Perspectives On Miniaturization (Part II)

In last month's *Perspectives*, the experiences of industry experts in facing the challenges of miniaturization of medical devices and their components was shared. Due to the overwhelming response to this question, *MDT* is pleased to present a "Part II" to the topic, extending the coverage of this obviously very hot topic.

Q: In the effort to make medical devices smaller, what has been the most challenging obstacle you have faced, and how were you able to resolve it?

Ely Zofan,

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Director of Engineering, Challenge Electronics

As with many high-tech trends, miniaturization spawns great innovation. However it often involves great challenge. This is particularly evident in the area of audible alarms where design challenges magnify as open real estate on end products shrinks.

Often, the barriers are physical. To output significant volume, an alarm needs to move air across a desired distance. Smaller devices move less air and do not generate the desired effect or signal strength. Human hearing is another consideration. Sonic reception deteriorates with age, particularly within higher octaves. Since smaller piezoelectric transducers or alarms produce higher signal frequencies, their sound may go unheeded, which can have dire consequences in a healthcare application. Sound vibration also increases kinetic stress on SMD solder connections, which can prevent the device from sounding properly&#151an equally serious issue in many healthcare settings.

We at Challenge Electronics have resolved these issues by enhancing the sound pressure level at the manufacturing level. This requires careful tuning of the sound chamber, followed by higher-fidelity adjustment and testing. Sound output is also optimized by controlling the driving circuit of the transducer, or, in the case of piezoelectric alarms, by raising the output voltage of the diaphragm with coils or transformers. In such instances, coils or transformers need to match the impedance of the piezoelectric element at resonant frequency which can be ten times lower than any other frequency.

To reduce resonant frequency, our engineers in some products mount the sound diaphragm on its edges instead of the traditional Nodal mount. This conserves premium space and reduces resonant frequency anywhere from 100 to 800 Hz. Other options include the use of larger, thinner diaphragms made with softer metals such as nickel alloy vs. the traditional brass or stainless steel variations.

To ensure long-term reliability, certain manufacturers will recommend that SMD audible devices be glued and soldered to the printed circuit board. This alleviates vibration-related stress on the SMT solder pad.

For applications where loudness is a factor, end-product engineers should consult with a specialist who is fully equipped with the knowledge necessary to ensure quality and reliability. Sounding devices may be easily categorized as commodity products, yet not all parts are equal in terms of performance and compliance.

Peter Lambert,

Peter Lambert

President, EFD Inc.

As medical devices continue to pack more and more features into smaller and smaller packages, tolerances become tighter and tighter. This has made the ability to control the amount and placement of the adhesives, lubricants, solder pastes, and other assembly fluids used to build them more critical than ever before.

EFD has met this challenge through a combination of new product development and enhancements to our existing dispensing technologies.
For applications with uneven substrates or where a dispensing needle cannot be used, we have added a non-contact jet dispensing system that can make deposits as small as two nanoliters, at speeds up to 150 dots per second.
For precision coating applications, we combined technologies from two of our precision dispense valves and created a new microspray valve that is capable of producing consistent spray patterns as small as 0.0625 inches in diameter&#151over 60% smaller than those produced with our standard spray valve.
Some applications require very small, precise deposits of thick fluids like silicones and epoxies, which can be difficult to dispense through straight steel needles. To meet this need, we recently developed a 27 gauge tapered tip that can produce dots and lines as small as 0.008 inches wide, while providing a fast flow rate and reducing the risk of bubbles in the fluid.
We've also expanded our family of air-powered dispensers to include models that allow dispensing time to be adjusted in increments as fine as 0.0001 seconds, for exceptional accuracy and process control. These dispensers are available with full calibration certification, and we can also provide calibration kits for companies that have in-house labs.

Ed Slavetsky,

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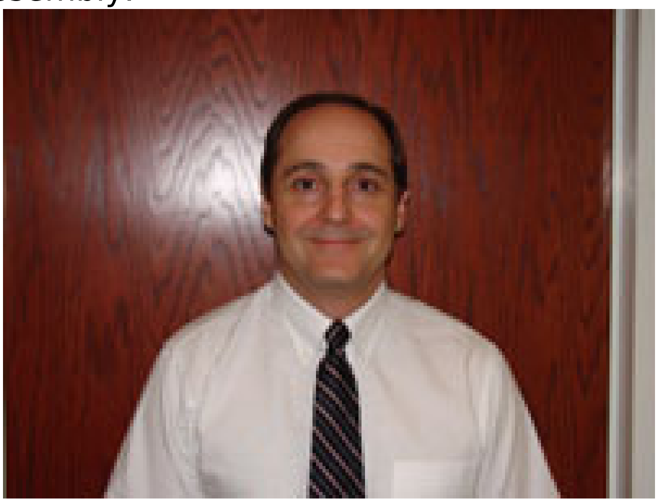
Market Research Analyst, Endicott Interconnect Technologies Inc.
Endicott Interconnect Technologies Inc. (EI) is recognized for our unique strengths in electronic device packaging. These include package substrate technology selection

of semiconductor devices and electrical/thermal/mechanical performance analysis, as well as the manufacture and assembly of these configurations. When our customer was trying to create the smallest possible electronic subsystem consisting of several large, high I/O flip chip ASICs to fit into an ultra-portable medical device, the challenge was brought to our engineering and manufacturing specialists. In addition to the unique spatial requirements with such a large number of interconnections, specifically challenging was the need to package them within extremely tight requirements for electrical performance. Factors involved included such items as low signal-to-noise ratios (SNR), low signal skew, and protecting high signal integrity from the crosstalk effects of high voltage pulses that would be present in the system.

