Microscopy from Carl Zeiss

Applications

TIC

Optical height measurement in the nanometer range

The PLD process

Pulsed Laser Deposition (PLD) is a new PVD technique (Physical Vapor Deposition) in which a pulsed laser beam of high energy is focused on a sintered target material. The laser light is absorbed in a volume area close to the surface. As a result, the target material is removed (stoichiometrically) while retaining its elementary composition. With respect to coating materials, PLD is a very flexible technique, which also allows multi-constituent and oxide materials to be deposited very easily. The strengths of the PLD technique: straightforward formation of multilayer systems and deposition of very complex compounds (e.g. ceramic materials) in the form of thin layers [1, 2, 3, 4].

PLD and Plasmaimpax™

Applications and materials:

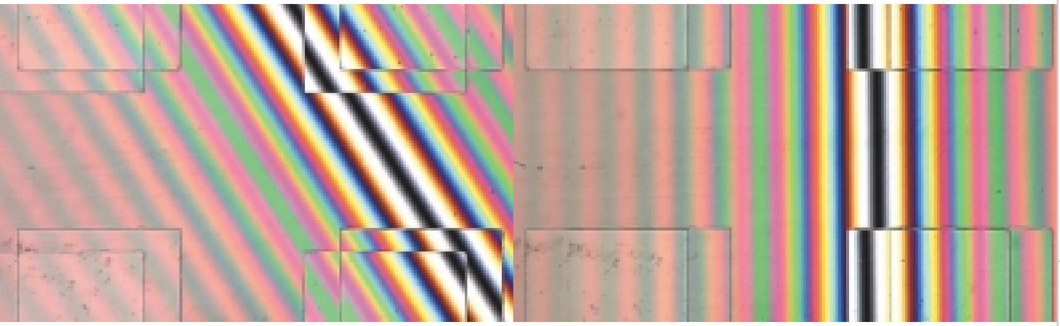
- Functional ceramics with special electrical, optical, magnetic and sensory properties
- extremely thin, chemically inert PTFE coatings
- extremely low-friction and wear-resistant coatings (tribology)
- surface modification (without coating) with respect to wear and corrosion resistance
- bio-compatible surfaces

Areas of application are:

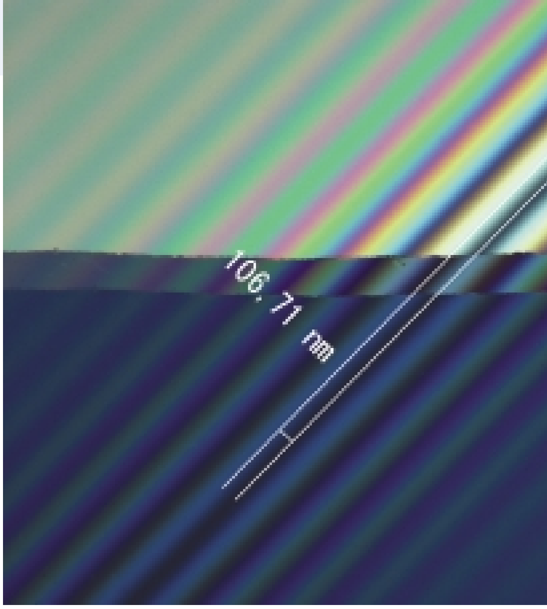
- automobile industry
- mechanical engineering
- medical engineering
- optics
- sensor development
- superconductor engineering

Dr. Bernd Schey

AxynTeC Dünnschichttechnik GmbH [5] is a technology provider in the area of surface and thin-film engineering with two innovative and unique coating technologies. On the basis of this technology, the company provides standard coatings and develops customer-specific coatings and processes, which include system conception as well as plant and process technology transfer. As a result, customers benefit from a "one-stop surface engineering solution". The two technologies are a laser and a plasma supported PVD technique: PLD and Plasmaimpax™. They allow a broad spectrum of materials to be applied as coatings for different applications and on various substrates.



