Plasma as a Key Technology: Increasing Efficiency and Quality Assurance in the Electronics Industry

The electronics industry is facing major challenges: Products must be manufactured economically, deliver higher performance, and become smaller and smaller. Increasing miniaturization in particular is raising the demands on manufacturing processes. Plasma technology has established itself as a key technology in the industry because it solves key production challenges. Openair-Plasma® and PlasmaPlus® from Plasmatreat optimally prepare electronic products for subsequent processes through activation, ultra-fine cleaning, oxide layer removal and nano-coating. They increase product quality, reduce defects and make processes efficient and environmentally friendly.

Modern electronic components, especially in the automotive industry, require ever higher levels of performance. Power modules in electric vehicles must be able to handle currents of up to 1,000 amps, while everyday applications such as charging smartphones only require up to 5 amps. At the same time, the trend is to produce ever smaller and more powerful electronic assemblies in 5G and beyond technologies. To ensure that the smaller components and products become more powerful, the quality must be right. High-precision processing is therefore essential. To be competitive, these processes must also be efficient. All of this places high demands on the manufacturing processes and technologies used.

Plasma technology - more efficient processes, reduced failure rates

Atmospheric pressure plasma technology is becoming increasingly important in solving typical manufacturing problems. The technology is based on a simple physical principle: the addition of energy causes a change in the state of matter. When energy is added to a gas, it becomes ionized and enters the high-energy plasma state as the fourth state of matter. When plasma with its high energy level comes into contact with materials, the surface properties change, e.g. from hydrophobic to hydrophilic. Plasmatreat GmbH, based in Steinhagen, North Rhine-Westphalia, has made this effect technically and industrially usable on a large scale and named it Openair-Plasma®. Openair-Plasma® is used inline under normal pressure and does not require low-pressure chambers. This technology enables precise pre-treatment of electronic components and many other materials through micro-fine cleaning and activation. Depending on the contamination, Plasmatreat's Openair-Plasma® systems use different process gases such as compressed air, nitrogen or forming gas. These differ not only in the power and temperature generated, but also in the subsequent surface effect.

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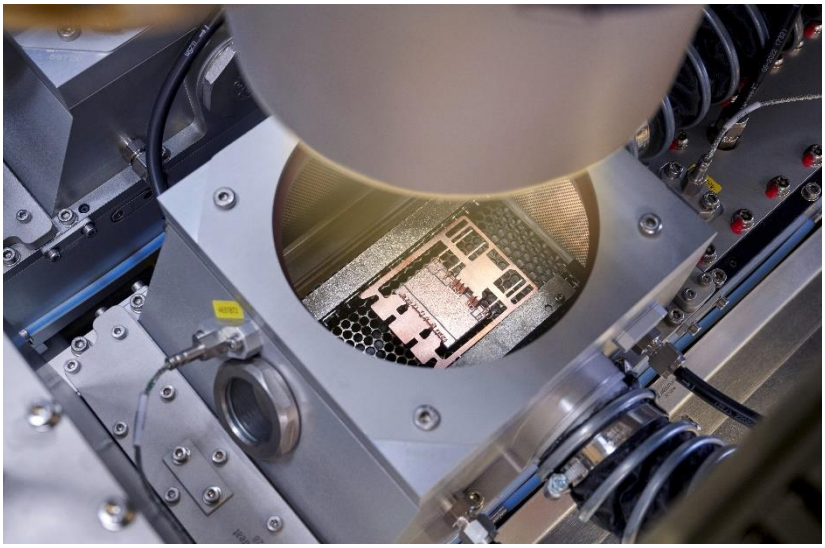
Activation optimizes the wettability of the surface and also significantly increases adhesion, thus enabling long-term stable adhesion, e.g. of adhesives, paints, varnishes and sealants. With the help of PlasmaPlus®, another process developed by Plasmatreat, nanocoatings can also be applied to surfaces in a targeted manner. The solutions developed by Plasmatreat stand for more efficient and environmentally friendly processes with reproducible results and reduced error rates - factors that are crucial for success in mass production in the electronics industry.

Various applications of plasma technology in the semiconductor and electronics industry:



Whether power modules, semiconductors or chips - oxide layers can be removed from metal electronic components in a matter of seconds using plasma treatment, thus supporting high-quality and durable end products. (Copyright Plasmatreat GmbH)

Environmentally friendly removal of oxide layers from semiconductors and power modules

One of the biggest challenges in electronics manufacturing is the oxidation of metal surfaces, which leads to contact and connection problems. In the manufacturing process of products such as semiconductors and power modules, this can lead to inferior solder joints. Atmospheric pressure plasma can be used to efficiently remove these oxide layers without using aggressive chemical processes such as solder fluxes. The REDOX®-Tool a dedicated Plasma Treatment Unit (PTU) from Plasmatreat, uses atmospheric plasma to remove oxide layers from metal surfaces. The system uses a mixture of nitrogen and hydrogen (forming gas). The components pass through a tunnel flooded with nitrogen. The plasma nozzles working with the forming gas reliably remove the oxide layers from the metal surface and prepare the metal surfaces for further process steps in production. Key advantages of this process: The reliable removal of oxide layers on metal contacts optimizes the electrical properties. This improves the quality of electronic components. At the same time, the use of Openair-Plasma® is an environmentally friendly alternative to polluting chemical flux processes. Plasmatreat's REDOX®-Tool makes this process highly efficient, as the

system can be integrated inline into existing production lines. Overall, the electronics industry benefits from improved quality and fewer defects in its products thanks to this process.