EI's CoreEZ organic semiconductor substrate was selected as the perfect choice for this particular application. With its superior electrical performance capabilities and flexible design/materials/manufacturing/assembly ground rules, the strict skew specification between ASIC die could be maintained. By splitting one of the four available power planes, the high voltage pulsed power needs could be accommodated yet isolated from the noise-sensitive digital power distribution. Utilizing the high performance wiring ground rules of CoreEZ, the large I/O flip chip ASIC die could be wired out in such a way as to minimize the size of each assembled module. Taking advantage of the substrate's low loss material properties, the individually packaged die were stacked vertically to further minimize the entire subsystem size, and EI's thermal and mechanical packaging engineers supported the customer's system cooling scheme by providing modeling of the laminate subassembly.

John Folsom,



John Folsom

Senior Research Engineer, MicroMo Electronics Inc.

Miniaturization in the medical device market has caused a substantial reduction in the size of motors and gearheads that MicroMo's customers utilize. Our greatest challenge required providing encoding solutions in increasingly smaller packages. Ten years ago, our customers needed motors 15-22 mm in diameter with integral 10-16 count encoders. Today, our customers need motors 6-10 mm in diameter with 16-256 count encoders.

Several sensor manufacturers have recognized the need for smaller sensors capable of higher resolution. In the past, manufacturers provided sensors down to SO-8 size packages, but now provide sensors as dies or in chip-scale packages. MicroMo incorporates chip packages 2.0 &#215 3.0 mm to offer encoders from 16-64 counts in 6.0 mm diameter housings and 5.0 &#215 6.0 mm chip packages to offer 256 counts in 8.0 mm diameter housings.
Advances in sensor technologies allowed MicroMo to move away from multi-pole magnets. In addition to requiring expensive equipment and intensive labor, smaller multi-pole magnets proved difficult to produce with usable pole counts. Newer sensors coming to market (including those developed by the Faulhaber Group) interpolate signals developed from sine and cosine waves. These sensors only require single pole-pair magnets, which are inexpensive and readily available.
Beyond supplying better sensors, manufacturers provide more design assistance. Many now provide their expertise in housing design, molding, circuit-board design, magnetic design, and optical-wheel design. These manufacturers have assisted MicroMo over technical hurdles to make a better product using their technologies.
While MicroMo's customers have asked for increasingly smaller solutions, the sensor industry has kept pace providing better and more compact technologies. In addition, sensor manufacturers have shifted their focus from just being chip suppliers to being partners in applying the new technologies.

Chris Turner,

Chris Turner

Director of Battery Technology, Nexergy Inc.
The greatest challenge is meeting the requirement for increased run-time and performance in the small size required by medical device manufacturers. Medical devices require a battery that can deliver an unprecedented level of reliability and performance over an extended period of time, yet still be small enough to allow the device to be portable, accessible, and easy to use.

To increase run time, the battery must provide increased energy from the cells, and increased fuel gauge (battery charge indicator) accuracy. To achieve the space requirements, the size of the electronic circuitry needed to be reduced. Nexergy works with medical device designers to develop custom battery packs that can achieve these requirements.

Newer device designs incorporate lithium ion (Li-ion) batteries, which are a high energy density, reliable power source for medical devices. Now device designers are trending towards Li-ion prismatic and Li-polymer batteries, enabling the design of even smaller, longer running devices. These batteries offer capacity of 0.5 Ah to 3.0 Ah in a form factor as thin as two millimeters.Older fuel gauge accuracies can be off by as much as 25%. This inaccuracy led to a lack of confidence in the fuel gauge or premature low battery warnings. The result was the user recharging the battery prematurely and not getting the benefit of all the available capacity or runtime. Impedance tracking technology, which has an accuracy of 99%, reduces fuel-gauge inaccuracies by using a unique algorithm that allows for real-time tracking of the battery pack's critical information. It automatically takes into account charge and discharge rates, self-discharge, and the mechanisms of cell aging, which results in excellent gas-gauging accuracy over the entire life of the battery.

Increased fuel-gauge accuracy gives medical professionals the confidence to get the maximum run time from the device and, by using smaller components to incorporate protection functions previously provided by external technology, the battery doesn't require any more space. Coupling this with new cell technologies gives a significant increase in run time in a smaller package.

Dr. Alexander Knitsch,

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Application Manager, TRUMPF Laser GmbH + Co.
"The laser is a pioneer of miniaturization" is a common statement in medical production technology and the laser is already considered a state-of-the-art production tool in the medical device industry. Whether welding on endoscopic instruments, pacemakers, or neurosurgical implants, the laser generates seam welds from a width of 100 to 800 micrometers, fast and accurately. The laser marking of these devices can be even smaller. For example, a 20-digit data-matrix code on a 2 &#215 2 millimeter area emphasizes the performance of laser marking, and when it comes to laser cutting thicknesses from 0.1 to 5.0 mm in stainless steel, titanium, or other metals, cutting kerfs of some ten microns are covered.

The future design of medical devices demands not only smaller dimensions, but also new applications in the field of micro-processing, such as cutting, drilling, ablating, and structuring. This is where new short and ultra-short pulse lasers have great potential. Short laser pulses featuring less than 10 picoseconds, high peak power and extreme focusability characterize this new generation of micro-processing lasers. As a result, precise material removal with high reproducibility in the micron range, where the ablating process has only minimal, if any, heat input on the material, is achieved.

Applications in the medical device industry include drilling of blind holes in micro needles, and the engraving of pharmaceutical ampoules with data-matrix codes. By ablating in layers, thin-walled stents can be cut or structured. The high quality of the laser process with a no heat affected zone reduces rework and increases production efficiency. The functionality of surfaces by systematic laser structuring offers new possibilities in medical technology (e.g., improving the osteointegration of medical implants). Further applications are being developed, and once more, laser technology continues to enable technology for further miniaturization.