# Atmospheric Plasma Treatment Prior to Conformal Coating

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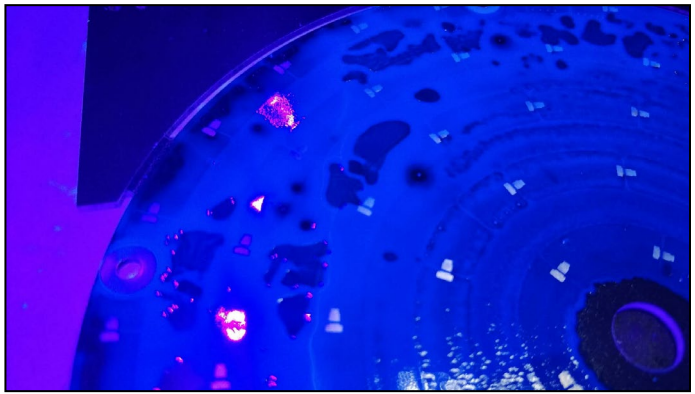
# Outline/Agenda

- Introduction
- Test Vehicle
- Electrical Discharge
- Dyne Testing
- Contact Angle Testing
- Test Procedure & Results
- Conclusion
- Further Work
- Acknowledgements
- Q & A

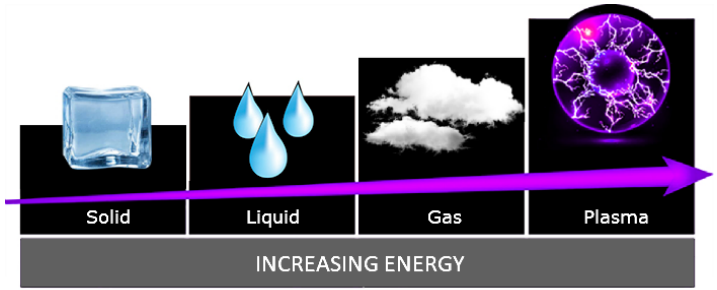
# Introduction

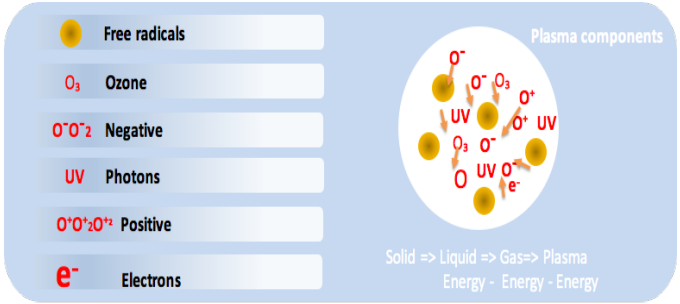
- Many PCB's require environmental protection or conformal coating.
- Contamination is a major cause of defects such as dewetting and delamination in conformal coating.
- Dewetting, delamination and bubbles can occur when the surface energy of the substrate is lower than the surface tension of the coating.
- Plasma Cleaning removes contaminates and increases surface energy.