Thin-film analysis used in LD processing



Application

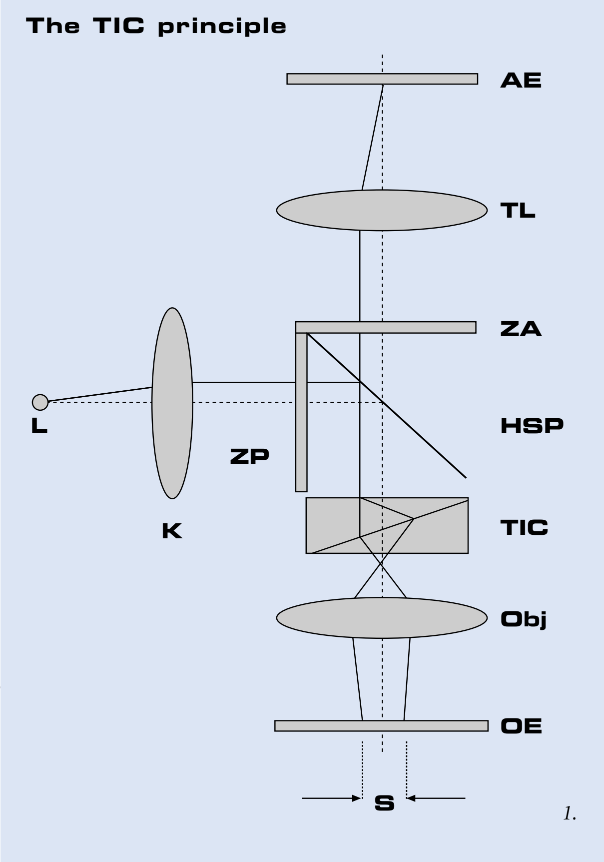
For customer-specific developments, it is essential to determine the deposition rates for individual process parameters, particularly for new target materials. This is done by determining the thickness of the deposited layers, whose thickness can range from a few microns down into the µm range. Measurements of layer thickness during the process are the prerequisite for successful layer development. This is especially important in the case of optical applications (e.g. interference filters), where the optical properties of the construction element are mainly determined by the film thickness of the deposited material. At the same time, it is important to maintain a homogeneous layer thickness over the total area to guarantee proper manufacturing and operation.

Characterization process requirements

- quick determination of layer thickness (height scale: from nm up to several microns)
- easy evaluation
- examination of layer thickness over large areas
- no complicated structuring steps
- measurement by optical transmission
- additional information on the surface

The TIC principle

TIC, the abbreviation for Total Interference Contrast, denotes the new polarization/optical shearing micro-interferometer from Carl Zeiss. Contrary to traditional polarization interferometers, work is carried out in circular polarized light and not in linear polarized light. This enables rotation of the TIC prism without alteration of the contrast of the interference pattern. There is no longer any need for stage rotation, which was necessary in conventional techniques, and specimen cohesion remains. This is of particular advantage for the imaging and measurement of specimen structures found in various directions, i.e. differently aligned specimen structures can be presented successively in high contrast and measured. Differences in height in specimen structures are determined by measuring the shift in the interference pattern.

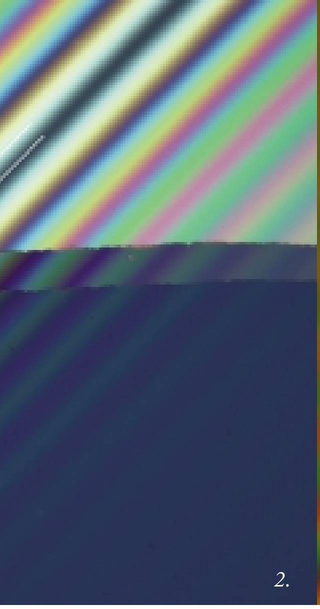


1.

Figure 1: TIC is the abbreviation for Total Interference Contrast and denotes the new polarisation/optical shearing micro-interferometer from Carl Zeiss.

Figure 1: Schematic structure of the TIC shearing micro-interferometer. The light emitted from the light source **L** passes the collector **C** and is circularly polarized by the polarizer **CP**. A semi-permeable beam splitter **BS** reflects the circular polarized light partly to the **TIC** prism. This results in a splitting **S** in the specimen plane **SP**, which is far greater than the resolution limit (creation of a dual image split).

