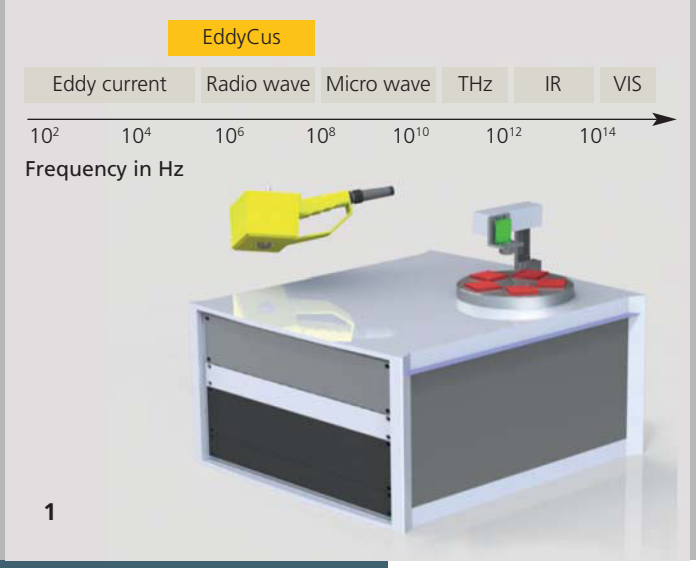

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IMPEDANCE ANALYSIS FOR MATERIALS DIAGNOSTICS

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Methods of impedance analysis

Impedance analysis methods are characterized by their versatility and convenient handling. The impedance is a material-specific parameter that describes the resistance of a material against the diffusion of an electromagnetic or mechanical wave. In the first case, we speak of electrical impedance, the second case is called acoustic impedance. Both methods can be applied to evaluate complex material parameters, such as density, elastic modulus, deviation of material composition, humidity and polymerization.

Electrical impedance analysis

The electrical impedance analysis can be performed by direct electrical bonding of a material or by capacitive or inductive coupling. Direct contact methods are usually bound to laboratory application and solid states. Capacitive and inductive methods are applied for fluids, pastes and green ceramics. Especially the inductive methods allow field focusing in the frequency range up to 100 MHz and sensors with high sensitivity, no contact and higher spatial resolution than capacitive transducers.

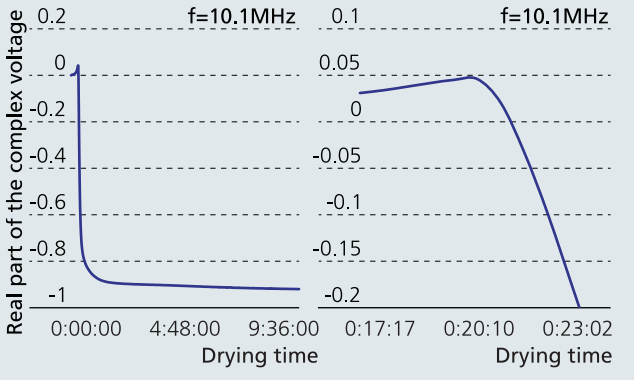
The method bases on an alternating electromagnetic field that will be coupled into the sample via an induction coil. This induces an eddy current flow in the material of electrically conductive samples. Dielectric materials can be analyzed by measuring the influence of dielectric currents and polarization effects on the field and, therewith, on the impedance of an inductive coil. Hence, materials diagnostics of conductive and non-conductive materials based on inductive impedance spectroscopy becomes possible.

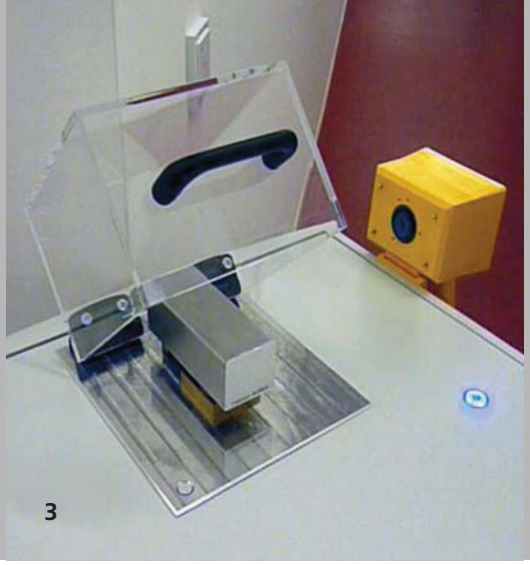
Electrical impedance analysis is applied, for example, to evaluate the drying behavior of electrically conductive coating systems. Such systems will be prospectively used for lightning protection in aircraft construction. In doing so, the surface of an airplane will be laminated with coatings of electrically conductive particles.

