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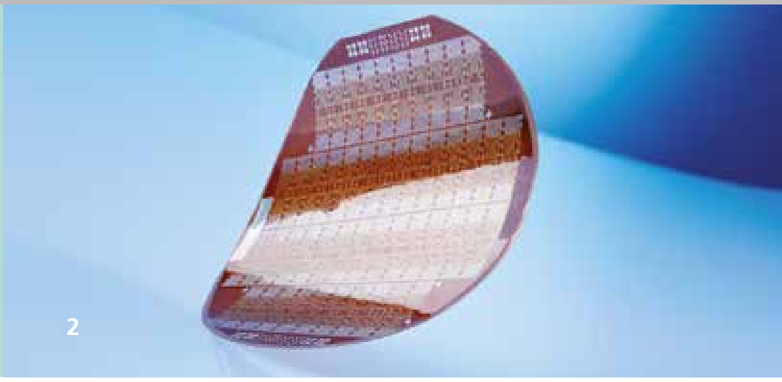


MEASURING WITH A TOUCH

EVALUATING MATERIAL PROPERTIES BY TOUCHING WITH A µ-STRUCTURED SENSOR

1 The measurement probe can be tailored individually to the material to be measured.

2 Wafer with sensor chips for the simultaneous measurement of thermal and electrical conductivity.

Measuring with pressure

Measuring thermal and electrical conductivity simultaneously without sample preparation. This is made possible by a new foil-based measuring concept for which a flexible measurement probe makes contact with the surface of the material by simply pressing it onto the sample.

Fraunhofer IPM has been working on the development of flexible sensors for many years. The flexibility of the new generation of sensors appears in two ways: they can be adapted to suit the measuring task at hand and are also pliable. Various electronic sensors on flexible plastic substrates such as polyimide or PET foils have already been developed. These »measuring tapes« are essentially capable of determining a wide range of physical variables simultaneously: from simple temperature measurements, measurements of electrical or thermal conductivity and heat capacity to determining parameters such as the Seebeck coefficient, the Lorenz number or porosity of adequately smooth surfaces of solids. In liquids, flexible »electronic tongues« can measure the pH value, density or viscosity by simply immersing them.

The latest development in the field of flexible measurement technology is a »material measuring stamp«. The measurement structures are integrated in a flexible plastic foil made of polyimide (kaptone) and are made using thin-film technology.

Mounted on a flexible measurement stamp support, the sensor measures electrical and thermal conductivity without any sample preparation by simply

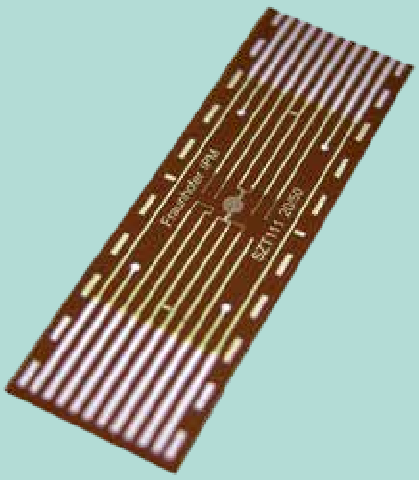
Fraunhofer Institute for Physical Measurement Techniques IPM

Georges-Köhler-Allee 301
D-79110 Freiburg, Germany

Contact

Martin Jägle
Phone +49 761 8857-345
martin.jaegle@ipm.fraunhofer.de

www.ipm.fraunhofer.de/en



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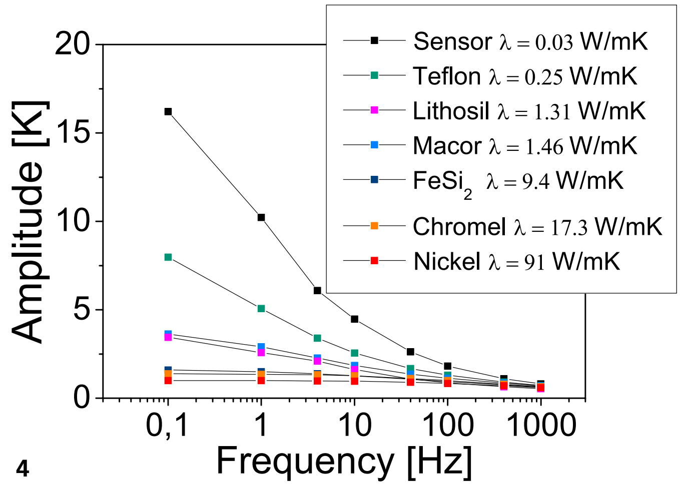

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pressing it on top of the smooth surface of a workpiece.

Unlike conventional measuring methods, the workpiece does not have to be machined for this purpose and therefore remains intact. By replacing the foil measurement head support, it is possible to determine other parameters such as type of charge carrier, Seebeck coefficient or the thermal and electrical capacity of a material. The measurement probe can be tailored individually to the material being measured, specific measurement parameters and the properties of the workpiece depending on the application.

»Thermal ultrasound«

This way, thermal conductivity, a variable that is typically difficult to measure, can be checked »on the fly« without interfering with the fabrication process. The measurement procedure is based on the so-called 3-omega method. A heater structure encased in the measurement foil is subjected to an alternating current with a frequency of omega. Pressed on to a body, this then feeds heat waves of twice this frequency into the material. The penetration depth of these waves differs depending on the frequency, material and material thickness.

The temperature increase this causes depends on the thermal material properties and the frequency and can be measured from the change in the resistance of the heater structure. If the workpiece being measured is made up of several layers of different materials or of a composite material, this allows a sort of »thermal ultrasound picture« to be generated as long as the thermal conductivity of the various components is different.

Air inclusions and delaminated layers can also be detected. The 3-omega method is not restricted to the measurement of solid materials but can also be used for measuring gases or liquids. The measurement head itself is around the size of a pen and can therefore very easily be flanged on to a robot arm. If the integration of all the required measurement structures is not possible for a multi-parameter measurement using one head, several measurement heads can be used on one workpiece at the same time. Flexibility is the key in this case, too.

3 *Flexible material sensor to determine the electrical and thermal conductivity as well as temperatures and the Seebeck coefficient.*

4 *Determining thermal conductivities (λ) from measured sensor signals for different materials.*