

SURFACE TREATMENT

Atmospheric Plasma: A Cleaner Path to Better Adhesion

How atmospheric plasma helps manufacturers improve product performance while reducing chemicals, emissions and waste.

By Erik Kiel, President, 3DT LLC

Manufacturers today face increasing pressure to improve product quality while reducing chemical usage, emissions, waste and energy consumption. Atmospheric plasma surface treatment helps meet these goals by replacing traditional surface preparation methods with a clean, inline process that improves adhesion and production efficiency

without sacrificing performance.

Unlike solvent cleaning, primers or abrasive surface preparation, atmospheric plasma simultaneously cleans, activates and micro-etches a surface in a single pass. The result is stronger adhesion for inks, coatings, paints and adhesives while reducing scrap, rework and the environmental impact associ-

ated with conventional pretreatment methods.

Beyond improving adhesion, atmospheric plasma enables manufacturers to transition toward greener production by supporting water-borne and ultraviolet (UV)-curable inks and coatings, eliminating many chemical adhesion promoters while integrating seamlessly into automated manufacturing lines.

While atmospheric plasma offers significant advantages, selecting the right surface treatment technology always depends on the application. Corona treatment remains the preferred solution for continuous films, foils and flexible web materials because it efficiently increases surface energy over large areas at high production speeds. Atmospheric plasma complements corona treatment by providing enhanced cleaning, micro-etching and precise surface activation for three-dimensional parts, molded components, electronics, glass, composites and other applications where maximum adhesion and surface cleanliness are required.

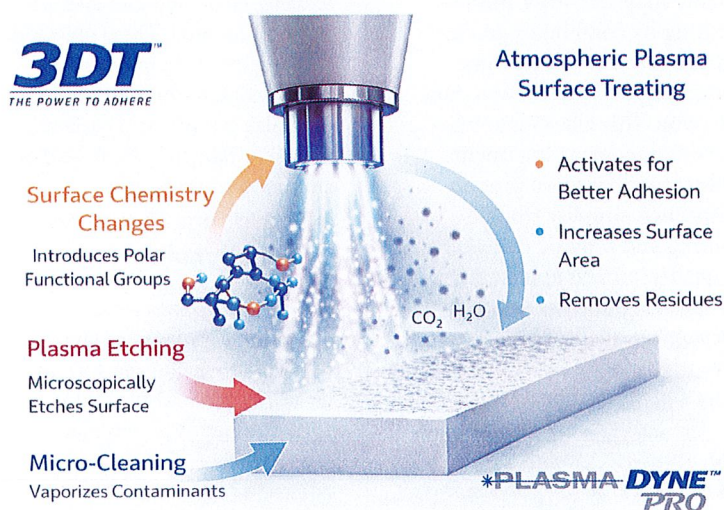


Figure 1: Three advantages of atmospheric plasma surface treatment. Image courtesy of 3DT LLC

Why Atmospheric Plasma?

Decorating, printing and bonding plastic parts begins with proper surface preparation. Many engineering plastics and polymers possess inherently low surface energy, making it difficult for inks, coatings and adhesives to wet out and bond effectively.

Atmospheric plasma addresses this challenge through three simultaneous processes:

1. Increases surface energy by modifying the material's molecular structure.
2. Removes organic contaminants such as mold release agents, lubricants and dust.
3. Micro-etches the surface to create additional bonding sites.

Together, these processes create a clean, highly receptive surface that produces stronger mechanical and chemical bonding while improving print quality, coating uniformity and long-term product durability. See Figure 1.

Atmospheric plasma is compatible with a wide variety of materials, including plastics, rubber, glass, composites, metals, foils and paperboard, making it an effective solution for many applications and manufacturing environments.

Improving Manufacturing Performance

For manufacturers, the benefits of atmospheric plasma extend well beyond improved adhesion. Because treatment occurs inline at atmospheric pressure, parts can be cleaned and activated during normal production without adding secondary cleaning operations. Eliminating separate pretreatment steps simplifies manufacturing, shortens production cycles and reduces handling.

