Innovative coating procedure opens new possibilities for photovoltaics

More efficient solar cell contacting, metallization and connection

Greater efficiency coupled with simultaneous optimized production costs – that is the goal of manufacturers of photovoltaic modules. The Plasmadust technology is a procedure which offers potential for more efficiency during contacting/connection. This innovative plasma coating procedure allows dry and solvent-free direct metallization of mono and polycrystalline silicon as well as the application of aluminum coats at low temperatures.

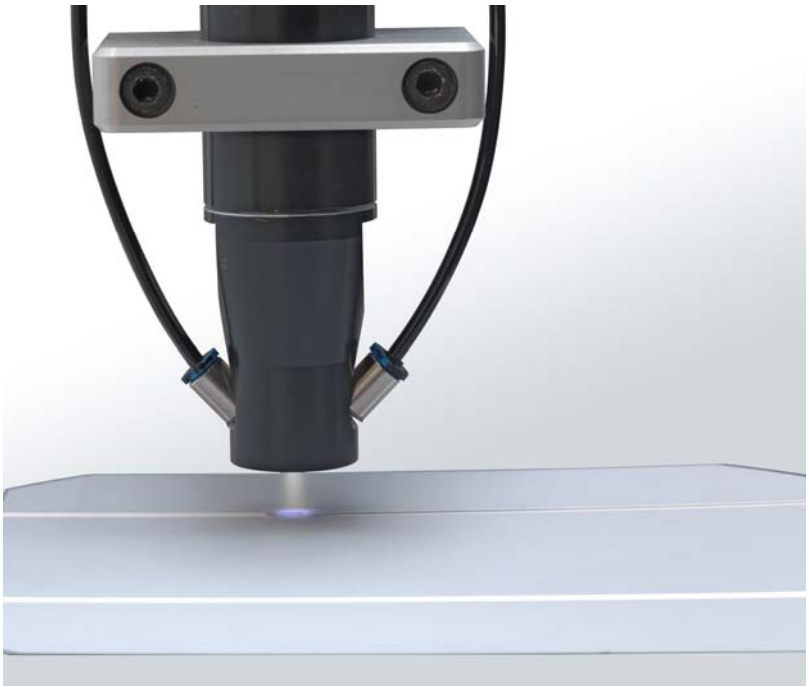
With the goal of increasing energy utilization, contacting with the latest generation of crystalline solar cells is done on the back. For this, an aluminum coat is applied on the back with the traditional plasma and/or PVD (Physical Vapor Deposition) procedure. This coat offers good electrical conductivity. However, soldering is problematic. Solder paste application of solderable metal pastes is the classical alternative to attach busbars and perform contacting but, due to the poor adhesion to the PVD aluminum, it cannot be used. The Plasmadust technology developed by the Reinhausen Plasma GmbH solves this problem. The reason: the dry and solvent-free coating procedure makes it possible to deposit nano and/or micro powders with a plasma under atmospheric pressure directly on a wide variety of substrates. This Plasmadust technology can also be used to process alloy systems so that, for example, substrates can be coated with six-component alloys – also lead-free.

Solderable coats with optimal adhesion

During the contacting and connecting of the solar cells, the locally limited deposit of soldering powder on the aluminum coat with the Plasmadust procedure represents a significant improvement. The solderable alloy powders can be deposited in reproducible coat thicknesses of 5 to 30 µm and the soldering structures can be applied linearly or by dots depending on the cell design. The soldering interface applied with Plasmadust offers adherence values greater than 10 N in the Peeling test. The PVD contact coat is not polluted or damaged by the coating process.

The Regensburg company has developed a plasma generator for coat deposition under environmental pressure. In contrast to conventional atmospheric pressure plasma technologies, the plasma generation uses pulsed energy. This opens up the possibility of regulating the power transfer to the plasma over wide areas. The temperature of the plasma reaching the surface of the solar cell can be kept very low. The temperature is measurably under 100 °C which permits a very material-friendly coating with comparably low power requirements.

An atomizer/conveyor technology was specially developed for the continuous soldering powder supply. The power agglomerates are not destroyed by the power input until just before injection into the plasma beam so that the powder is uniformly introduced into the plasma in the form of particles. The particle flow can be adjusted to the demands of the particular application and this guarantees homogeneous and reproducible coating thicknesses.



To improve the solderability of back contacted solar cells, locally limited soldering powder can be deposited on the aluminum coat in a reproducible coating thickness of 5 to 30 µm with the Plasmadust process.

