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CASE STUDY

Encapsulating Wearable Sensors Using a Pre-Mixed Two-Part Epoxy Product

How the combined expertise of fluid dispensing leader ***Nordson EFD*** and specialty adhesive manufacturer ***Master Bond*** ensured an optimal manufacturing process

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The growing field of wearable medical technology relies heavily on miniaturized sensors capable of providing accurate and continuous physiological data. Ensuring the long-term reliability and performance of these sensors — often subjected to demanding conditions including physical stress, thermal fluctuations, and exposure to bodily fluids hinges on robust manufacturing processes. A critical aspect of this manufacturing involves the precise application of biocompatible adhesives for encapsulating delicate sensor components.

This case study examines the selection and implementation of a non-cytotoxic adhesive chosen for its ability to encapsulate sensors from harsh environmental factors such as humidity, dust, and mechanical impact. It will also explore the automated dispensing equipment utilized to achieve the accuracy and consistency required for the scalable production of these advanced medical devices. To ensure that the manufacturing process was optimized, the combined expertise of fluid dispensing leader Nordson EFD and specialty adhesive manufacturer Master Bond were critical for producing high-quality wearable sensors.

Material and Dispensing Requirements

The product selected for this encapsulation process needed to meet several key requirements to ensure its effectiveness and compatibility with this wearable sensor. The sensor required a low-viscosity epoxy with capillary flow characteristics that enabled easy and precise dispensing. It was critical that the material flowed easily around the sensor components and filled intricate spaces without leaving voids.

The material also needed to be curable below 80°C, to prevent heat-sensitive electronic components from being damaged. Optical clarity was another key requirement. Additionally, a non-cytotoxic encapsulant was a must to ensure safe use when it encountered the skin or the human body. Finally, the dispensing process had to be automated, capable of dispensing approximately 3cc of the material per sensor consistently.

Material Solution: EP21LSCL-2Med

Master Bond's EP21LSCL-2Med, a two-component epoxy adhesive, met the overall application requirements. This product's ISO 10993-5 non-cytotoxicity rating meant that it was easier to qualify for the wearable sensor.

EP21LSCL-2Med was also engineered for low-temperature heat curing, allowing it to fully cure at temperatures below 80°C. This was instrumental in protecting the integrity of the sensitive electronics within the wearable device. One of the adhesive's standout properties was its low mixed viscosity, measured at 500–1000 cps at room temperature. This made it highly suitable for capillary action, helping the adhesive flow easily, which ensured that the intricate spaces were properly filled with no voids.

The material was packaged in pre-mixed and frozen syringes, delivered in 3cc Nordson EFD syringes, making the process highly efficient and reducing waste.

The Master Bond EP21LSCL-2Med fluid was shipped in a temperature-controlled box and stored at -40°C until use.

To maintain product integrity, the syringes were shipped in dry ice and stored at –40°C until use. Operators could simply thaw and load the syringes into Nordson's dispensing system, streamlining the workflow and minimizing handling errors.

Packaging / Equipment: Dispensing Solutions for Wearable Sensor Manufacturing

Nordson EFD offers several fluid dispensing solutions for effectively encapsulating wearable electronics. The company's broad selection of fluid dispense solutions enables manufacturers to choose the right technology for their unique application needs.

Because the Master Bond EP21LSCL-2Med has a working life of 6-8 hours, this informed the dispense solution selection for the application. The working life of a fluid is the amount of time before the epoxy becomes too thick to be applied. An additional consideration for fluid dispensing technology selection was that once the Master Bond compound was thawed to room temperature from the -40°C freezer in the manufacturing process, it could not be re-frozen.

To meet the requirement for the material to flow easily around the sensor components and fill the intricate spaces without leaving voids in the application, a fluid dispenser, valve, automation, cartridge, and tip technologies were recommended to the manufacturer.

Master Bond fluids were shipped frozen and after thawing offered 6-8 hours of working life.

To maximize the usage within the Master Bond EP21LSCL-2Med's working life, Nordson EFD engineers recommended using the Ultimus V high precision dispensers. This solution provided a high-precision benchtop fluid dispensing control for the manual or automated application of fluids that change viscosity. Thus, as the viscosity of the epoxy changes, the full electronic press regulation feature kept the critical fluid dispensing processes consistent from start to finish.

