Fraunhofer IWS Dresden

FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

LAWAVE – NON-DESTRUCTIVE TESTING OF THIN FILMS AND MATERIAL SURFACES

Characterization by laser-induced surface acoustic waves

LAwave

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Task

Surfaces play a vital role in optimizing products and processes. Modification of surface properties by coating, machining or other treatment cannot be measured with conventional bulk testing methods and requires sophisticated characterization for research and quality control.

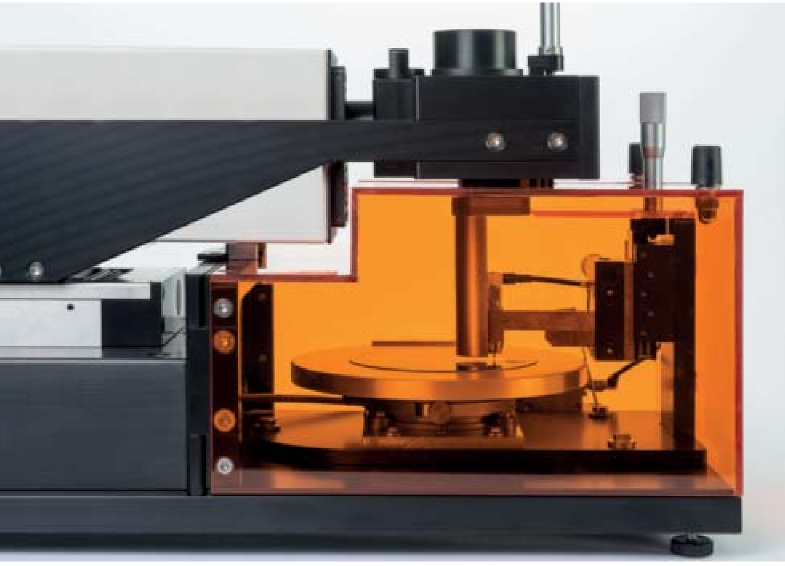
Solution

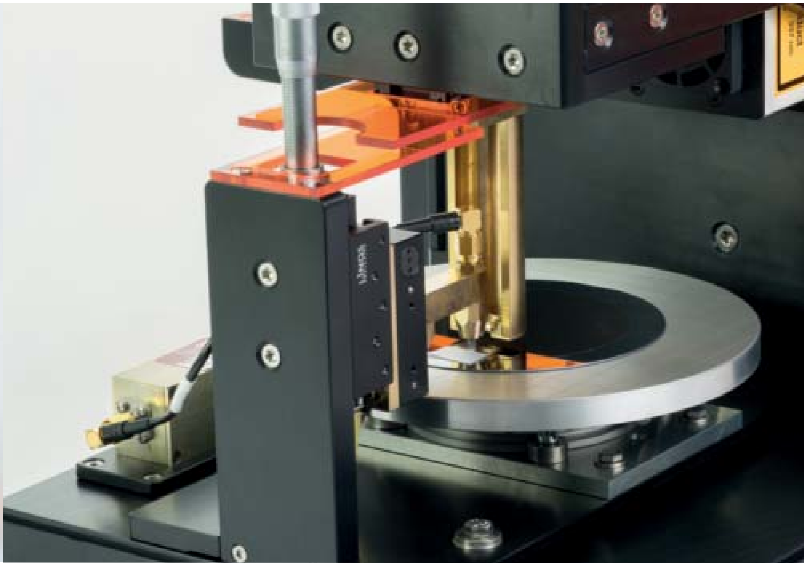
LAwave, a laser-acoustic test system developed at the Fraunhofer IWS, allows the evaluation of surface properties in a sensitive and rapid manner. Surface acoustic waves are generated from laser pulses. The velocity of the waves is measured and contains information about the elastic behaviour and the density of the upper surface regions and bulk. The method can analyze films with very different mechanical properties, from soft polymers to superhard diamond like carbon, from smooth nanometer films to rough surfaces like thermal-sprayed coatings. Furthermore, gradients and defects of the micro-structure, e.g. machining layers can also be characterized. The system can be optimized for differend applications by customizing soft- and hardware.

The LAwave method complies with EN 15042-1 and was granted the well-respected »R&D 100 Award« as one of the hundred most significant technical developments of the year.

Highlights

- extremely sensitive
- non-destructive
- fast and reliable
- film thickness: from nano- to millimeter
- no sample preparation





Examples of application

In general, **a broad range of films and changes in surficial micro-structure** (e.g. bonding, porosity, composition) can be detected.

Young's modulus, thickness and density of

- PVD coatings, e.g. DLC, nitrides, carbides, oxides, other ceramics
- CVD coatings and CVD diamond
- thermal-sprayed coatings
- low-k films
- Si, GaAs semiconductors
- polymeric sensor films
- bulk materials, e.g. steel, brass, cemented carbide

Depth of

- subsurface damage from silicon wafer processing
- work hardening zone after metal finishing
- surface hardening

Nanometer DLC films

The hardness and Young's modulus of hydrogen-free DLC (ta-C) directly depends on the inter-atomic bond strength of the carbon atoms and is a key property for the application as a protective coating. The LAwave method allows an unparalleled quick, precise and non-destructive characterization of such films from the micrometer to the nanometer range.

Figure 1 shows the Young's modulus of ta-C films used as a protective coating for hard disks. It steadily decreases for a film thickness below 10 nm. Furthermore, an improvement of the film quality by reducing the deposition temperature is indicated. LAwave measurements have enabled an optimized deposition technology.

Subsurface damage

Sawing a semiconductor wafer from an ingot produces a region of high defect density at the surface, to be removed by a careful grinding and polishing process. Determining the depth of this subsurface damage is desirable in order to optimize the machining process.

Figure 2 shows dispersion curves measured by LAwave in the as-sawn state, after several grinding steps, and at the final state of the polished wafer surface. The defective zone has the effect of a surface layer with a lower Young's modulus. Removing this layer reduces the negative slope of the dispersion curve. The depth of the defective zone can be measured from the curve's slope.

References

- National Physical Laboratory, London, UK
- AIST Institute Mechanical Systems Engineering, Tsukuba, Japan
- Tsinghua University, Beijing, China
- National Metrology Institute of Germany, Braunschweig, Germany
- and many more…

Fig. 1: Young's modulus of ta-C coatings in dependence of coating thickness, showing the influence of deposition temperatures and different PVD technologies

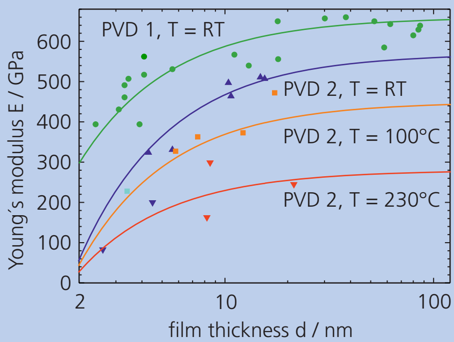


Fig. 2: Dispersion curves of surface acoustic waves for sawn, different states of grinded, and polished silicon wafers