Nordson
ELECTRONICS SOLUTIONS

Case Study

# Precise Underfill Success: Global Semiconductor Leader Surpasses 99% Yield with Nordson

## BACKGROUND

In this application, we worked with a global semiconductor leader in power systems and loT who provides solutions for green and efficient energy, clean and safe mobility, and secure loT.

The manufacturer approached Nordson to support a challenging capillary underfill application for two types of components: a Gallium Nitride (GaN) semiconductor and a driver circuit.

The GaN package required the most extensive experimentation of the two package types to achieve the desired results.

This case study focuses on the process used to ensure successful capillary underfill results for the GaN package, which required dispensing material into a 300-µm gap between two packages to achieve a nearly void-free underside encapsulation.

Precise dispensing, control, and uniformity were critical to fulfill the application objectives, ensuring the package's structural integrity, electrical connectivity, and stability under thermal cycling and mechanical stress.

All illustrations represent actual results, are used for illustrative purposes only, and are not an exact representation of the customer part.

**Acknowledgments**

We thank our colleagues Ehan Umapathy, Application and Service Technician; Ernel Avila, Application Manager EPS SEA; Jayaraj Kannan, Applications and Service Engineer; and Jose Rebua Llarena, Applications and Service Engineer, for their insight and technical expertise, which made this case study possible.

## GaN PACKAGE DETAILS

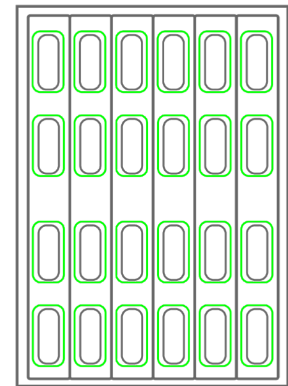
| | |
|---|---|
| Package size | 5 mm x 6 mm x 0.9 mm |
| Die size | 2.616 mm x 4.336 mm |
| Die thickness | 0.3 mm |
| Minimum bump pitch | 0.17 mm |
| Bump metallurgy | SAC solder bump |
| Solder bump dimension | 0.2 mm x 0.6 mm x 0.179 mm |
| Number of bumps | 24 |
| Underfill material | Loctite® Eccobond UF 8830S |

## CHALLENGE

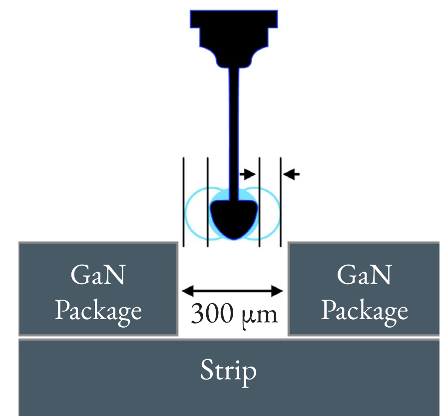
In addition to the precise dispensing requirements, a unique challenge involved voids in the underfill material, which contributed to short circuits in the GaN package. Conductive flux residue between the solder bumps and inside the voids created unintended electrical paths between the solder connections, negatively impacting yield and total cost of ownership (TCO) outcomes.

The application goals were as follows:

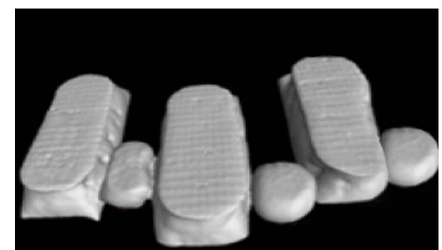
- Remove flux residue.
- Dispense with high precision into a 300-µm gap
- Achieve complete underfill encapsulation
- Deliver uniform and consistent fillet formation with a maximum flow out of < 0.7 mm from the package edge.
- Prevent the occurrence of voids.



GaN package bump layout.




Highly precise placement accuracy.



Conductive flux residue between the solder bumps.

Nordson
ELECTRONICS SOLUTIONS

Case Study

## PROCESS EQUIPMENT

The Nordson applications team selected the ASYMTEK Forte® Series and IntelliJet® jetting system to ensure exceptional fluid dispensing productivity and accuracy for this high-volume application. The MARCH AP-1000™ plasma treatment system was also used for plasma cleaning before dispensing.

### Recommended Equipment

- Forte Series precision dispensing system
- IntelliJet Jetting System – single valve
- Nano 1450 camera
- Precision scale
- Substrate heater
- High-flow vacuum chuck
- Picture frame to secure pre-heated strips
- AP-1000 plasma treatment system

Forte Series Precision Dispensing System

IntelliJet Jetting System

AP-1000 Plasma Treatment System

Nordson ELECTRONICS SOLUTIONS

Case Study

## APPLICATION DEVELOPMENT

The manufacturer provided several 140 µm strips with the GaN packages and the driver circuit for testing purposes. During testing, the team worked with the following factors to meet the application requirements:

| Factors | Customer Requirements |
|---|---|
| Plasma cleaning and pre-bake | Eliminate flux residue. |
| Underfill encapsulation | Full encapsulation and consistent fillet formation. |
| Flow-out control | < 0.7 mm from the package edge. |
| Void occurrence rate | 0 |

### Plasma Surface Treatment

Each strip underwent a pre-bake and plasma surface treatment to address the flux residue issue before the underfill dispensing process.

