measurements in HiLo Microscopy based on adaptive lenses.
  In: DGaO 117th Annual Meeting, Hannover, 17 - 21 May 2016, No. P14. (poster)
- A. ***Tausendfreund***, D. Stöbener, S. Patzelt, G. Ströbel, A. Fischer:
  In-Prozess-Verformungsmessung auf Basis von Speckle-Korrelationsverfahren.
  In: XXX. Messtechnisches Symposium des Arbeitskreises der Hochschullehrer für Messtechnik e. V. (AHMT), Hannover, 15 - 16 Sep 2016, pp. 201-207.
- A. ***Tausendfreund***, D. Stöbener, G. Ströbel:
  In-process measurements of strain fields during grinding.
  In: 16th International Conference of the European Society for Precision Engineering and Nanotechnology (euspen), Nottingham/UK, 30 May - 3 Jun 2016, pp. 85-86.
- J. F. ***Westerkamp***, M. Sorg, A. Fischer:
  High resolution speckle sensor for contactless torque measurement in wind energy systems.
  In: AMA Conferences 2017 - SENSOR 2017 and IRS² 2017, Nuremberg, 31.5.-1.6.2017, pp. 233-237.
- P. ***Zhang***, A. von Freyberg:
  A closed loop quality control system for laser chemical machining.
  In: 16th International Conference & Exhibition of the European Society for Precision Engineering and Nanotechnology (euspen), Nottingham/UK, 30 May - 3 Jun 2016, pp. 505-506.
- H. ***Zhang***, R. Kuschmierz, A. Fischer, J. Czarske:
  Camera-based speckle noise reduction for interferometric non-incremental shape measurement.
  In: DGaO 117th Annual Meeting, Hannover, 17 - 21 May 2016, No. P64. (poster)

Conference contributions without proceedings

- G. ***Alexe***, A. Tausendfreund, D. Stöbener, A. Fischer:
  In-process measuring methods for nano-structures.
  Special Interest Group Meeting: Structured and Freeform Surfaces, Technical University of Denmark (DTU), Copenhagen/DK, 09 - 10 Nov 2016. (oral presentation)
- G. ***Alexe***, A. Tausendfreund, D. Stöbener, G. Ströbel:
  In-process characterization of sub-wave-length structures.
  In: 16th International Conference & Exhibition of the European Society for Precision

Patents

Engineering and Nanotechnology (euspen), Nottingham/UK, 30 May - 3 Jun 2016. (poster)

- G. ***Alexe***, A. Tausendfreund, D. Stöbener, A. Fischer:
  Modellunterstützte Messmethode für periodische Sub-Wellenlängen-Nano-strukturen.
  DGaO 118th Annual Meeting, Dresden, 6 - 10 Jun 2017. (oral presentation)
- C. ***Dollinger***, R. Lipinski, M. Sorg:
  In-Prozess-Detektion thermomechanischer Schädigungen für einen geregelten Schleif-prozess.
  DFMRS Windenergietagung 2017, Bremen, 16 Mar 2017. (poster)
- J. ***Osmers***, A. Patzko, M. Sorg, A. von Freyberg:
  Einfluss des intraokularen Drucks auf ein gekoppeltes Feder-Masse-Dämpfer-System – Validierung eines kontaktlosen Selbsttonometers.
  DOG 2016 Augenheilkunde – ein großes Fach, Berlin, 29 Sep - 02 Oct 2016.
  Abstract in: Der Ophthalmologe, 113(2)2016:PFr07-09. (oral and poster presentation)
- V. ***Renken***:
  Auswirkung der geographischen Verteilung und zeitlichen Korrelation von Wind- und solarer Einspeisung auf die Stromversorgung (GEOWISOL).
  Konferenz „Zukunftsfähige Stromnetze“, Berlin, 22 -23 Sep 2016. (oral presentation and poster)
- V. ***Renken***, M. Sorg, A. Fischer:
  Regionale Bewertung der Einspeisung erneuerbarer Energien auf Basis von Messdaten und einer modellbasierten Datenergänzung.
  DFMRS Windenergietagung 2017, Bremen, 16 Mar 2017. (oral presentation)
- A. ***Tausendfreund***, D. Stöbener, A. Fischer:
  Messbarkeitsgrenzen der Speckle-Fotografie bei In-Prozess-Verformungsmessungen hochdynamischer Fertigungsprozesse.
  DGaO 118th Annual Meeting, Dresden, 6 - 10 Jun 2017. (oral presentation)

Patents

- A. ***Fischer***, J. Czarske, L. Büttner:
  Bestimmung der Geschwindigkeit eines bewegten Fluids unter Einsatz eines Fabry-Pérot-Interferometers.
  Date of registration: 09 Feb 2012,
  Date of granting: 23 Jun 2016,
  No. of patent: 10 2012 201 949