After reflection on the object, the two images, polarized at 90° with respect to each other, pass the lens **Obj** again, are reunited by the prism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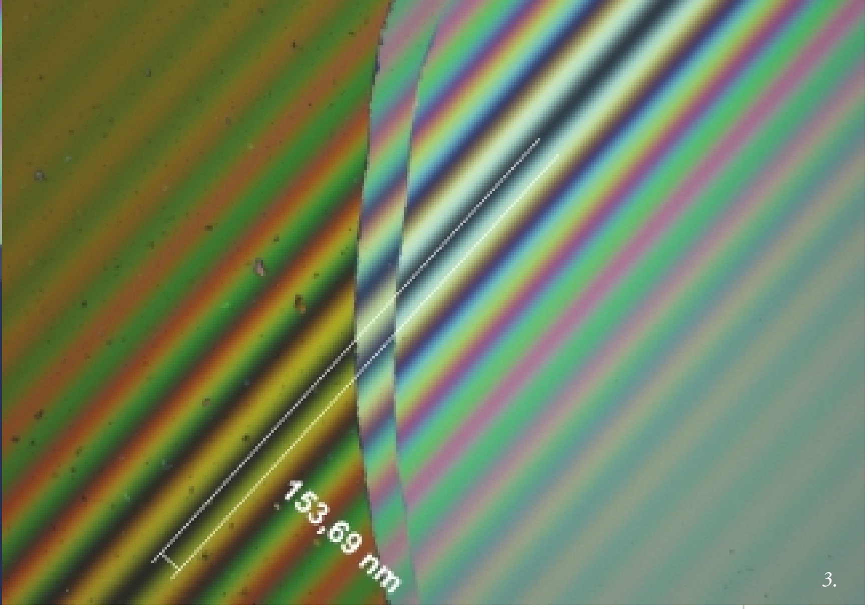


3.

Figure 2: TIC exposure with 10x lens on amorphous TiO_2 layer: 107 nm.

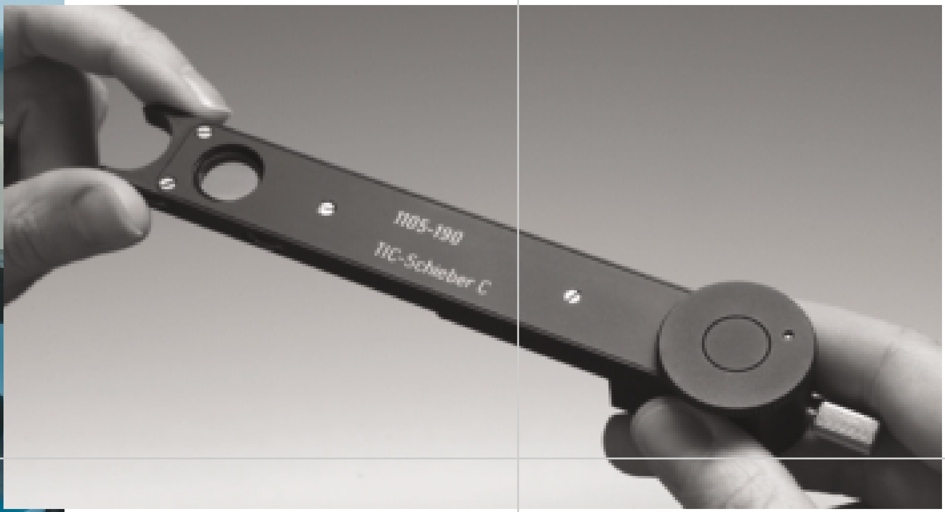
Figure 3: TIC take with 10x lens on amorphous ZrO_2 layer: 154 nm.

TIC and pass the circular analyzer **CA**. The resulting visible interference pattern is imaged through the tube lens **TL** into the detector plane **I** (AxioCam or ocular focal plane).

Results and discussion

During the development of highly refractive thin layers of TiO_2 and ZrO_2 by means of PLD, Axioskop 2 MAT with TIC was used for layer analysis accompanying the process. This microscope was used on the one hand to investigate the surface morphology of the layers and, on the other, to determine the thickness of their layers. TIC images in reflected light mode with evaluated layer thickness can be seen in Figures 2 (TiO_2, 107 nm) and 3 (ZrO_2, 154 nm). Supplementary investigations were carried out on these layers with a profilometer and a scanning force microscope (AFM), which verifed the TIC measurements and proved the high precision of the TIC process.

As can be clearly seen in Figures 2 and 3, there is no need for precise specimen structuring to determine layer thickness. A random edge course is sufficient. In addition to layer thickness, the material-dependent phase jump in light reflection can be determined. This is a key property for optical applications. From the measurements on the amorphous layer systems shown in Figures 2 and 3, there are phase jumps in the case of reflection for TiO_2 of 136° and 159° for ZrO_2.



