Plasma Technology for Surface Cleaning

by Relyon Plasma GmbH

Introduction

Ultrafine cleaning of surfaces with cold atmospheric pressure plasmas is a process of removing organic, inorganic and microbial surface contaminants, as well as strongly adhering dust particles. It is highly efficient and at the same time very gentle to the treated surface. At higher strength, it can remove weak surface boundary layers, cross-link surface molecules and even reduce hard metal oxides. Plasma cleaning promotes wettability and adhesion, enabling a wide array of industries to prepare surfaces for bonding, gluing, coating, printing and painting. Plasma cleaning is performed using air, or typical industrial gases including hydrogen, nitrogen and oxygen, and it avoids wet chemistry and expensive vacuum equipment, which can positively affect costs, safety and environmental impact. Fast processing speeds further facilitate numerous industrial applications.

Typical surface contaminants

Multiple layers of contaminants usually cover surfaces, even if the latter visually appears to be clean. Contaminants form naturally due to exposure to air. They include layers of oxides, water, various organic substances and dust. Furthermore, technological processes leave surfaces covered with oils, release agents, compounding ingredients, monomers and exuded low molecular weight species. Contaminants can greatly reduce the quality of adhesive bonding by introducing a weak intermediate layer. Moreover, their typically low wettability results in incomplete surface covering by the adhesive, further reducing bonding strength.

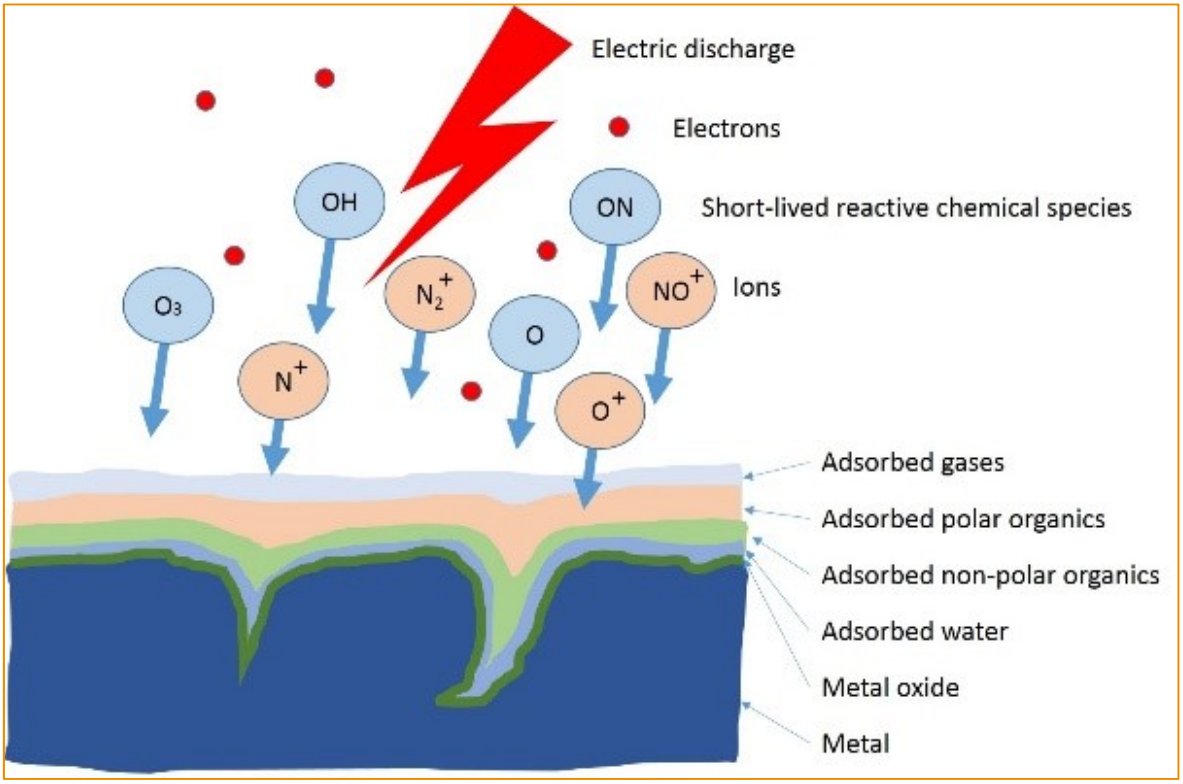

Figure 1 – Layers of contamination on a surface

Cold atmospheric plasmas

Plasma is a partially ionized gas. Electric arcs, dielectric barrier discharge, corona and piezoelectric direct discharge ionize gases at atmospheric pressures creating plasmas. The charged particles – electrons and ions – accelerate to very high energies. Only a small fraction of the gas molecules is turned into the energetic electrons and ions; the rest of the gas remains neutral and cold. Its temperature reaches only 50°C in the case of the piezoelectric direct discharge, and 250-450°C in the case of the arc discharge. At the same time, the very energetic electrons and ions collide with the gas molecules producing large quantities of short-lived chemical species, such as atomic H, N and O species, OH and ON radicals, ozone, nitrous and nitric acids, as well as various other molecules in metastable excited states. They make this plasma chemically very active.