Before Plasma Treatment



After Plasma Treatment



Figure 2: Contact Angle Results Before and After Treatment

Shown are the results of a surface analyzer test before and after plasma treatment. Note the reduced contact angle of a droplet of liquid from 83° to 23°, demonstrating a significant improvement in surface activation, cleaning and adhesion potential. Image courtesy of 3DT LLC

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Modern atmospheric plasma systems support Smart Manufacturing by combining precise digital control with real-time monitoring and production data collection. This allows manufacturers to document treatment performance, improve process consistency, simplify troubleshooting and provide traceability for quality-critical applications. The resulting process data can also support quality initiatives, preventive maintenance and continuous process improvement.

The result is higher first-pass yield, improved product consistency and greater confidence that downstream decorating or bonding operations will perform as intended.

Measuring Treatment Effectiveness

Successful surface treatment is verified by measuring how readily liquids spread across the treated surface. Contact angle testing provides a fast, quantitative method for evaluating surface activation and cleanliness.

As shown in Figure 2, plasma treatment reduced the contact angle of a water droplet from 83° to 23°, demonstrating a significant improvement in wetting characteristics and adhesion potential. These objective measurements help manufacturers validate their processes, optimize treatment parameters and maintain consistent quality throughout production.

Atmospheric Plasma vs. Conventional Surface Preparation

Traditional surface preparation methods — including solvent cleaning, grit blasting, flame treatment and vacuum plasma chambers — can improve adhesion but often introduce additional process steps, higher operating costs or environmental concerns.

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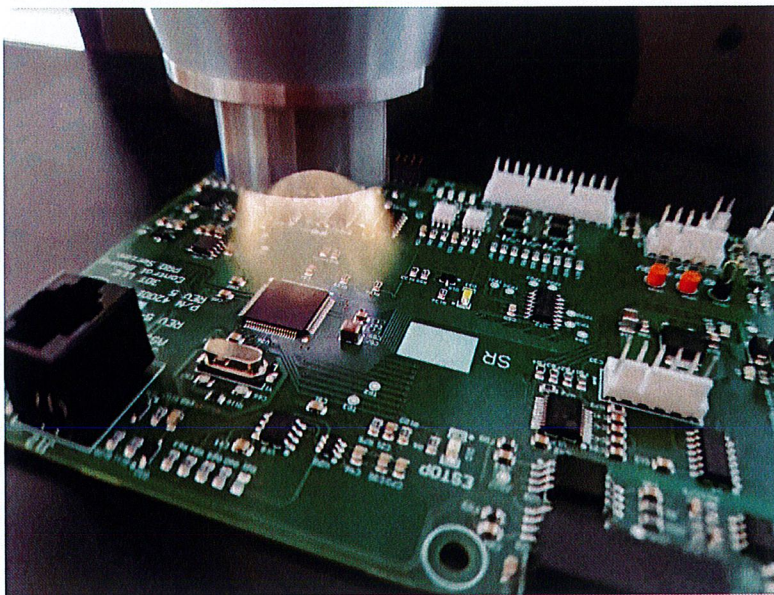


Figure 3: Manufacturers of printed circuit boards (PCBs) use plasma treating to clean dust, flux and residue from boards and connectors before applying conformal coating. *PlasmaDyne Pro* image courtesy of 3DT LLC

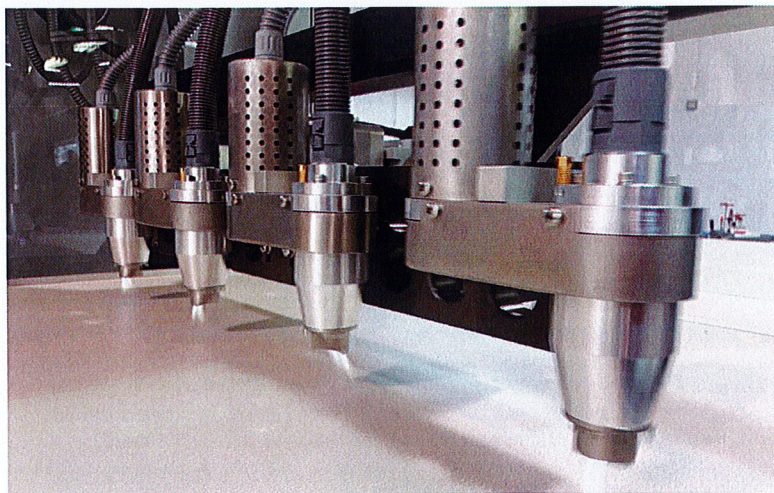


Figure 4: Four PlasmaDyne Pro rotating treatment heads mounted on a linear actuator above a conveyor provide inline atmospheric plasma surface treatment and cleaning of wide, flat materials. *Image courtesy of 3DT LLC*