# Introduction

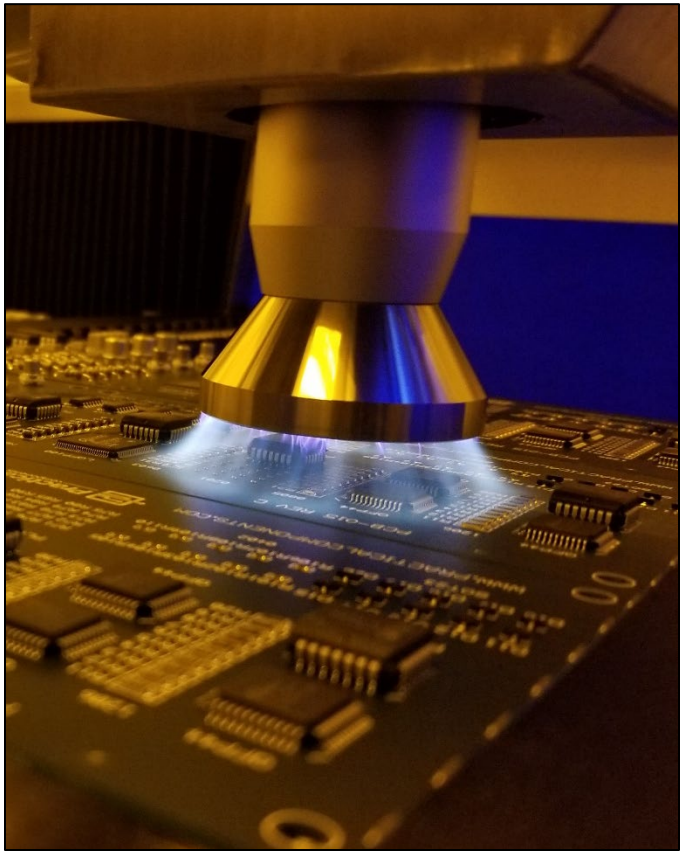
- Plasma is generated by combining a gas with an increased amount of energy
- The gas becomes charged with freely moving electrons in both positive and negative state
- Neutral gas atoms, positive ions, UV light and other excited gas molecules and atoms are packed with loads of internal energy
- Plasma Treatment is initiated when this energy comes into contact with the substrate surface



# Test Vehicle

- Gantry Robot Workcell
- X, Y, Z Motion Control
- Inline System (with conveyor)
- 500-Watt Plasma Generator
- 50mm rotary nozzle
- Workcell similar to selective conformal coating robots.



# Electrostatic Discharge

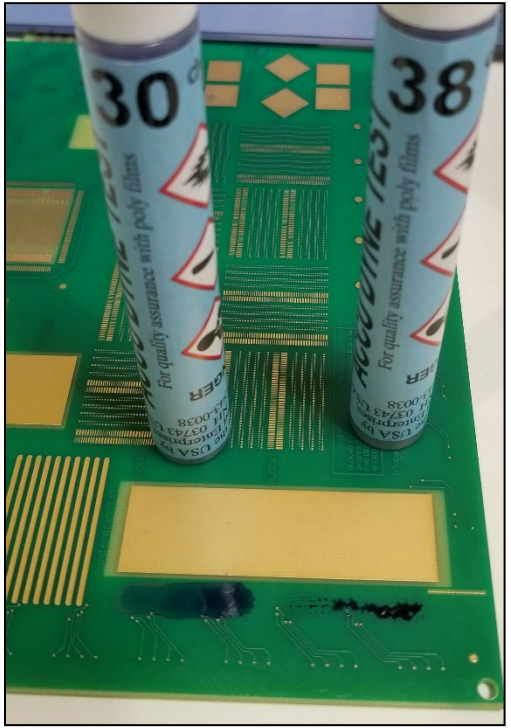
While plasma is produced under high voltage discharge, Plasmas are electrically neutral.

To demonstrate that Plasma is safe for use on sensitive electronics, an Electrostatic Field Meter was used. No ESD concerns were found.

# Dyne Marker Testing


- Relatively Inexpensive.
- Easy to Use.
- Measures surface tension of the substrate.
- 22 Standard dyne levels, from 30 to 72 dynes/cm, all formulated from 100% reagent grade materials.