Plasmadust – quicker coating with less energy

The current densities for standard solar cells are between 30 and 50 mA/cm^2. Sufficient conductive contact coats are needed so that the generated current can be conducted off as loss-free as possible. Depending on the particular cell design, between 10 and 20 µm aluminum are deposited on the back of the cell with the PVD procedure. Due to these coating thicknesses, very long process times are required for the PVD coating.

The metallization on the back with the plasmadust offers two-fold advantages here: Process speeds of up to 150 meters per minute significantly reduce the time required to apply the necessary coating thicknesses. The relatively large surface of the nano to micrometer-size powder particles (grain diameters of 100 nm to 20 µm) also allow them to be melted on at comparatively low temperatures. This means that the Plasmadust coating process consumes significantly less energy than conventional procedures. The metallization of a basic area of one square meter uses only about 1/10 to 1/100 of the energy required for thermal injection processes.

In addition, the solderability of the aluminum can be positively influenced by the possibility of depositing alloy systems already during the metallization on the back.

The Plasmadust procedure also offers advantages during the direct metallization of the cell backs. Process speeds of up to 150 meters per minute significantly reduce the time required for the coating process.

Constant module performance through innovative connection

To achieve greater efficiency and a largely constant performance during the life of the product, Reinhausen Plasma has also developed a new and easy-to-implement process for connecting the cells to the module. As the basis, the individual cells are enveloped in a special adhesive which also provides the connection to the glass. This then permits electrical contacts to be metallized from one silicon cell to the next and also via the adhesive. The specific characteristics of the plasma treatment also cause the metallic contact coat to adhere permanently to the adhesive. And this holds true regardless of weather conditions, mechanical stress during transportation and installation, and the chemical aging processes inside the modules due to moisture and gas emissions.

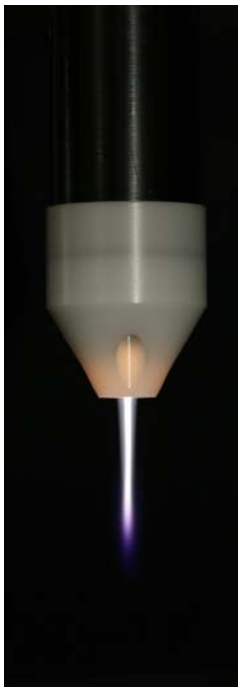
Plasmabrush – solvent-free inline cleaning with cold-active plasma

Purity for optimized adhesive bonding for photovoltaics

In addition to the adhesive, surface pre-treatment is decisive for the long life of the adhesive bonding on photovoltaic modules. The Plasmabrush cold-active atmospheric pressure plasma device is a tool which guarantees maximum purity and ease of integration in industrial processes.

Whether connection box, frame profiles, back rails or carrier foils – adhesive is used for a wide variety of connections on photovoltaic modules. Clean surfaces are essential if the connection of bonded parts is to hold up even under difficult conditions. The purity required for a stable, long-term bond can be economically and ecologically obtained with the cold-active Plasmabrush technology of the Reinhausen Plasma GmbH. The Regensburg company used innovative solutions to generate plasma under atmospheric pressure. This procedure uses pulsed energy. A cold, non-thermal plasma is created

whose maximum gas temperature of 100 °C on the substrate surface is clearly below the thermal stress which occurs with conventional, "cold" atmospheric pressure plasmas. This makes for very gentle material pretreatment. In addition to the much lower temperature, Plasmabrush also uses less electricity and slower gas speeds, both of which help to reduce gas consumption and add to the high economic efficiency of the procedure.