Atmospheric plasma combines cleaning and surface activation without chemicals or abrasives. Since the process operates at atmospheric pressure, it integrates easily into automated production

lines while maintaining high throughput.

Unlike flame treatment, atmospheric plasma offers precise, repeatable process control. Treatment levels can be adjusted and

monitored digitally, helping manufacturers achieve consistent results while consuming less energy.

Atmospheric plasma is also potential-free, allowing conductive materials such as metal foils, electronic assemblies and printed circuit boards to be treated safely — applications where conventional corona treatment is generally not suitable.

The most effective surface treatment technology depends on the application. Corona treatment excels on continuous web materials, while atmospheric plasma offers additional cleaning and surface modification capabilities for complex geometries, conductive substrates and applications requiring the highest levels of surface preparation.

Supporting Greener Manufacturing

As manufacturers pursue sustainability initiatives, atmospheric plasma offers environmental benefits that extend throughout the production process. Because plasma is a dry, non-chemical technology, it eliminates or significantly reduces the need for solvents, primers and other chemical adhesion promoters that generate hazardous waste, VOC emissions, and work-place health concerns.

Improved adhesion also supports the use of water-borne and UV-curable inks and coatings, helping manufacturers adopt lower-emission decorating processes without compromising adhesion or product quality.

Plasma technology also means fewer rejected parts, less rework and reduced material waste. Combined with lower energy requirements than many conventional surface preparation methods,

atmospheric plasma helps manufacturers improve both operational efficiency and environmental performance.

Selecting the Right Plasma System

Because every production process and material are different, achieving these benefits begins with selecting the right equipment supplier. An experienced supplier should evaluate the specific application, perform laboratory testing to verify treatment effectiveness, provide documented results, and collaborate closely with your team to engineer a system that meets all criteria and integrates smoothly into the production environment. For many manufacturers, truly

custom, complete turnkey systems that include automation, product handling and process integration deliver the greatest long-term value.

When evaluating the plasma system itself, look for intuitive programming, modular design and Smart Manufacturing. Variable plasma discharge adds flexibility for treating different parts and materials with one system. Equally important are reliable service, responsive technical support and readily available replacement parts to ensure years of dependable operation.

Conclusion

Atmospheric plasma has evolved beyond a surface treatment

technology into a practical manufacturing tool for improving both production performance and sustainability. By replacing other surface preparation methods with a clean, digitally controlled inline process, manufacturers can improve adhesion, reduce waste, lower emissions and produce high-performing products. ■

ABOUT THE AUTHOR

Erik Kiel is founder and president of 3DT LLC. For more than 35 years, he has led the company with a commitment to innovation, quality and customer-focused solutions. Under his leadership, 3DT has become a pioneer in corona and atmospheric plasma surface treatment technology. Visit: www.3DTLLC.com

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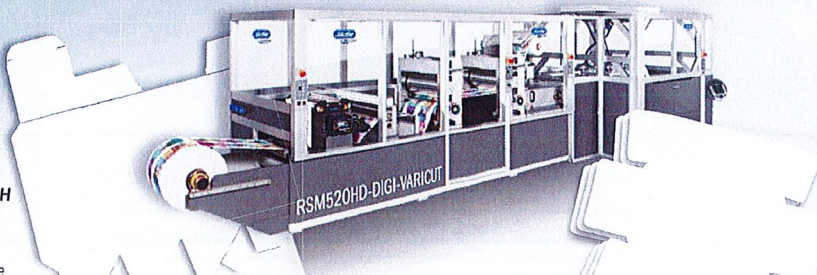
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