# Dyne Marker Testing



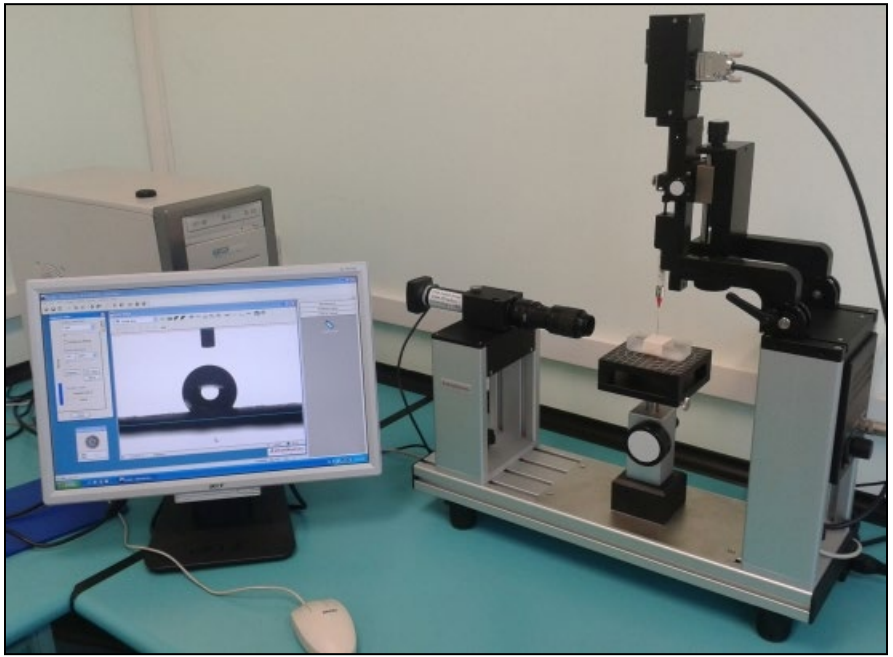

Prior to Plasma Treatment


After Plasma Treatment

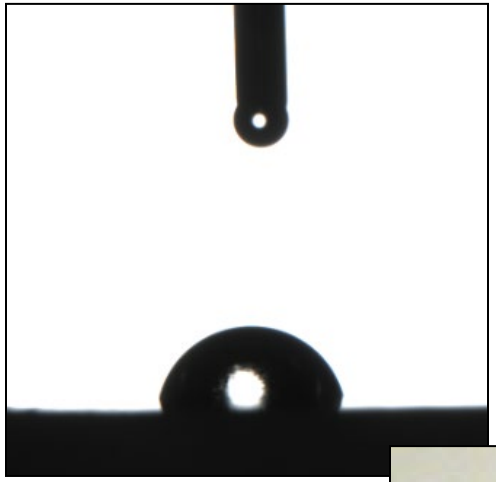
# Contact Angle Testing

The contact angle is the angle, conventionally measured through the liquid, where a liquid–vapor interface meets a solid surface. It quantifies the wettability of a solid surface by a liquid via the Young equation.

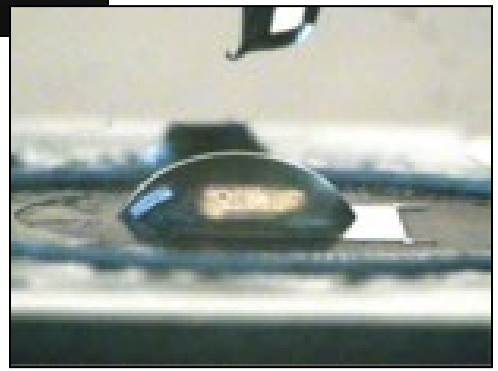
A high contact angle indicates the substrate is hydrophobic while a low contact angle indicates the substrate is hydrophiling. For strong adhesion of conformal coatings and other adhesives, a low contact angle is desired. Opposite of dyne marker testing where a higher number is desired.

