WHITEPAPER

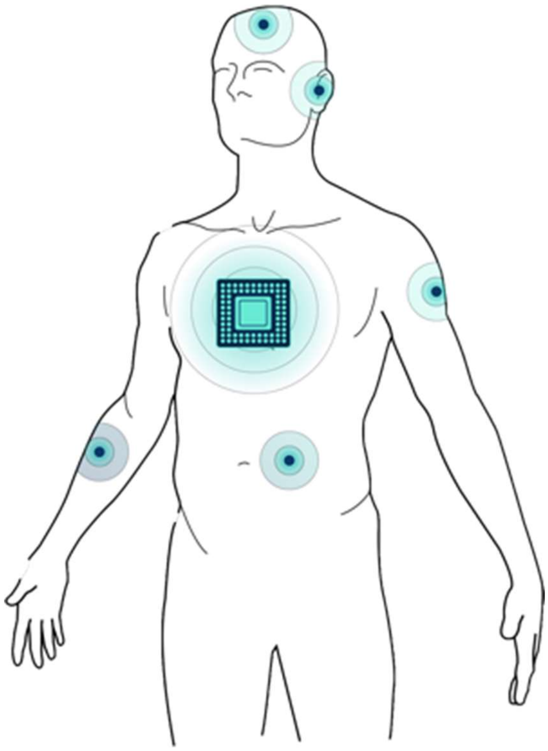
How to solve miniaturization issues in the medical industry

Introduction

Be it implantable devices such as pacemakers or neurostimulators, hearing aids or portable multi-parameter monitoring systems: High-end medical applications have to become smaller and smaller to make life as comfortable as possible for patients. At the same time, an improved form factor and ever-more space is needed for additional or more powerful components and new features to increase the functionality of such applications.

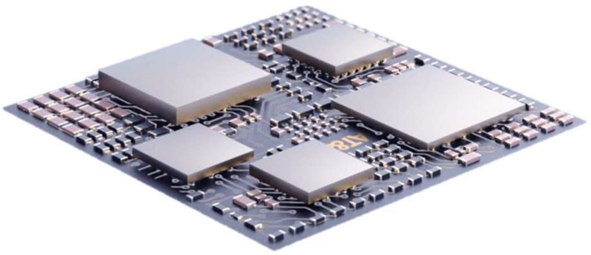
These needs result in conflicting goals for developers and manufacturers of high-end medical devices: Either the application becomes smaller, or it includes higher functionality but requires more space. But is it really the case that there has to be a trade-off when it comes to miniaturization? Or would it be possible to achieve both, miniaturization and an increase in functionality, at the same time?

The ways of scaling down medical applications are manifold, confronting developers and manufacturers with a variety of new challenges. Maximum stability and reliability have to be guaranteed, as do minimum energy requirements and the fastest data transmission. However, not just the product itself features a high level of complexity. The management and quality assurance of the supply chain are also time-consuming and involve costs that cannot be neglected.



1+1 equals more than 2

Miniaturization itself is no standalone solution to achieve the aforementioned results – but in combination with heterogeneous integration both smaller form factors and increased performance, can be achieved. In the case of medical applications, heterogeneous integration would combine the components for sensors, electronics, data processing, and power supply into one microsystem. With an optimized combination of technologies, materials and functionalities, it is possible to increase the system performance compared to the performance of the single components.



Heterogeneous Integration combines various components, thus making the complete system more powerful than just adding up the performance of each sub-component.

New PCB solutions help enable heterogeneous integration

In this context, the printed circuit board plays a crucial role as a carrier and connector for all the components. Modern printed circuit boards and interconnection processes create additional value, which entails numerous benefits for both the producer and the end-user.

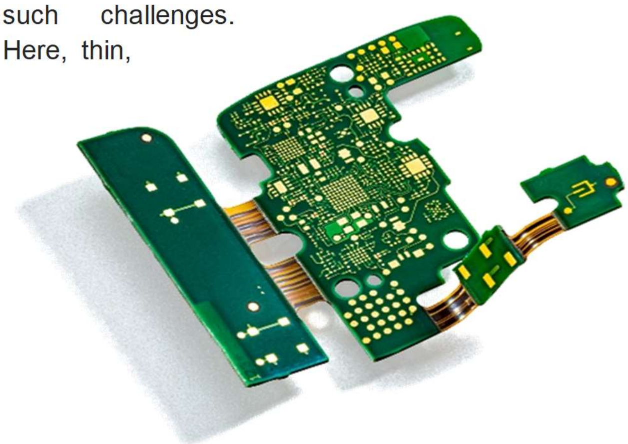
By combining different production technologies and processes, the printed circuit board itself becomes a high-tech component that is much more than just a carrier of microchips and sensors. When manufactures involve PCB specialists at an early stage of the design process, they can considerably short the development process, reduce time to market as well as save costs. Additionally, increased interconnection possibilities mean the end application offers more functionality, improved safety and a better quality of life.

