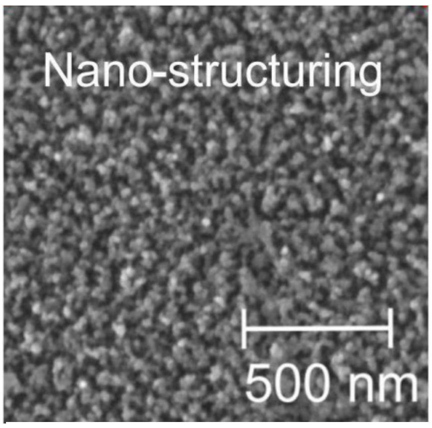
Interface and Surface Research for Joining Technologies and Hybrid Engineering Materials

Hybrid demonstrator fan-blade, which is composed of a CFRP fan bladed bonded to Ti-6Al-4V



A laser pretreatment of titanium alloys functionalizes and structures the surfaces on the nanometer scale, rendering them suitable for long-term stable adhesive bonding

Interfaces play a key role for defining the properties of adhesively bonded or brazed hybrid engineering materials and structures. This applies to adhesive polymer-metal and fiber-reinforced-polymer to metal joints such as used in fiber-metal-laminates (FML), thermoplastic-thermoplastic joining and welded or soldered metal-fiber or metal-metal joints. A detailed understanding of the interfaces is essential for assessing as well as advancing these materials and structures in a knowledge-based, systematical manner.

Adhesively bonded joints, for instance, offer numerous advantages over other common joining technologies (e.g. riveting or bolting). Large bonding areas, for instance, allow more homogenous load-paths without simultaneously introducing "damaging constraints" such as drill holes, which lead to stress concentrations and weakening. Thus, adhesive joining enables significant weight improvements by reducing the amount of rivets and can be viewed as an enabling technology for modern light-weight design.

The adhesive joining technologies pose stark requirements towards the properties of the joint surfaces and, therefore, the pretreatment of the joining partners. The influence of the joint surfaces becomes evident particularly during aging or degradation of the adhesive bonding by chemical media (e.g. humidity), since a poor pretreatment may lead to an early failure under mechanical loads. Reactively setting thermoset matrices typically behave less critical towards media influence than thermoplastics that are already completely polymerized and chemically less reactive on consolidation.

A suitable surface pretreatment depends on the particular material combination and use case. Among the commonly employed technologies for metal surfaces are grit blasting, anodization and laser pretreatments, the latter of which are particularly studied in the framework of these activities. Laser pretreatments act to clean, structure and functionalize a joint chemically, creating e.g. oxidic nano-structures on micro-roughened surfaces.

The fundamental mechanisms of bonding and degradation are investigated in detail at the Institute with the aim to tackle the failure origins and derive new and improved pretreatments for different titanium, aluminum and steel alloys and polymers combinations. In particlar a laser surface pretreatment was developed in recent years that leads to outstanding strength and aging resistance for titanium-thermoset and titanium-thermoplastic joints. The surfaces, interfaces and joints are characterized with a variety of laboratory and synchrotron tools micro-analytically (e.g. SEM, TEM, XPS or ptychographic tomography) and mechanically.

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