Modulbezeichnung:	Optical Manufacturing Metrology (OMM) (Optical Manufacturing Metrology)	5 ECTS
Modulverantwortliche/r:	Tino Hausotte	
Lehrende:	Tino Hausotte	

Startsemester: SS 2015	Dauer: 1 Semester	Turnus: jährlich (SS)
Präsenzzeit: 60 Std.	Eigenstudium: 90 Std.	Sprache: Englisch

Lehrveranstaltungen:

Optical Manufacturing Metrology (SS 2015, Vorlesung, 2 SWS, Tino Hausotte)
Optical Manufacturing Metrology - Übung (SS 2015, Übung, 2 SWS, Tino Hausotte et al.)

Inhalt:

- **Introduction:** manufacturing metrology and main task: fields of industrial metrology, main tasks (control the conformity, readjusting/correcting of process parameters), objectives and aims (ensure the function, interchangeability, correction parameters for manufacturing processes) - measuring, testing, monitoring - equipment in manufacturing metrology - optics (theories: quantum, wave, ray), effects, properties and principles of measurement
- **Geometrical tolerances:** basic (GPS) Framework, duality principle and operations (partition, extraction, filtration, association, collection, construction) - definitions of geometric elements, standard geometrical elements - geometrical parameters of workpieces, classification system for form deviations - linear and angular dimensions (terms and definitions) - ISO-system for tolerances of linear sizes (terms and definitions, types of fits, code system) - symbols and drawing indication of geometrical tolerances - definition of form tolerances - datums - orientation, location and run-out tolerances - several essential specifications for GPS (CT, E, M, F) - surface texture parameters (determination, types)
- **Measurement and Evaluation Strategies:** determination of measurement strategy, probing strategy and evaluation strategy (Minimum and recommended number of probing points, Nyquist's Criterion, probing of feature segments, evaluation criteria) - influences on the uncertainty of measurement results (uncertainty of measurement, Golden Rule)
- **Optical Principles and Components:** Theories of optics - Geometrical optics (reflection, refraction, fibre optic components, ray tracing, lenses, aberration, beam splitter, mirrors, prisms, reflectors) - Wave optics (wave equations, polarisation, polarisers, beam-splitting polarisers, coherence and interference, diffraction) - Quantum optics (spontaneous emission, light-emitting-diodes and detectors, stimulated emission, laser, photoelectric effect and detectors)
- **Tolerances of optical Components:** reference wavelengths - testing areas and volumes - dimensioning of lenses and of edges, dimension and protective chamfers - specification of angle - material specification (stress birefringence, bubbles and other inclusions, inhomogeneities and striae) - surface treatment and coating
- **Scales and Encoders:** Abbe comparator principal (traceability, 1th order and 2nd order error, Abbe comparator) - linear encoder (principle, Moiré-effect and reticle, detection of motion direction) - output signals and demodulation of encoder signals (counting and resolution enhancement) - reading head of encoders (imaging and interferential measuring principle, transmitted and reflected light) - reference marks - absolute encoders (U- and V-scanning and Gray code)
- **Interferometer for length measurements:** interference and interferometer - Michelson-Interferometer - superposition of waves, Basics of the interference, Interference of light waves - homodyne and heterodyne principal - interference at a Michelson-Interferometer - interference of a homodyne interferometer - demodulation at a homodyne interferometer (dead path) - demodulation at a heterodyne Interferometer - refractive index of air (dependency, measurement) - coherence (spatial and temporal, interferograms with two monochromatic light, white light) - He-Ne-Laser (modes and mode distances, stability) - interferometer setups and adjustment
- **Interferometer for surface measurements:** interference of equal inclination - interference of equal thickness - multiple beam interference - demodulation with phase shifting (principle, generation of phase shift, unwrapping) - application of Fizeau Interferometry - interference microscopes (setups,

evaluation)
- **Optical Surface Measurements:** microscope designs, measuring microscope - numerical aperture and resolution - focus variation - confocal microscope (principle, setups, laser-scanning microscope) - chromatic white-light sensor - laser autofocus method (characteristic curve, principles with astigmatic lens and Foucault knife) - summary: optical probing

Lernziele und Kompetenzen:

Learning targets and competences:

Remembering
- The students have knowledge about the objectives, main tasks, and quantities of manufacturing metrology
- The students have knowledge about inspection equipment in manufacturing metrology

Applying
- The students are able to analyze the GPS concept and geometrical tolerances.
- The students are able to compare optical measurement procedures and its applications.

Literatur:

- Yoshizawa, T.: Handbook of optical Metrology: Principles and Applications. Boca Raton, CRC Press, 2009
- Gåsvik, K. J.: Optical metrology. New York, Wiley, 2002
- Benteley, J. P.: Principles of Measurement Systems. Essex, Prentice Hall, 1995
- International Vocabulary of Metrology - Basic and General Concepts and Associated Terms, VIM, 3rd edition, JCGM 200:2008

Verwendbarkeit des Moduls / Einpassung in den Musterstudienplan:

Das Modul ist im Kontext der folgenden Studienfächer/Vertiefungsrichtungen verwendbar:

[1] **Maschinenbau (Bachelor of Science): ab 3. Semester**
(Po-Vers. 2009w | Wahlmodule | Technische Wahlmodule)

Dieses Modul ist daneben auch in den Studienfächern "International Production Engineering and Management (Bachelor of Science)", "Maschinenbau (Master of Science)", "Mechatronik (Master of Science)", "Wirtschaftsingenieurwesen (Master of Science)" verwendbar.

Studien-/Prüfungsleistungen:

Optical Manufacturing Metrology (Prüfungsnummer: 49003)
(englische Bezeichnung: Optical Manufacturing Metrology)

Prüfungsleistung, Klausur, Dauer (in Minuten): 90
Anteil an der Berechnung der Modulnote: 100%
weitere Erläuterungen:
Prüfungstermine, eine **allgemeine Regel der Prüfungstagvergabe** und **Termine der Klausureinsicht** finden Sie auf StudOn: Prüfungstermine und Termine der Klausureinsicht

Erstablegung: SS 2015, 1. Wdh.: WS 2015/2016
1. Prüfer: Tino Hausotte

Organisatorisches:
- Vortragssprache: Englisch
- Unterlagen zur Lehrveranstaltung werden auf der Lernplattform StudOn (www.studon.uni-erlangen.de) bereitgestellt. Das Passwort wird in der ersten Vorlesung bekannt gegeben.

Bemerkungen:

Wenn Sie ein Technisches Wahlmodul ausgewählt haben, setzen Sie sich bitte mit dem Dozenten wegen der Prüfungsmodalitäten in Verbindung. Sie benötigen einen benoteten Schein, auf dem folgende Informationen angegeben sind:
- Studiengang: Maschinenbau (Bachelor)
- Modul: Technisches Wahlmodul

- ECTS: 5 [oder 2,5]
- Prüfungsnr.: 17102(bei 5 ECTS) [oder 17101 (bei 2,5 ECTS)]
- Prüfungsinhalt/Lehrveranstaltungen: eine Benennung des Themas der Prüfung oder eine Aufstellung der Lehrveranstaltungen, über die geprüft wurde (diese Informationen werden für den "Transcript of Records" benötigt).

Diesen Schein können Sie dann beim Prüfungsamt zur Verbuchung einreichen.