Fraunhofer ICT

Microwave and plasma technology

Nano-porous adhesion layer

Fraunhofer ICT´s expertise in the area of plasma technology goes far beyond simple coating technologies. It includes the development of tailored coating equipment and deposition processes, in particular for microwave-enhanced chemical vapor deposition and atmospheric plasma polymerization.

Bonding hybrid materials

A sustainable use of resources means that materials should be used where they are best suited due to their properties. Prominent examples are polymer-metal hybrid materials, which are often adhesion bonded. However, this has the disadvantage that primers, adhesive layers or adhesive films must be applied, which are the main cause of environmental pollution from bonding. Also, separating the bond at the end of life is difficult, and the recycling of hybrid materials is rarely possible.

Nano-porous adhesion layer

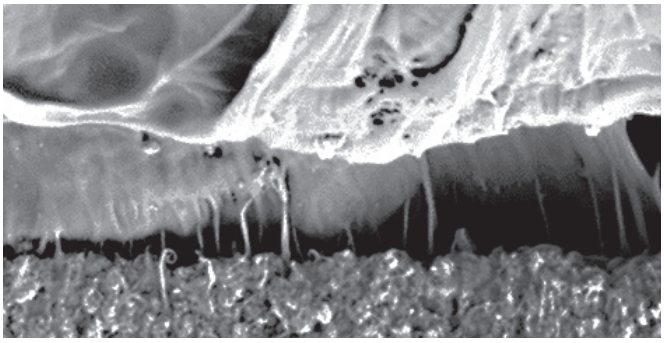
During plasma polymerization, complex molecules in a gaseous state are introduced into a plasma along with working gases. The molecules and gases are excited by the plasma and chemically react to form a layer on a substrate surface. This layer can be deposited in a porous form under specific process parameters. The porous layer can be used as an adhesive layer between metals, glasses, or ceramics and polymers. If a liquid polymer, such as melted thermoplastic or resin, is applied to the surface, it infiltrates into the pores. Upon solidification, the polymer becomes interlocked with the porous structure, forming a very strong bond.

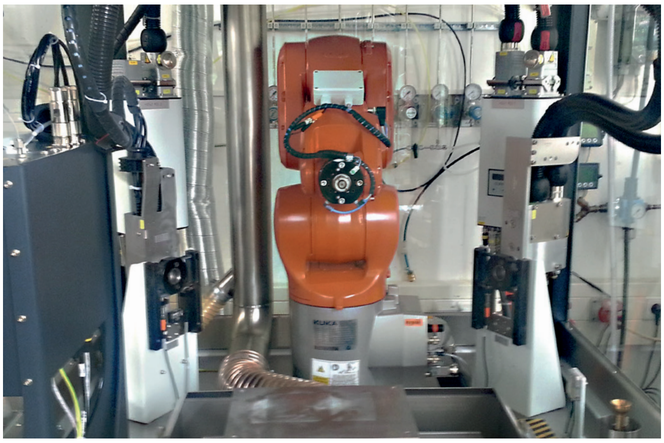
*Above:
SEM photo of the nano-porous adhesive layer bonded to polypropylene.*

*Below:
Plasma machine.*

Summary

- Direct joining of polymers with metal, glass or ceramics via polymer processes, e.g. injection molding, LTF-D, etc.
- Applicable for nearly all polymers and substrates
- Resource-efficient and sustainable bonding technology
- Highest adhesion strength





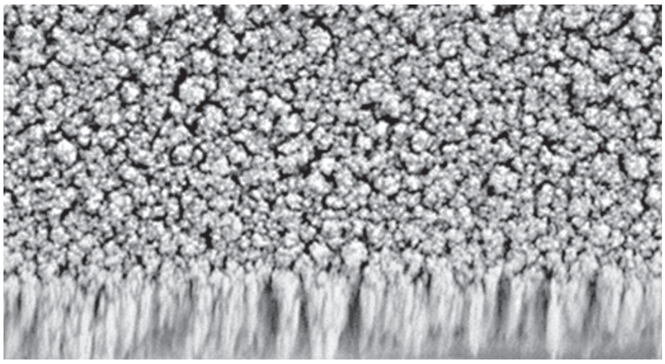
Success stories

Direct bonding of metal in the injection molding process:

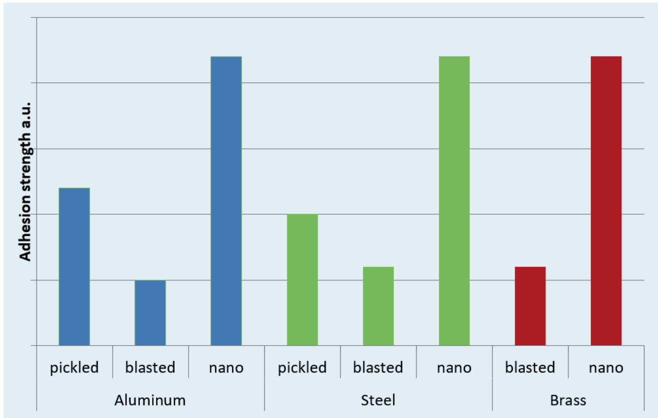
- Direct bonding of **polyphenylene sulfide** (PPS-GF) with stainless steel in the injection moulding process. Bond strength is about **45 MPa;** failure of the PPS is mostly cohesive.
- Direct bonding of **polypropylene** (PP-20% talcum) with stainless steel in the injection molding process. Bond strength is about **17 MPa;** failure of the PPS is mostly cohesive.
- Direct bonding of **phenol resin** (20% GF) with aluminum in the duromer injection molding process. Bond strength is about **50 MPa;** failure of the PPS is mostly cohesive.

Direct bonding of metal in the wet compression molding process:

- Direct bonding of **carbon-fibre-reinforced polyurethane** with aluminum in the wet compression molding process. Bond strength is about **40 MPa;** failure of the PPS is mostly cohesive.
- Direct bonding of **carbon-fibre-reinforced epoxy resin** with aluminum in the wet compression molding process. Bond strength is about **25 MPa;** failure of the PPS is mostly cohesive.



SEM photo nano-porous adhesion layer, shear strength.



Adhesion strength of the nano-porous layer compared to selected surface treatments.

Our offer

- Consulting and know-how transfer
- Feasibility studies
- Testing and validation

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