Various technologies and solutions could be used to realize the benefits of miniaturization and heterogeneous integration. In this whitepaper, we want to put a spotlight on three of them and point out, how they could help you realize innovative medical applications.

Flexible & rigid-flex PCBs

Requirements regarding the miniaturization of printed circuit boards are rapidly increasing. A complex layer structure and constantly decreasing lines and spacing have enabled exciting developments over the past years. Although new technical processes are now possible as a result of **lines and spacing of 25 µm** (in comparison: an average human hair is between 60 and 80 µm on average), sooner or later, this scope will no longer be enough due to the technical and physical limitations.

Another limitation is the increased space, which electronic components require on the surface. **Flexible or rigid-flexible printed circuit boards** can resolve such challenges. Here, thin,



Flexible and rigid-flex PCBs can be used in a wide range of medical applications.

flexible printed circuit boards with sufficient space for SMT population (surface mount technology) are used. These are folded after the mounting process, and by using the third dimension offering adequate area within a very small space.

A further advantage of flexible printed circuit boards is the possibility of **replacing connectors and wiring**. This means fewer process steps, easier installation and lower costs for manufacturers, while simultaneously increasing quality. Furthermore, the connections are more resistant and reliable in terms of external mechanical influences.

The use of flexible printed circuit boards also opens up new opportunities in product and functional design, such as new and more appealing designs for hearing aids, for example. In addition to optical improvements, medical applications can also be functionally enhanced. One example is a catheter for three-dimensional heart mapping: when inserted through the blood vessel, the catheter is folded up and the diameter is as small as possible. Once it gets to the heart, it opens up in order to bring the electrodes on the flexible printed circuit boards into the correct position.

The usage of Flex PCBs allows for new examination methods when it comes to heart catheters

These examples show the broad application spectrum of flexible printed circuit boards, which will continue to expand in view of the current trends and developments towards wearable devices and smart patches in medical technology.

Embedded Component Packaging

Another way of saving space is to **embed components** in the printed circuit board, meaning that components, which previously had to fit on the surface "disappear" into an inner layer of the printed circuit board. While the size of the end device may remain the same, more components can be integrated into the printed circuit board, thus allowing increased functionality. Alternatively, the scope of functions remains the same, but the printed circuit board is smaller, which in turn enables compacter end devices. Even both can be accomplished, if the design is adjusted accordingly. This **Embedded Component Packaging (ECP®)** is made possible by a special production process. After the relevant components are integrated into a resin layer during additional, special production steps, they are connected through copper-filled, laser-drilled microvias.

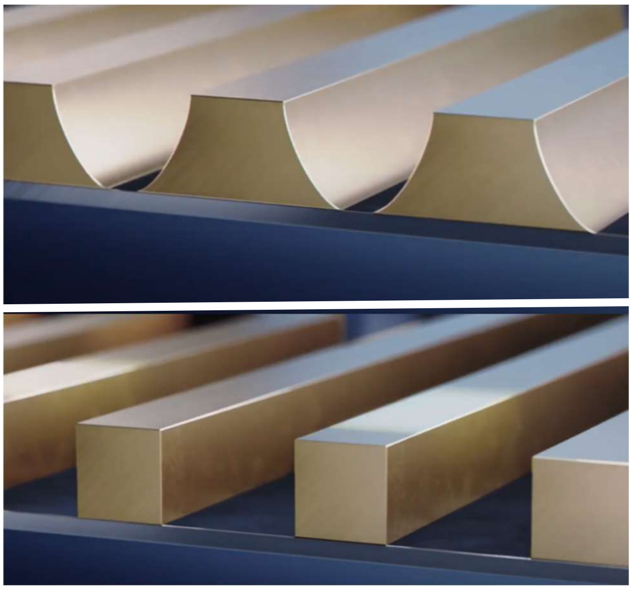
Solder joints are no longer necessary for the embedded component, and finer designs on the outer layer are possible at the same time. Embedding is also one of the safest methods to prevent external influences, such as mechanical shocks and vibrations, from causing issues. The result is a smaller, more compact end device that is also more robust and long-lived. Additional benefits of the embedding technology include optimized heat dissipation and better shielding from electromagnetic radiation, which is a crucial aspect for implantable electronics, for example.