Participation in scientific committees and associations

Member		Short Name	Scientific Committee / Association
	BIMAQ	AUKOM	AUKOM Ausbildung Koordinatenmesstechnik e. V.
	BIMAQ	FQS	Forschungsvereinigung Qualität
Andreas	**Fischer**	DGaO	Deutsche Gesellschaft für angewandte Optik
Andreas	**Fischer**	AHMT	Arbeitskreis der Hochschullehrer für Messtechnik e. V.
Andreas	**Fischer**	ForWind	ForWind – Zentrum für Windenergieforschung
Andreas	**Fischer**	MAPEX	Center for Materials and Processes
Andreas	**Fischer**	SPIE	The International Society for Optics and Photonic
Andreas	**Fischer**	EOS	European Optical Society
Andreas	**Fischer**	OSA	The Optical Society
Andreas	**Fischer**	IEEE	Institute of Electrical and Electronics Engineers
Andreas	**Fischer**	VDI	Verein Deutscher Ingenieure
Andreas	**Fischer**	GALA	Deutsche Gesellschaft für Laser-Anemometrie
Andreas	**Fischer**	DHV	Deutscher Hochschulverband
Andreas	**Fischer**		Boppardkreis
Andreas	**Fischer**	SFB 747	Sonderforschungsbereich 747 Mikrokaltumformen
Andreas	**Fischer**	SFB TRR 136	Sonderforschungsbereich TRR 136 Prozesssignaturen
Gert	**Goch**	WGP	Wissenschaftliche Gesellschaft für Produktionstechnik
Volker	**Renken**		Forschungsnetzwerke Energie: Systemanalyse, Erneuerbare Energien, Stromnetze
Michael	**Sorg**	DFMRS	Deutsche Forschungsvereinigung für Meß-, Regelungs- und Systemtechnik e. V.
Dirk	**Stöbener**	VDI	Verein Deutscher Ingenieure
Dirk	**Stöbener**	VDI FA 3.61	VDI Fachausschuss 3.61 Messen an Zahnrädern und Getrieben
Gerald	**Ströbel**	DFMRS	Deutsche Forschungsvereinigung für Meß-, Regelungs- und Systemtechnik e. V.
Gerald	**Ströbel**	EVIGEM	The European Virtual Institute of Geometric and Dimensional Metrology
Gerald	**Ströbel**	VDI/VDE-GMA	VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik

Events

Participation at events and conferences

Date of event	Event / Conference	Location	Participant(s)	
16 Feb 2016	Jugend forscht - Regional-wettbewerb Bremen-Mitte Subject: Jugend forscht – Schüler experimentieren „Neues kommt von Neugier"	Bremen	Axel von Freyberg Marc Lemmel	jury members/ jurors
17 May - 21 May 2016	DGaO 117th Annual Meeting	Hannover	Stefan Patzelt	oral presentation with proceedings
30 May - 04 Jun 2016	16th International Conference & Exhibition of the European Society for Precision Engineering and Nanotechnology (euspen)	Nottingham/ UK	Gabriela Alexe Andreas Tausendfreund Peiran Zhang	poster presentation without proceedings oral presentations with proceedings
15 Sep - 16 Sep 2016	XXX. Messtechnisches Symposium 2016 des Arbeits-kreises der Hochschullehrer für Messtechnik e. V. (AHMT)	Hannover	Stefan Patzelt Andreas Tausendfreund	oral presentations with proceedings
29 Sep - 02 Oct 2016	DOG 2016 Augenheilkunde – ein großes Fach	Berlin	Jan Osmers	oral and poster presentation without proceedings
22 Sep - 23 Sep 2016	Zukunftsfähige Stromnetze	Berlin	Volker Renken	oral and poster presentation without proceedings
05 Oct - 07 Oct 2016	The Science of Making Torque from Wind (TORQUE 2016)	Munich	Christoph Dollinger	oral presentation with proceedings
26 Oct - 28 Oct 2016	HK 2016 - 72. HärtereiKongress	Cologne	Helmut Prekel	oral presentation with proceedings
09 Nov - 10 Nov 2016	Special Interest Group Meeting: Structured & Freeform Surfaces, Technical University of Denmark (DTU)	Copenhagen/ DK	Gabriela Alexe	oral presentation without proceedings
01 Mar 2017	Jugend forscht - Regional-wettbewerb Bremen-Mitte Subject: Jugend forscht – Schüler experimentieren „Zukunft – Ich gestalte sie“	Bremen	Axel von Freyberg	jury member/juror
16 Mar 2017	DFMRS Windenergietagung 2017	Bremen	Christoph Dollinger Volker Renken	oral and poster presentation without proceedings
16 Mar 2017	DFMRS Windenergietagung 2017	Bremen	Andreas Fischer Michael Sorg	participants