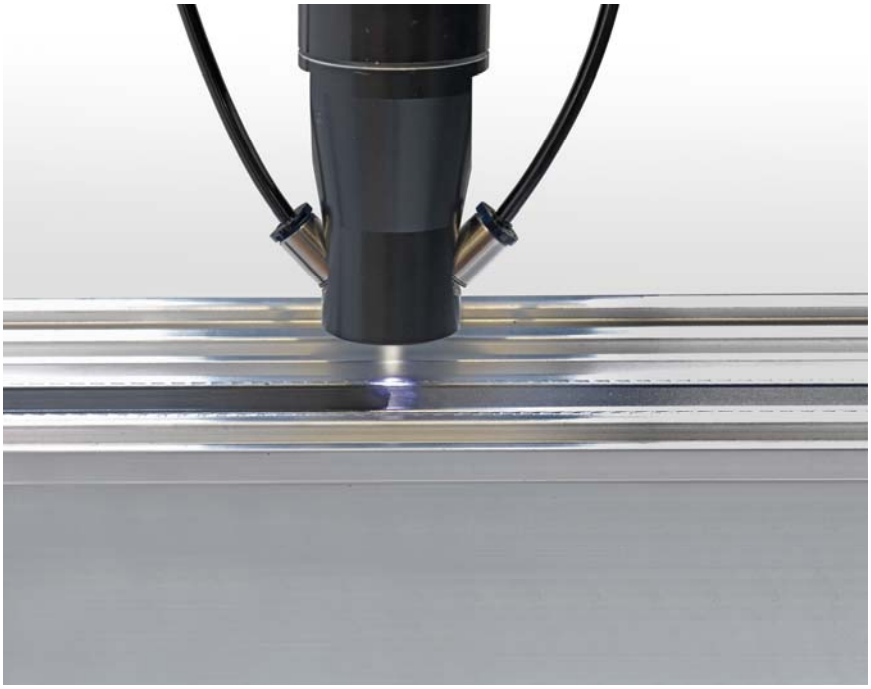
The cleanliness required by photovoltaics for long-term, stable adherence can be provided economically and ecologically with cold-active Plasmabrush technology.

Reliable gluing of the connection box

One example of an application area for the Plasmabrush procedure is the treatment prior to gluing the connection box. This procedure cleans and activates the surface at the same time. This double function is based on the physical and chemical reaction of the process. The atoms which are set free in the plasma "bombard" the surface. This is like micro-sandblasting in the nanometer range which completely removes organic soil (e.g., oil and grease) and even fingerprints residue-free. At the same time, free ions and electrons settle on the surface and chemically bond with it. This increases the surface tension which ensures more stable adhesive bonding.

No more adhesion problems for frame connections

Many photovoltaic modules are equipped with aluminum frames which, on the one hand, are necessary for installation, and, on the other hand, offer the module stability and protection. To provide characteristics such as water tightness, UV resistance and an elastic connection between glass and frame, structural sealants and adhesives are used. The adhesion problems which frequently occur with these connections can also be solved by pretreating the surface with the Plasmabrush.



Structural sealant and adhesives are used for the elastic bond between glass and aluminum frames. The adhesion problems which frequently occur with such connections can be solved with pretreatment by the Plasmabrush.

Strong adhesive bonding of back rails

Frameless thin-film modules simplify installation with their less complicated carrier systems. One possibility is to glue special prefabricated, aluminum profiles to the back of the photovoltaic modules. These so-called back rails then connect the modules with the carrier system. This type of installation offers great stability even under extreme weather conditions such as strong wind, snow and ice – provided the adhesive bond between back rail and module holds up. One criterion for this is the cleaning of the back rail which is usually done with a wet chemical process. Changing to the Plasmabrush procedure improves cleaning by utilizing the twin function of cleaning and

activating the adhesive characteristics for the gluing process which follows. In addition, treatment with plasma is solvent-free and thus more friendly to the environment.

Pretreatment of thin-film photovoltaic foils

So-called photovoltaic foils offer advantages when it comes to flat roofs and building-integrated applications. For this, thin-film photovoltaic laminates are glued to foils. The lower temperature of the Plasmabrush procedure allows even such foils to be pretreated in order to optimize the adhesiveness of the connection.

High performance and simple to automate

The Plasmabrush system is available as both a stand-alone device and for easy, space-saving integration in assembly line and robot processes as well as in roll-to-roll procedures. The plasma beam permits processing speeds of up to 600 m/minute and, depending on the jet being used, a treatment width of up to 40 mm per jet. Partial or total treatment of the surface is possible depending on what the cleaning task requires. The central processor can control and monitor any number of plasma generators. The standard system also offers real-time performance measurement and gas flow monitoring.

About the Reinhausen Plasma GmbH

Also located in Regensburg, the Reinhausen Plasma GmbH is a subsidiary of Maschinenfabrik Reinhausen GmbH – the world market's technology leader in the regulation of power transformers. Reinhausen Plasma sees itself as an innovative provider of plasma solutions for surface refinement and coating. The company has set new standards in the purification and surface activation with plasma by its development of the cold.active, atmospheric pressure plasma tools – Plasmabrush and Piezobrush – which offer low temperatures, slow gas speeds, extremely good ability to enter cavities and high purity of the gases. For the first time, the patented plasmadust procedure makes it possible to directly coat and metallize 2 and 3-

dimensional components made from almost all materials without solvents (VOC-free) and with energy efficiency.

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We look forward to receiving a specimen copy or link to all publications including contents from this press release. Many thanks in advance.

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