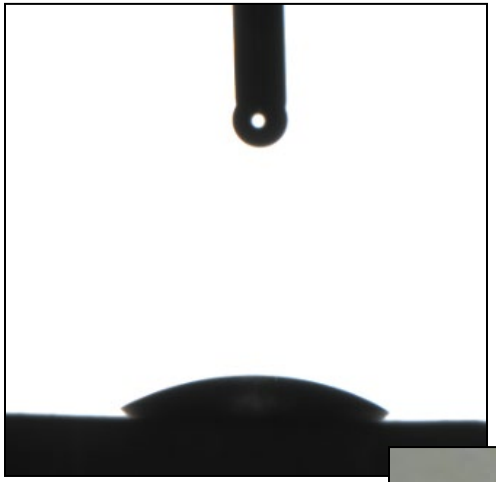


# Contact Angle Testing

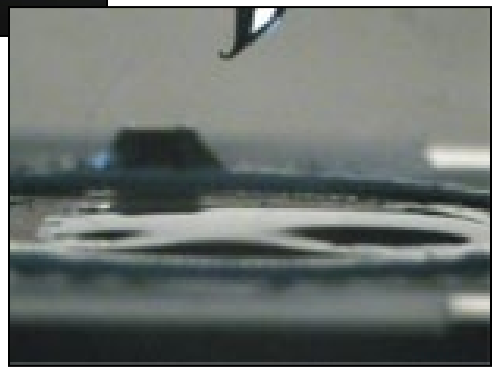


Before Plasma Treatment





After Plasma Treatment



# Contact Angle Testing

Treatment analysis was conducted to determine the optimal atmospheric plasma treatment processing speed. Using the same 50mm, rotating plasma nozzle, both dyne and contact angle measurement were conducted before and after plasma treatment. All samples failed 38 dyne/cm testing but passed 30 dyne/cm prior to plasma treatment. The chart below illustrates the contact angle test results:

| Speed | Temperature | dyne/cm | | | Contact Angle | |
|---|---|---|---|---|---|---|
| | | 34 | 38 | 72 | Before | After |
| 50mm/s | 93C | Pass | Pass | Pass | 82.7 | 6.65 |
| 100mm/s | 72C | Pass | Pass | Pass | 84.2 | 8.64 |
| 150mm/s | 60C | Pass | Pass | Fail* | 81.6 | 20.94 |

*Pass at 68 dyne/cm

# Contact Angle Testing

**Goals of the initial testing:**

- Less than 15 degrees contact angle
- Greater than 72 dyne per centimeter.
- Minimize temperature rise

*Based on the initial testing, it was determined that the optimal treatment speed is 100 millimeters per second.*

# Contact Angle Testing

Given enough time, the surface energy (and resulting wettability) of the treated substrate will return to the untreated state. Because of this, it was decided to perform additional testing to determine the time limit for next step processing, such as Conformal Coating.

# Contact Angle Testing

Ten samples were treated with Atmospheric Plasma with post-treatment results recorded almost immediately after treatment, as well as at twenty and forty minutes intervals post-treatment.

The results of this testing are shown on the next slide.

# Contact Angle Testing

| | ~2 minutes | ~20 minutes | ~40 minutes |
|---|---|---|---|
| Sample 1 | 7.516 | 12.824 | 20.486 |
| Sample 2 | 8.468 | 16.682 | 28.519 |
| Sample 3 | 13.341 | 15.951 | 22.498 |
| Sample 4 | 10.797 | 13.326 | 18.04 |
| Sample 5 | 8.063 | 14.817 | 23.118 |
| Sample 6 | 6.928 | 13.081 | 20.486 |
| Sample 7 | 7.946 | 17.294 | 29.179 |
| Sample 8 | 8.085 | 17.008 | 27.547 |
| Sample 9 | 6.803 | 13.065 | 29.135 |
| Sample 10 | 7.503 | 14.487 | 23.686 |
| **Average** | **8.545** | **14.854** | **24.269** |

