



**Fraunhofer Institute for
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– Adhesive Bonding Technology
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MULTIFUNCTIONAL THIN LAYER INSULATING COATINGS FOR ELECTRICAL COMPONENTS

The challenge: Meeting complex requirements

Insulating coatings are essential for the reliable operation of modern electrical equipment and machinery. The requirements here are not merely electrical insulation – innovative ideas and applications call for coatings with multifunctional properties that are also suitable for components having complex geometry.

A coating process that is suitable for complex geometries allows flexibility and freedom of component design during the entire development phase. In order to realize the complex coating specifications, there must be an optimum strategy that takes into account the entire coating process:

- Material selection
- Pre-treatment
- Definition of the coating chemistry
- Layer application
- Process monitoring
- Application-oriented testing
- Analyses during the development phase

For the cast coils of an electric motor (Fig. 1-3), for example, the coating must be of minimum thickness, electrically insulating, and heat resistant. Good heat resistance here prolongs the service life and increases the power density. A minimal layer thickness allows higher fill factors and gives improved thermal management due to more efficient cooling.

Your partner – Fraunhofer IFAM

A key work area of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, is the development of functional coatings for technical surfaces. The main technologies employed for this are wet chemical methods e. g. anodization, plasma methods and paints/lacquers.

- Wet chemical methods produce uniform, homogeneous coatings and are particularly suitable for components of complex geometry.
- Low pressure plasma processes are cold processes and can be used to produce a variety of functional layers of sub-micron thickness. Complex shaped components can also be effectively coated.
- Adaptation and optimization of existing paint/lacquer formulations allow the development and application of coatings for specific tasks.

Pre-treatment for high-quality, durable coatings

The importance of cleaning and chemically activating surfaces prior to the coating process is often underestimated. Only with optimum pre-treatment can an adherent coating resistant to sub-surface migration and with lasting functional properties be realized. High coating quality in combination with prolonged component service life opens up new fields of applications for components.

Pre-treatment methods available at Fraunhofer IFAM include:

- Wet chemical methods such as etching, electropolishing, anodization
- Dry chemical methods such as CO₂ snow cleaning, plasma activation, laser treatment

Quality via layer analysis and functionality testing

The development of multifunctional thin layer insulating coatings at Fraunhofer IFAM is facilitated by accompanying chemical and physical analyses and testing. This includes the evaluation of each process step and the characterization of the insulating coatings before and after exposure to defined climatic conditions.

- Insulating properties (partial discharge resistance and dielectric strength)
- Roughness parameters in accordance with DIN standards
- Microstructure of surfaces and layers (microscopy, SEM, TEM), and other analytical techniques)
- Chemical composition (XPS, FT-IR, TOF-SIMS, and other analytical techniques)
- Surface energy
- Adhesion strength of coatings, etc.

Range of services offered by Fraunhofer IFAM

Fraunhofer IFAM, with its comprehensive range of coating processes and expertise in layer analysis, is a competent and flexible partner for your development work.

The range of services we offer include:

- Development of customized coatings
- Adaptation of existing processes
- Analysis of processes
- Quality assurance concepts
- Testing of coatings

Fraunhofer IFAM can also assist with the designing of pre-treatment and coating plants to meet your specific needs. This includes concepts for in-line quality monitoring and the analysis of random samples.

Different stages of the manufacture of an aluminum coil with an insulating coating:

- 1 Cast coil.
- 2 Electropolished coil.
- 3 Coil with insulating coating.