Plasma treatment removes more than flux residue. Various contaminants can remain on package surfaces, causing unpredictable performance. Plasma treatment benefits the underfill process by increasing wicking speed, improving underfill adhesion and encapsulation results, enhancing fillet height uniformity, and minimizing voids for optimal quality control and circuit performance.

### Capillary Underfill

With flux residue addressed, the application team focused on the underfill process. In capillary underfill applications, a precise volume of underfill material is dispensed along the side of a chip or package to flow underneath through capillary action, filling air gaps around solder bumps that connect the chip package to the substrate.

Every underfill application is unique. Factors such as fluid type, dispense height, placement accuracy, preheat temperature, cartridge type, nozzle temperature, valve frequency and settings, dispense orientation, the number of passes, and the dot weight per part all combine to deliver void-free underfill encapsulation results with consistent fillet formation. As the team aligned the various process parameters, they also worked to optimize the cycle time and avoid quality issues such as potential contamination caused by splashing fluid.

### Process Overview

- Plasma clean and pre-bake the strips.
- Determine the ideal dispense location, direction, volume, and number of passes.
- Pre-heat the strips.
- Dispense and cure.
- Perform void inspection.

## SOLUTION DETAILS

Initially, the Nordson applications team dispensed underfill material vertically along the edge of the GaN packages. However, they observed fluid splashing, outgassing on all four die sides, and flow-out encroaching on neighboring components.

Through subsequent tests, the team determined that the best approach was to dispense horizontally along the edge of the GaN package. To ensure dispensing accuracy in this narrow-gap application, a high-flow vacuum chuck was introduced to secure the high-temperature pre-heated strips.

In addition to the dispensing orientation and equipment refinements, the table details the final process parameters the Nordson applications team used to deliver a yield of more than 99% in this application.

| Process Parameters | Process Recommendations |
|---|---|
| Strip pre-heat temperature | 120C |
| Pre-bake | Yes |
| Plasma clean | Yes |
| Cartridge type | RT-01 |
| Nozzle temperature | 57C |
| Valve settings | Frequency: 600Hz<br>Valve on-time: 0.7<br>Valve stroke: 70 µm<br>Fluid pressure: 10 psi<br>Open rate: 0.25<br>Close rate: 1 |
| Fluid weight (x2 GaN) | 4 mg |
| Dot weight | 2.2 – 2.4 µg |
| Dispense gap | 0.8 mm |
| Dispense passes | 4 |
| Cycle time | 720 seconds |

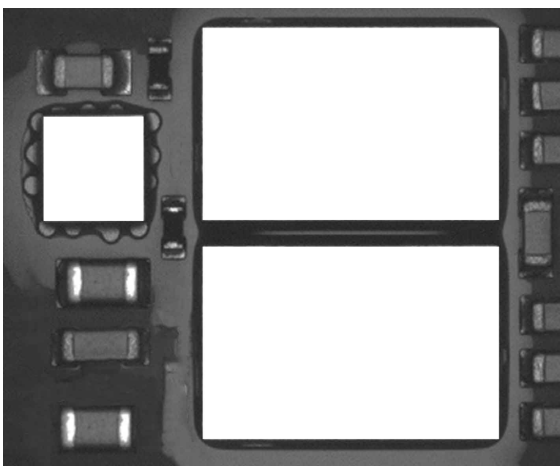
Nordson
ELECTRONICS SOLUTIONS

Case Study

## SOLUTION DETAILS CONTINUED

After applying the process recommendations, the applications team tested and validated their findings. The table below details the progressive test results that produced a greater than 99% yield in this application.

| Final Test Results | Void Occurrence | Yield |
|---|---|---|
| Strip 1 | 1.05% | 98.95% |
| Strip 2 | 2.83% | 97.17% |
| Strip 3 | 0.00% | 100.00% |
| Strip 4 | 0.00% | 100.00% |
| Strip 5 | 0.00% | 100.00% |
| | **AVERAGE = 0.78%** | **AVERAGE = 99.22%** |



- Free of flux contamination for better yield.
- Complete encapsulation and uniform fillet formation on all sides of the package.
- Flow-out controlled at < 0.28 mm from the package edge.
- Average void occurrence rate 0.78%

Discover how Nordson can optimize your process. For more information, visit our website to find your local regional office or representative.

We have several global locations to serve you.