**HANSER** 

User report
Ferdinand Braun Institute
Leibnitz Institut für Höchstfrequenztechnik
(Institute for High Frequency Technology)

# Measuring the Nearly Immeasurable

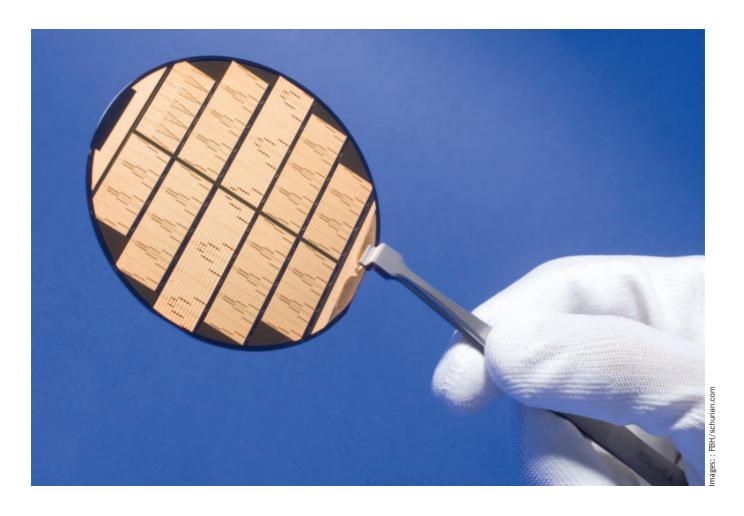




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#### MULTISENSOR CMM MEASURES WAFER LAYER THICKNESSES

## **Measuring the Nearly Immeasurable**

The wafers produced at the Ferdinand Braun Institute in Berlin for diode lasers and high frequency amplifiers must be lapped to a precise layer thickness. Clean room workers monitor this process with a multisensor coordinate measuring machine from Werth Messtechnik, Giessen. The machine is equipped with a chromatic sensor for precisely capturing the required measured values without contact.

Visitors to the Ferdinand Braun Institute, Leibnitz Institute for High-Frequency Technology in Berlin, known as FBH for short, will find uncompromised high technology (see box). A total of 220 employees, including 110 scientists, develop and produce diode lasers for material machining, medical technology and precision measurement technology, as well as other

products. Another focal point is the production of high frequency components for communications technology, power electronics and sensors.

"Diode lasers from FBH have very low installed heights, as well as high precision, brilliance and power," explains Dr. Andreas Thies, a science associate in the process technology department. Although such a laser is no bigger than a grain of rice, it can output up to 20 Watts in continuous wave operation, or 100 Watts in quick pulse mode. To put this in perspective: that is about 5,000 to 25,000 times the level of a laser in a CD player. These characteristics, together with high reliability under extreme conditions, have made FBH lasers valuable around the world. They have even been proven in outer space, for example, in the atomic clocks in next generation GPS satellites.

There are many areas of application for light sources. In medical technology, they help with photodynamic cancer therapies by activating a medication that has been built up in tumor cells with a precisely defined wavelength and the affected cells are destroyed. Further applications include optical precision measurements, industrial metrology and material processing (welding, soldering, engraving).

## Wafers are subjected to various machining processes

Research and development work in microwave technology and optoelectronics is done on the basis of the fundamental technologies. Using epitaxy (depositing single crystal semiconductor layers on a monocrystalline substrate), razor thin layers with the desired material properties are



Figure 1. In the clean room: Employees use a 3D CNC multisensor coordinate measuring machine with a chromatic focus sensor for measuring wafer thickness.

formed on the wafers. Using modern, industrial compatible systems, the wafers are further processed. The process chain includes photolithographic methods, wet and dry chemical etching processes and metallization steps. About 2,000 chips with microwave circuits, or 10,000 laser chips, can fit on a 4 inch wafer.

Before the technicians separate the chips from the wafer and assemble them into optoelectronic or high frequency components, the wafer must first be thinned. To do this, it is glued to a carrier material and then lapped to a defined dimension. Dr. Andreas Thies is a process technology specialist at FBH and is responsible for clean room work. He explains, "The thickness of the wafer is an important criteria for the usability of the component. As a rule, the wafer is ground down from an initial thickness of 350  $\mu m$ to as little as 100 µm, depending on the application." For 4 inch wafers made of gallium arsenide (GaAs) or gallium nitride (GaN), the preferred materials for high frequency applications, it takes about two hours for GaAs, and significantly longer for GaN.

To reach the precise target thickness, the wafer must be measured several times. Until recently, this process was done solely by tactile measurement.

This method works as follows, the thickness of the wafer is measured before it is glued to a carrier. It is measured again after gluing and the difference between the two values can be used to approximate the thickness of the layer. This is

used to calculate the thickness of the wafer after material has been removed by lapping.