The Ultimus V benchtop fluid dispensing solution featured a full electronic press regulation that benefited manufacturers with consistent dispensing as the viscosity of the epoxy changes.

The Ultimus V fluid dispensing solution was recommended because the shot size stays consistent regardless of changes in viscosity in the EP21LSCL-2Med. To maintain the accuracy required for the application, the Ultimus V solution offered electronic control of the dispensing time, air pressure, and vacuum. The Ultimus V fluid dispense solution adjusts to the viscosity of the fluid — once programmed the air pressure automatically adjusts as the fluid gets thicker. Alternatively, if the pressure required is less than 5 PSI, the Ultimus II is a better choice.

The Nordson EFD Ultimus II fluid dispensing solution is an excellent option for manufacturers dispensing epoxies at less than 5 PSI.

If larger volume is required (30cc or more), an xQR41V Series needle valve can be an alternative to avoid full-to-empty variation issues. The design of the xQR41V allows for quick fluid change over and easy cleaning of wetted parts at the end of the shift. The needle valve features a patented quick release clasp, enabling fast and easy servicing in the field. In addition, the low level of fluids retained in the fluid body reduces fluid waste, and the reduced form factor of the solution increases production capacity.

After benchtop testing was successful, in order to meet the longer time requirement for automated dispensing, Nordson EFD advised that the customer use the EV Series of tabletop automated dispensing systems. The automation system offered easy integration into the customer's manufacturing operations.

The xQR41V series needle valve provides a proven choice for manufacturers that require 30cc or more of epoxy for higher volume applications.

The Nordson EFD EV series of tabletop automated dispensing systems offered easy integration into the customer's manufacturing operations.

The consistent application of the fluid was maintained by using Nordson EFD for general purpose orange or red stainless-steel tips. The orange tip is 23 gauge and has an inner diameter of 0.33 mm/0.013". This tip is most optimal when the material is applied manually. The red tip is 25 gauge and has an inner diameter of 0.25 mm/0.010". This tip is more suited for automated processes.

Nordson EFD uses a laboratory-focused approach to recommending fluid dispensing technologies — evaluating fluids, substrates, application goals and production needs to provide a consultative approach to selecting the right solution for your needs. The Nordson EFD technical services professionals can assist you with your unique production challenges – click here to learn more.

Minimizing Air Bubbles for Pre-mixed and Frozen Packaging

One of the most common challenges in dispensing epoxy adhesives is the presence of air bubbles. To address this, Master Bond implemented rigorous degassing protocols during the packaging process. After mixing the two components of the EP21LSCL-2Med, the formulation underwent centrifugation at 2000–3000 rpm for 1–2 minutes. This critical step effectively removed entrapped air and reduced the risk of voids during application. This degassed mixture was immediately frozen. By packaging the adhesive in 3cc EFD syringes, Master Bond enabled the end user to apply the epoxy with high precision and confidence, knowing that each syringe contained a uniform, bubble-free material ready for automated dispensing.

This method not only eliminated the need for on-site mixing, a process prone to variability and contamination, but also dramatically improved production uptime and consistency. It was a seamless integration of materials science and process engineering, ensuring that the encapsulant performed flawlessly in a demanding medical application. Master Bond's motto is always to help engineers and end users alike meet specific adhesive application requirements – click here to learn more.

Minimizing Air Bubbles While Dispensing

Since the frozen fluid thaws at a different rate than the packaging it is contained in, Nordson EFD reminded the customer not to rush the process and carefully thaw the syringes to avoid creating air bubbles, known as freeze thaw voids (FTVs).

To absolutely ensure no air pockets after thaw, EFD recommends centrifuging the material for 1-2 minute prior to usage. For this application, the manufacturer used the ProcessMate 5000 Universal Centrifuge.

Using a centrifuge system like the ProcessMate 5000 Universal Centrifuge is a proven way to ensure no air pockets exist after thawing the epoxy used in this application.

Conclusion

The collaborative application of Master Bond's innovative pre-mixed and frozen epoxy alongside Nordson's best in-class dispensing technology proved instrumental in the customer's success in manufacturing their wearable sensor solution. This synergy effectively addressed the challenge of air bubble elimination, which ensured that the encapsulation process was state of the art. The sensors were fully secured and offered the highly protective capabilities required in the application.

Have a dispensing question you'd like us to answer?
Don't hesitate to submit your question or comment at info@nordsonefd.com

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About the Authors

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