How and which components can be embedded in a printed circuit board depends on multiple factors and may vary from application to application. Finding the best fitting solution for the respective application requires the involvement of the PCB manufacturer at an early stage in the development process. The earlier the collaboration begins, the more the manufacturer benefits.

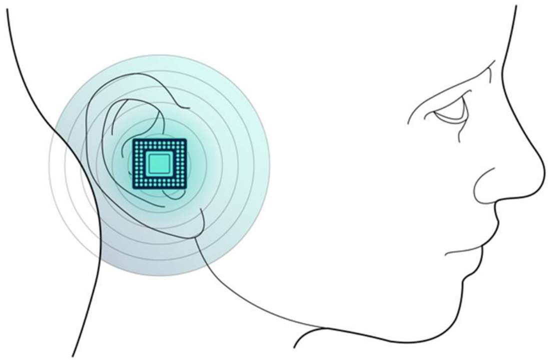
One example of the successful use of ECP technology can be found in modern, miniature hearing aids. The embedding of components allows such a reduction in the size of the application that it is barely visible when worn in the auditory canal.

Modified Semi-Additive Process

The standard process to achieve the desired conductive pattern on a PCB is subtractive, meaning that areas where the conductive copper is supposed to remain are protected and the excess copper is removed in an etching process. As a result of the etching process, the edge of the conductor path is not vertical but instead has a radius, potentially causing short circuits in case of very narrow spacing. With the increase in functionalities in state-of-the-art medical devices like implantables or hearing aids, more complex circuits are required.



While the standard subtractive process leads to a radial edge of the conductor path, the mSAP process allows for vertical conductor paths. vertically sloping edge of the conductor tracks.



With a new production process, called **mSAP (modified Semi-Additive Process)**, these challenges can be mastered: In contrast to the conventional method, copper is added to the printed circuit board as specified by the pattern (=additive) by using this technology. This eliminates the radius and the edges of the conductor paths become vertical, enabling ever-smaller line/spacing.

Using this new technology, the conductor paths can move closer together, thus reducing space requirements without changing the design. In addition to the positive effects of miniaturization, the straight-line shape is also beneficial for higher frequencies and prevents signal loss. Moreover, mSAP enables complex sandwich structures, making printed circuit boards not only smaller, but also thinner.

This is why the tmainboards of smartphones and smartwatches, as well as those of hearing aids, are manufactured using mSAP technology. While the line/spacing of a conventionally manufactured PCB is 40/40 µm, it can be reduced **down to 25/25 µm with this mSAP technology.** Thus, the main board size is effectively reduced by making tighter patterns and eliminating the risk of short circuits.

Conclusion

The medical industry is advancing more and more every day, helping many people around the globe to maintain their health, to become healthier or to live a life with as little restrictions as possible.

Manufacturers of medical applications are facing numerous challenges when it comes to product development. Every single part used in a medical device has to meet the highest safety standards, the most stringent quality requirements, while increasing reliability. At the same time, more and more functionality has to be added to the device while shrinking it to the lowest possible size.

Miniaturization and heterogeneous integration help push the boundaries of state-of-the-art medical applications. Innovative PCB- and interconnection solutions play a major role in this development and allow for ever-smaller devices with increased functionality.

However, the best-fitting technology mix to meet the requirements of miniaturization, increased functionality and reliability, varies from case to case. An important step to optimally capture the advantages of miniaturization of interconnect solutions for medical applications, is for PCB producers and manufacturers of the respective application to collaborate. Only by starting to cooperate in the early stages of development, the possibilities of new PCB technologies can be optimally incorporated into the product design and development.

Besides the technical challenges, the medical market is known for its strict regulations and complex ramp up procedures influenced by the processes required by institutions like the FDA or the European MDR.

To overcome this obstacles in a smooth matter all players along the supply chain are required to have experience in the medical sector, provide dedicated staff and know-how as well as the suited certifications and proven quality standards.

Further information on that topic can be found here:

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