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solid state batteries for the connected world

Application Brief AB002: How to Design Medical Implantable Devices with Solid State Batteries?

Introduction

Whilst designers of disruptive medical implantable devices have clinically perfected their technologies to allow pain reduction and improved patient well-being, they are often frustrated by the lack of hardware to make their project a reality. The main trend in medical product design is miniaturisation, in order to more efficiently implant devices nearer to the targeted organs and avoid costly operations, risks of complications and infections. What are the battery requirements for next-generation medical implantable devices? How can customisable solid state batteries support disruptive medical implantable product design?

Think about the battery first to unlock the potential of your technology!

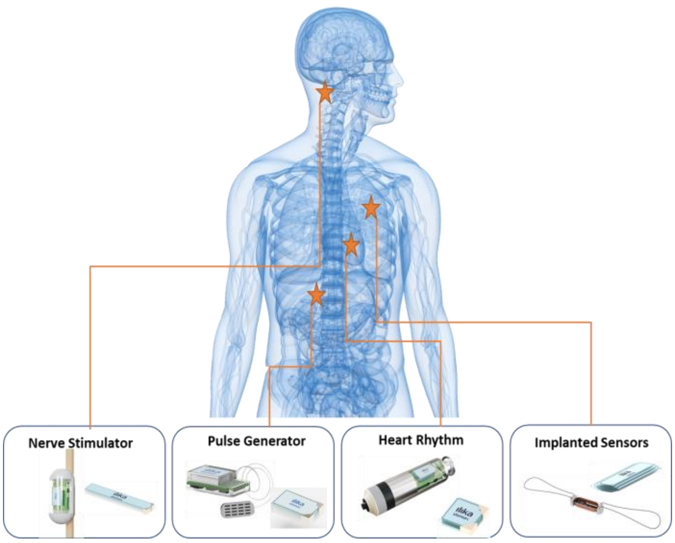

Figure 1: Disruptive implanted devices with possible solid state battery shape

Disruptive medical implantable devices

Innovative product design requiring miniature electronic components is taking place in these fileds, and more:

- Neuromodulation devices, from Vagus Nerve to Deep Brain to Spinal Cord Stimulation
- Leadless pacemakers
- Implanted sensors, measuring blood pressure, heart rate, oxygen stauration levels

What are Miniature Solid State Batteries?

This application brief explores how clever product design can be enabled by Solid State Batteries (SSB): this novel technology developed by Ilika has no liquid component which may leak or explode. A drawback with conventional batteries is that they contain a toxic liquid (electrolyte) which needs to be prevented from leaking out by packaging (usually in metal cans, pouches or coins). The more you miniaturise the battery, the larger the proportion of packaging until you have no space left for active battery materials. Usually the minimum dimension is ~ 2mm for rechargeable batteries. SSB are fully solid, don't need much packaging and can be made really small in planar directions (~15 mm^2 now, <5 mm^2 soon) and very thin (150 μm now, 100 μm soon). They can be also stacked to increase energy per footprint. (read more).

Vagus Nerve Stimulation

Key to a new generation of VNS devices is their very small size in order to be placed directly on the left Vagus Nerve. Current VNS devices instead consist of two components (the pulse generator and the leads) which requires two incisions. The energy requirement is based on a use case of regular but not very frequent (could be every few hours) short electrical stimulations (a few seconds), i.e. a *relatively* mild drain on batteries. However, to avoid repeated surgery, cycle life up to 10 years is desired.

Figure 2: Vision of a SSB in Vagus Nerve Neurostimulator

Battery features for VNS:

- Capacity range ~ 1 mAh
- Narrow (a few mm wide)
- Thin (< 1mm)

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Implanted Pulse Generators

Whilst VNS or obstructive sleep apnoea stimulation devices require *relatively* low energy density, other areas such as deep brain or spinal cord stimulation require much more energy in a few mm^3 volume. With these dimensions, the device could be inserted by a single incision, with no stiches required and only a small wound. Yet no battery technology beyond SSB has the potential to power devices small enough to be injected with a minor operation under local anaesthetic.

Battery features:

- Battery range > 5 mAh
- cm^2 footprint
- Multi-stack to increase energy density

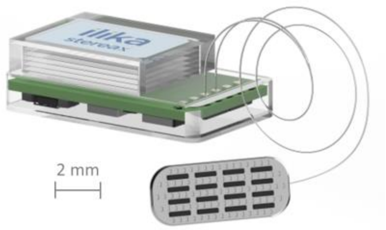

Figure 3: Vision of a SSB in an Implanted Pulse Generator

Leadless pacemakers

Implantation of small size, transcatheter pacemakers can now be performed by the femoral veins and under local anaesthetic. The device is generally inserted via a sheath of internal diameter 18F to 23F (< 8 mm). Primary batteries cannot fit such a low volume and provide energy for up to 15 years, therefore a rechargeable solution is required alongside a smaller back-up battery in case of battery malfunction (0.5% of patients suffer battery malfunction[1]). The back-up battery must have ultra-low electrical leakage to ensure it has enough energy left when it is needed.

Battery features:

- Capacity range ~ 2-3 mAh
- Battery architecture optimised in cylindrical cavity
- Long shelf life

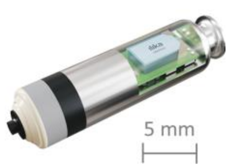

Figure 4: Leadless pacemakers

Implanted Sensors

Rather than going through a risky hospital operation, if the sensors were inserted via a needle through a 13 or 14 gauge catheter, this could take place in a doctor's surgery instead. A unique form factor is required for the battery in that case.

Battery features:

- Battery range <1 mAh
- Ultra-thin (<2 mm)

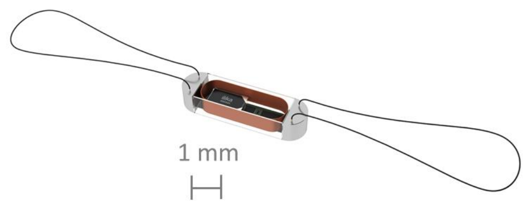

Figure 5: Implanted sensor

We can help you integrate disruptive batteries in your next disruptive product

As this Application Brief shows, next-generation devices need next-generation batteries which are customizable in shape, form and energy density to optimize the efficiency of the device. We are battery experts and work with companies at the design stage to ensure their device has the customised battery it needs. Contact us now to help ensure your device reaches its full potential tomorrow.

Learn more about the

Stereax microbatteries

Contact us for more info