# Contact Angle Testing

**Findings of effectiveness vs. time:**

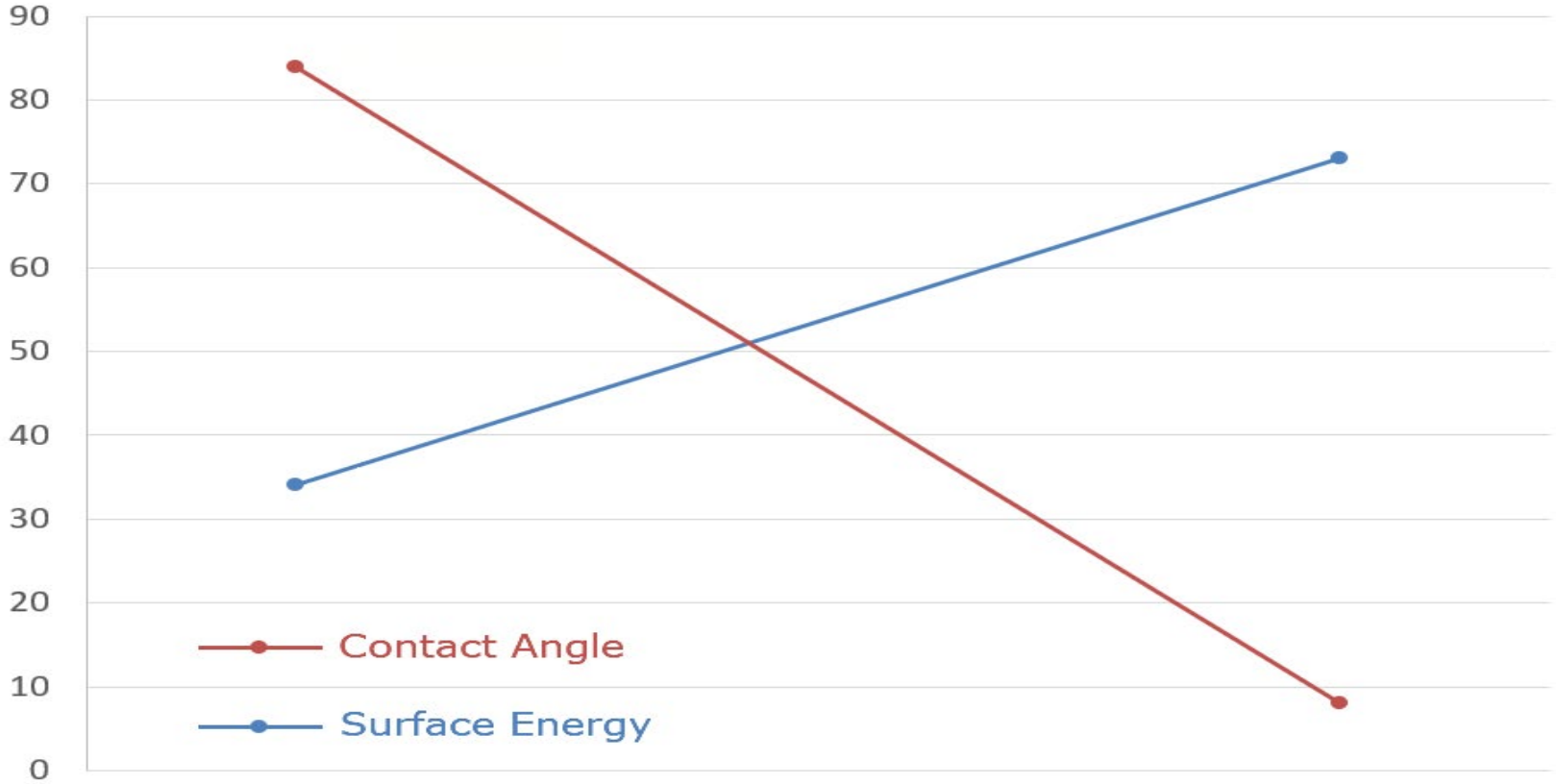
- Post Processing should occur as soon as possible after plasma treatment
- Acceptable window is approximately 20 minutes

Typical tact times in an automated conformal coating process line are short, often measured in seconds rather than minutes. Even when processing complex assemblies, time between atmospheric plasma treatment and conformal coating can be maintained to far less than twenty minutes.

# Conclusion

- Surface Energy Increased by Greater than 40 dyne/cm
- Contact Angle Decreased by Greater than 70 degrees
- Plasma Cleaning removes contaminates and increases surface energy
- High Surface Energy promotes flow or “wetting” of the adhesive
- The higher the surface energy, the greater the strength of adhesion
- Atmospheric Plasma Treatment can be inserted inline with other manufacturing equipment such as prior to a Selective Conformal Coating Workcell.
- Atmospheric plasma treatment allows for a next-step process window of up to 20 minutes

# Conclusion



# Future Work

Future work will require additional testing to include:

- Automated Optical Inspection (AOI/ACI)
- Adhesion testing of the applied conformal coating.
- Analyzing adhesion strength of different coatings such as Silicones, Acrylics and Urethanes.
- Examining the feasibility of atmospheric plasma treatment on real world printed circuit assemblies, particularly those with component heights that exceed the effective reach of the plasma nozzle.

# Acknowledgements

For the time and effort spent on running equipment and gathering data for this report, the author wishes to thank:

- Yao Yong Li, Dongguan ANDA Automatic
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- Jacky So, ANDA Automation Hong Kong

# Thank You!

*Optional -*

- **Speaker contact info** (click to insert)
- **Brief speaker bio**