The REDOX®-Tool, a special plasma treatment unit (PTU) from Plasmatreat, uses Openair-Plasma® to remove oxide layers from metal surfaces.

(Copyright: Plasmatreat GmbH)

Comparison of copper plates treated with the REDOX tool (left) and oxidized copper plates (right). The difference between the copper plates without and with oxide layer is clearly visible.

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Perfect results in conformal coating and overmolding of sensors

In sensor manufacturing, atmospheric plasma is used to enhance functionality and reliability. Plasma technology plays a particularly important role in conformal coating, the application of a protective layer to protect the electronics from harmful environmental influences. Openair-Plasma® pretreatment increases the adhesion of the conformal coating to minimize defects and product failure. Openair-Plasma® surface pretreatment is potential-free and can treat even highly sensitive sensors.

Openair-Plasma® and PlasmaPlus® are also used in overmolding, a process in which electronic components such as sensors and power modules are embedded in plastic housings. First, the electronic components undergo a gentle, ultra-fine cleaning with Openair-Plasma®. Then they are coated with an ultra-thin adhesion-promoting layer using the special PlasmaPlus® process. Finally, they are overmolded with a plastic, for example by injection molding. Plasma pretreatment and plasma coating ensure that

the plastic adheres securely to the components. The housing reliably protects the sensitive products from external influences and ensures that the components have a long service life.

High-quality display bonding and coating

Plasma technology is also used in a wide range of display applications, from smartphone manufacturing to automotive. A key challenge is the formation of air gaps between the display and the protective layer of glass or plastic. This can cause reflections and impair readability, especially in sunlight. Treatment with Openair-Plasma® removes dust particles and contaminants and creates optimal conditions for subsequent bonding. The optical bonding process uses a transparent liquid adhesive that completely fills the space between the display and the protective layer. The plasma treatment ensures that the adhesive is evenly distributed and that there are no unwanted air pockets. This not only improves the optical quality, but also extends the life of the display. In the manufacture of plastic displays, plasma technology optimizes the surface properties before antistatic and scratch-resistant coatings are applied. Here, too, Openair-Plasma® ensures that even the smallest particles are removed so that the protective coatings can adhere perfectly. This also significantly reduces reject rates in production. In the production of liquid crystal displays (LCDs), plasma pretreatment ensures reliable cleaning of the contact surfaces, increases the surface energy and enables the etching of the finest structures, which increases the efficiency and resolution of the displays. Combined with a heat-seal film that provides stable electrical contact, plasma treatment creates secure, long-lasting connections between glass and electronic components. Manufacturers can achieve higher contact quality and reduce the number of defective products.

Plasma treatment of displays prior to bonding. A dust-free and clean surface is critical to the quality of the final product. (Copyright: PVA)

Plasma as a future technology for the electronics industry

Atmospheric plasma technology is revolutionizing the electronics industry by making processes more efficient, sustainable and reliable thanks to its in-line capability. Overcoming the challenges of miniaturization and increasing performance requirements, it is proving to be a key technology in mass production that not only

helps reduce costs, but also reduces environmental impact. Plasma is paving the way for a sustainable and competitive electronics industry.

For more information, visit: www.plasmatreat.com

Info box:

How Openair-Plasma and PlasmaPlus optimize industrial processes.

When plasma with its high energy level comes into contact with materials, it changes the surface properties, for example from hydrophobic to hydrophilic. Plasma technology requires only compressed air and electricity for operation. Fine cleaning with Openair-Plasma gently and reliably removes dust, release agents, additives, plasticizers and hydrocarbons from surfaces. Especially with non-polar plastics, plasma treatment achieves surface activation. It supports the increase of surface energy by introducing hydroxyl groups and thus improves adhesion in subsequent processes such as bonding, printing, painting and sealing. Plasmatreat's PlasmaPlus technology can also be used to create targeted functionalized surfaces with defined properties by applying (depositing) nanocoatings, e.g. as an additional adhesion promoter layer.

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About Plasmatreat

Plasmatreat is an international leader in the development and manufacture of atmospheric plasma systems for the pretreatment of substrate surfaces. Whether plastic, metal, glass or paper - the industrial use of plasma technology modifies the properties of the surface in favor of the process requirements.

Openair-Plasma® technology is used in automated and continuous manufacturing processes in almost every industrial sector. Examples include the automotive, electronics, transportation, packaging, consumer goods and textile industry, but the technology, cost and environmental advantages of the plasma technology are used in medical technology and in the renewable energy sector as well.

The Plasmatreat Group has technology centers in Germany, USA, Canada, China, and Japan. With its worldwide sales and service network, the company is represented in more than 30 countries by subsidiaries and sales partners.

For more information, visit: www.plasmatreat.com