Events

Participation at events and conferences

Date of event	Event / Conference	Location	Participant(s)	
28 Mar - 29 Mar 2017	GetPro Kongress	Würzburg	Andreas Fischer Axel von Freyberg	participants
31 May - 01 Jun 2017	AMA Conferences 2017 - SENSOR 2017 and IRS² 2017	Nuremberg	Matthias Auerswald Jan F. Westerkamp	oral presentations with proceedings
31 May - 01 Jun 2017	AMA Conferences 2017 - SENSOR 2017 and IRS² 2017	Nuremberg	Andreas Fischer	session chair
06 Jun - 10 Jun 2017	DGaO 118th Annual Meeting	Dresden	Andreas Fischer	programme committee session chair
06 Jun - 10 Jun 2017	DGaO 118th Annual Meeting	Dresden	Gabriela Alexe Andreas Tausendfreund	oral presentations with proceedings
12 Jun 2017	NWMK-Workshop "Norddeutsche Energieforschung"	Hamburg	Andreas Fischer	delegate
13 Jun 2017	MAPEX Methods Workshop I	Bremen	Andreas Fischer	participant
25 Jun - 29 Jun 2017	SPIE Optical Metrology	Munich	Andreas Fischer Stefan Patzelt	oral presentations with proceedings

Events in Bremen

Event	Date	Organizing institution
VDI FA 3.31 Verzahnungsmesstechnik	05 and 06 Oct 2016	VDI / Meeting at BIMAQ Institute
DFMRS Windenergietagung 2017	16 Mar 2017	DFMRS
Infra Tec Thermography Workshop	05 Apr 2017	Infra Tec / Workshop at BIMAQ Institute
Girls Day 2017 "Exploring the world with electronic sense"	28 Apr 2016 27 Apr 2017	University of Bremen / Workshop at BIMAQ institute
Inaugural lecture Prof. Fischer: Model-based, dynamic measurement systems - "Measure what is measurable, and make measurable what is not so!"	29 Jun 2017	BIMAQ

- VDI FA 3.31 Verzahnungsmesstechnik

The VDI committee with focus on measuring of gears and gearboxes met at BIMAQ on 5th and 6th October 2016. This committee organized by The Association of German Engineers (VDI) draws up standards for the measurement on gears and for assessing the quality of gearings. In order to ensure a precise and rational production of gears and gearings, a functioning measuring technique is mandatory.

The VDI/VDE guidelines developed for testing and measuring gears and gearings are currently being revised and adapted to the state of the art.

- DFMRS-Windenergietagung 2017

On 16th March 2017, the third DFMRS wind energy conference was held in Bremen. Place of this event was the "Haus Schütting" in Bremen, located directly at the Bremen Market Place.

BIMAQ presented results from the research project GEOWISOL on the topic “Regional assessment of the feed-in of renewable energies on the basis of measurement data and a model-based data extension”. At the same time, the conference offered the opportunity for a lively exchange of experiences and ideas.

Events

Events in Bremen

- Infra Tec thermography workshop

InfraTec offered a free thermography workshop at BIMAQ enabling interested researchers to learn more about thermography camera technology and the variety of applications of this technology.

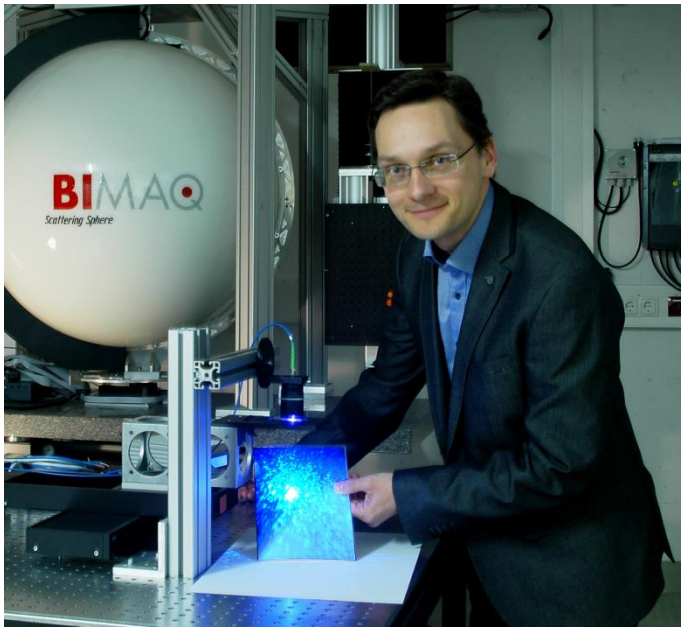
In only a few hours, the interplay of cameras, accessories and software has been demonstrated and gave an initial impression of what is possible using InfraTec thermography systems.

- Girls' Day

In 2016 and 2017 BIMAQ offered the workshop "Exploring the world with electronic senses". Simple experiments were used to show how what we see or feel, such as temperature, force or size, can electronically be detected and used. The photo shooting with a thermal imaging camera took place in the afternoon, a special photo workshop that made the world seem very colorful, as different temperatures were displayed in different colors.

- Inaugural lecture Prof. Fischer

Since 1st August 2016 Professor Fischer is the new director of the Institute BIMAQ and chair of the thematic field Metrology, Automation and Quality Science at the faculty of Production Engineering at the University of Bremen. On Thursday, 29 June 2017, Professor Fischer held his inaugural lecture: Model-based, dynamic measurement systems - "Measure what is measurable, and make measurable what is not so!"



Impressum

BIMAQ

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