Because this method is not particularly precise, the responsible parties decided to buy a special measuring machine that would provide precise results and work without contact as much as possible. Their choice was a Werth VideoCheck 400 x 200 x 200 3D-CNC, with a chromatic focus probe (CFP) (Fig. 1). This 3D CNC multisensor coordinate measuring machine, from Werth Messtechnik, Giessen, is very precise due to its unique magnetic preloaded guide system. The modular machine concept of the VideoCheck series allows various sensors to be combined to suit the application (Fig. 2). In addition to the image processing sensors included in the basic version, various mechanical, contacting probe systems, the patented 3D Werth Fiber Probe microsensor, and various distance sensors can be integrated.

### Chromatic focus sensor measures only the wafer material

The integrated Werth Chromatic Focus Probe measures the thickness of the wafer. It was specially developed for precisely measuring, without contact, materials that are shiny, reflective and transparent to visible light. The sensor is thus particularly well suited for optical components, such as mirrors and lenses.

To be able to measure semiconductors, such as wafers that are normally not transparent to white light, a special vari-

#### Components on a grain of rice

The Ferdinand Braun Institute, Leibniz Institut for High Frequency Technology (FBH) is a leading international institute for application oriented and industry related research in microwave technology and optoelectronics. It is part of the Forschungsverbunds Berlin e.V. research consortium, a member of the Leibnitz Gemeinschaft and a participant in many networks. The FBH produces high frequency components circuits based on III/IV compound semiconductors for technical communications, power electronics and sensors. The institute also develops high power diode lasers for material processing, medical technology and precision metrology. Close cooperation between the FBH and industrial partners, research centers and universities supports the goal of rapid implementation of these developments. The institute has been honored many times for its successful technology transfers.

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ant is used with a spectrum in the infrared range, whose light can penetrate the semiconductor material (Fig. 3). The physical effect of front and rear face reflection at each of the boundary surfaces of the materials produces interferences that are used to compute the thickness of the layer. The critical advantage of this sensor is "that it measures the wafer material precisely and ignores the adhesive layer, any metal layers, and electrical structures on the front face," explains Andreas Thies.

The measurement can be set up and performed quickly. The operator first positions the wafer to be measured in one of the prepared fixtures on the X-Y table. He then uses the WinWerth measurement software on the PC, selects the appropriate position and enters the required basic information about the size and material of the wafer. Andreas Thies states more precisely, "We can measure gallium arsenide, gallium nitride, sapphire, silicon, and silicon carbide. These are our main materials. For other materials, the refractive index can be entered. Entering an approximate thickness

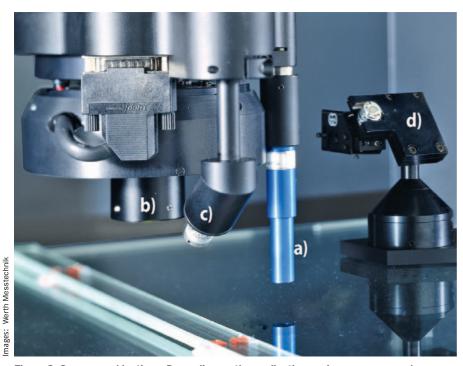






Figure 3. Scanning: Wafers are inspected for particulate impurities using the image processing sensor.

of the test sample (estimated dimension  $\pm$  50  $\mu$ m) speeds up the measurement".

Now the operator just needs to press start and the machine starts the measurement process. The sensor scans the wafer in two tracks across the center, once in the X and once in the Y direction. The layer thickness measured during each pass is displayed on the screen. The workers find it practical to be able to analyze the data directly on the machine PC. Using routines written in house, the layer thickness distribution is calculated and displayed graphically. The measurement takes about two minutes for a 70 mm wafer. The user can then see a precise image of the thickness distribution of the wafer and continue to lap it if necessary.

#### Non-contact measurement prevents damage

When working with sensitive wafers, it is common to have slight mechanical damage during machining, such as a fine crack. Tactile measurement would then cause further damage to the wafer, due to the contact pressure, making it com-

pletely unusable. If, however, the measurement can be done without contact, then the process can be continued despite the minor damage. In most cases, a large portion of the chips on the wafer can still be used.

The CFP sensor is not the only tool used in the FBH thinning lab. The Video Check IP has a optical beam path as standard equipment that allows the wafer to be inspected with high resolution and precision. The zoom optics can be positioned and focused either by the CNC controller or manually, using a joystick. Various zoom settings are available to select the desired magnification. By illuminating the test object in different ways, different tasks can be performed. Lighting at an angle, with the MultiRing darkfield incident light, for example, accentuates the edges, so that their roughness can be evaluated. Perpendicular lighting, using the brightfield incident light, can be used to check whether the surface has been contaminated with particles.

Andreas Thies has also used this flexible tool to "photograph" components, "In just a few minutes, I generated an ex-

tremely high resolution raster image of the wafer being inspected, completely automatically. A large number of individual images are recorded in a defined raster and then merged to form a larger image. This allows images to be generated that show the wafer down to the finest detail. This is an excellent basis for scientific discussions."

Translated by Werth Messtechnik GmbH

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