Plasma cleaning mechanisms

Upon contact with the treated surface, the chemically active cold atmospheric plasma initiates a multitude of physical and chemical processes. The main reaction agents are highly reactive short-lived neutral chemical species. Additionally, when the electric discharge touches the treated surface, the latter is also irradiated by VUV light and bombarded by the energetic electrons and ions. Although the quantities of the charged particles are small, their highly reactive nature strongly enhances the cleaning effect. The following processes contribute to the ultra-clean surface:

- Plasma breaks organic bonds of heavy organic molecules producing lighter and more volatile molecules evaporating from the surface.
- Reactive chemical species oxidise organic contaminants forming carbon oxides and water vapour.
- These processes also destroy and remove microbial contaminations, sterilizing the surface.
- With the increased treatment strength, plasma removes surface layers with the lowest molecular weight. It also oxidises the uppermost atomic layer of the polymer.
- The bonds of the polymers, broken by the plasma, cross-link forming a stronger surface layer.
- Plasma discharges, ignited in the forming gas, typically containing 5% hydrogen and 95% nitrogen, produce large quantities of reactive hydrogen species. By contact with oxidised metal surfaces, they react with metal oxides reducing them to metal atoms and water.
- Electric discharges having direct contact with the substrate erode the substrate surface on the micrometre scale. This creates microstructures that are filled by the adhesives improving the mechanical binding of the adhesives.
- Plasma deposits polar OH and ON groups on the cleaned surface, significantly increasing the energy of the surface and its wettability. As a result, the subsequently applied adhesives wet the surface efficiently and fill the microstructures due to the capillary action.

Advantages of plasma cleaning

As the plasma processes, initiated on the treated surface, break contaminants turning them into vapour, no residues are left on the surface, leaving the latter in the ultra-fine clean state. Most importantly, the plasma cleaning process works at atmospheric pressure. Its advantages in comparison to standard chemical and vacuum plasma cleaning processes include:

- Ultra-fine cleaning, no residues
- Gentle surface treatment
- No wet chemistry

- Air or cheap non-toxic working gases
- Environmental friendliness
- No expensive vacuum equipment
- Fast processing speeds
- Easy integration into existing production lines
- Promotion of wetting and adhesion

Plasma cleaning products by Relyon Plasma GmbH, available from INTERTRONICS

To cover a wide spectrum of industrial, medical and laboratory applications, Relyon Plasma GmbH developed a series of products well suited for plasma cleaning:

Plasmabrush® PB3 is a universal highly reliable plasma generator based on Relyon's proprietary Pulsed Atmospheric Arc (PAA) Technology. With its power of 1 kW, very compact dimensions and exceptional long-time stability, this generator is well suited to integration into high-speed industrial production lines.

Plasmatool is a handheld instrument based on the Plasmabrush PB3, ergonomically optimized for safe manual operation. Together with a portable module including a high voltage supply, an air compressor and controlling electronics, it enables highly efficient plasma cleaning of large structures, areas that are difficult to access, or where automation is not possible or practical.

Piezobrush® PZ2 is a low power handheld plasma generator, which is based on our proprietary Piezoelectric Direct Discharge (PDD) Technology. It enables manual plasma cleaning work in laboratories. It can create corona and dielectric barrier discharges and apply them for precision ultrafine plasma cleaning of small components.

Picture credits

Figure 1 and product images – www.relyon.com

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intertronics
adhesives, coatings, sealants & equipment
for your manufacturing and technology applications

INTERTRONICS
Station Field Industrial Estate
KIDLINGTON
Oxfordshire
OX5 1JD
England
t 01865 842842
e info@intertronics.co.uk
www.intertronics.co.uk

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We specialise in adhesives and adhesive systems, namely bonding, coating, sealing, encapsulating, potting, masking and gasketing products, together with the most appropriate equipment and accessories for surface preparation, mixing, application, dispensing, and curing them. The provision of insightful technical and applications guidance is a cornerstone of our business. We help you find the optimal materials and processes for the manufacture, assembly or repair of your products, safeguarding and enhancing performance and integrity and, in turn, your profitability and reputation.

Ever since being established in 1979, when our main market was the printed circuit board assembly industry, we have enjoyed a reputation for customer focus, excellent service and post-sales support. We now supply over 3,000 regular customers, including multinational manufacturers, production facilities, specialist design and development businesses, universities, training organisations and government establishments.

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