Summary and evaluation

Working with Axioskop 2 MAT and TIC has shown that precise determination of layer thickness on thin films can be easy and user-friendly. In contrast to conventional layer thickness measuring devices such as profilometers or scanning force microscopes (AFM), this technique is impressive: fast and precise measuring and evaluation times, easier specimen preparation and the option of rapidly analyzing large-area specimens. The combination with a conventional microscope has proven to be extremely favorable and greatly simplfies determining the specimen area to be examined. Thanks to these advantages, the Axioskop 2 MAT with TIC has great potential as a combined analysis system (optical microscope and layer thickness measurement device), particularly in thin-film engineering.

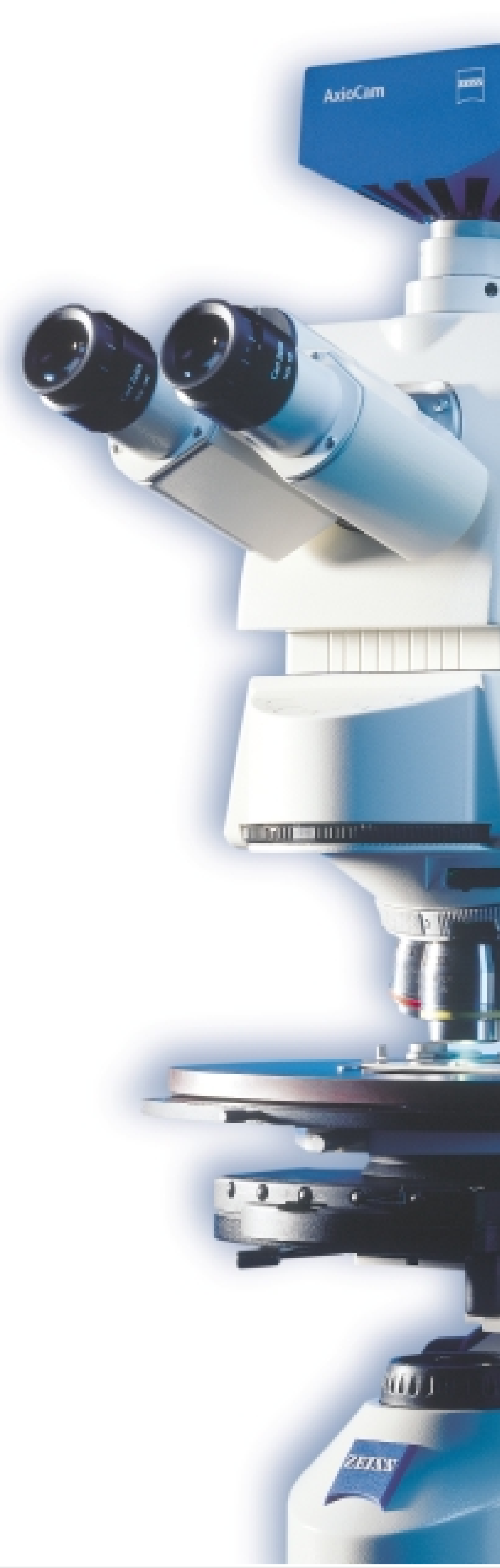
[1] B. Schey, W. Biegel, M. Kuhn, R. Klarmann and B. Stritzker; Pulsed Laser Deposition of YBCO on 7 x 20 cm^2; 3rd European Conference on Applied Superconductivity 1997, 30 June - 3 July, Enschede, NL, Inst. Phys. Conf. Ser. No 158 (1997) 225

[2] B. Schey, T. Bollmeier, M. Kuhn, W. Biegel, G. Östreicher, B. Stritzker; Large-area deposition of YBCO-films by pulsed laser deposition, Rev. Sci. Instr. 69 (2) (1998) 474

[3] B. Schey, W. Biegel, M. Kuhn, B. Stritzker; Large-area Pulsed Laser Deposition of YBCO Thin Films: Homogeneity and Surface, Appl. Phys. A 69 (1999) 419-422

[4] R. Klarmann, B. Schey, M. Kuhn, W. Biegel, B. Stritzker; Pulsed Laser Deposition of Ceramic Thin Films on Various Substrates, Surface Engineering, EUROMAT Vol. 11 (2000) 479

[5] www.axyntec.de



Carl Zeiss
Light Microscopy

P.O.B. 4041
37030 Göttingen
GERMANY
Phone: ++49 551 5060 660
Telefax: ++49 551 5060 464
E-Mail: micro@zeiss.de

www.zeiss.de/mat

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