One purpose of the approach is to predict the conductivity of conductive coatings still in wet state after drying. Thereby, the coating can be reworked or removed in cases of defective layer thickness or differing particle concentration in the wet state. So far, the coating results can only be tested if the varnish is dry. This can be very expensive if the varnish on a defectively coated airplane surface has to be removed mechanically.

The inductive impedance analyzer "EddyCus® Wet", developed at Fraunhofer IKTS, allows for the determination of percolation behavior of particle-based coatings via contact-free impedance measurement immediately after layer deposition. Since the particles are not directly connected after the coating process, the layer shows dielectric properties. The percolation begins during drying, i.e. the particle concentration increases and conductive paths are created.

Changes of impedance by percolating particle-based conductive paint





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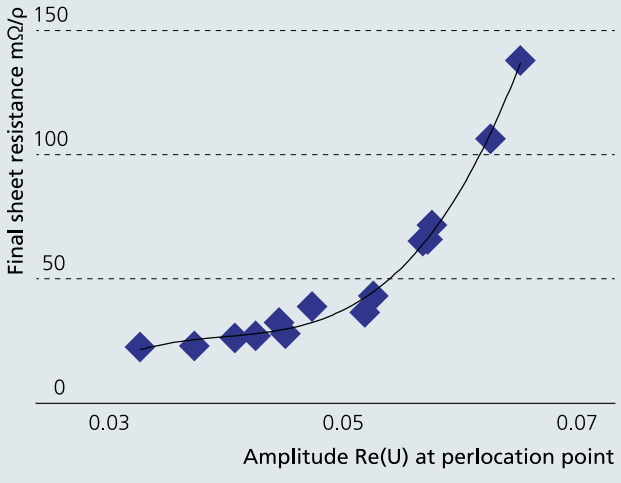
Just before the percolation point is reached, capacitive effects dominate between closely adjacent particles. After the percolation, the layer is electrically conductive but still moist. The percolation point in time can be determined by impedance measurement very well and correlates with the prospective thickness in the dry state. The particle concentration and, therefore, the layer conductivity in the dry state can be predicted from the amplitude of the percolation point.

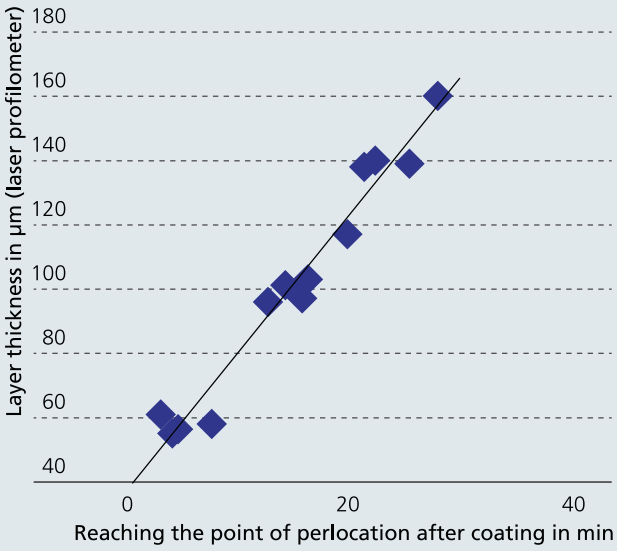
By calibrating the measurement system, the future layer thickness and layer conductivity can be concluded from the percolation point.

The developed prototype "EddyCus® Wet" is equipped with a fixed and mobile sensor. The fixed sensor acts as referencing, whereas the mobile sensor can be used, for example, on a scaffold for overhead work on an airplane.

Prediction of the sheet resistance from the amplitude



Prediction of layer thickness from percolation point in time



1 *Classification of radio wave methods.*
2 *"EddyCus® Wet" prototype.*
3 *Fixed sensor for referencing of the developed impedance analyzer.*
4 *Mobile sensor for contact-free impedance measurement.*

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