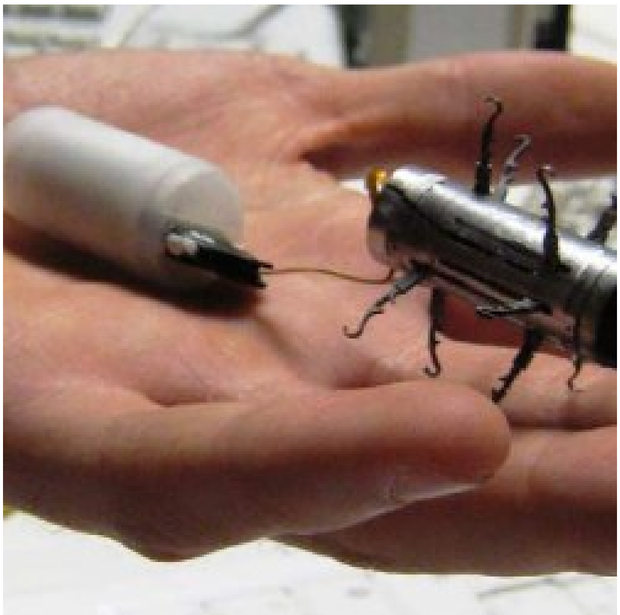
High Powered Medicine

Dr. Thomas Dittrich

The trend to miniaturize medical devices is active throughout the industry. With it, the challenge of identifying power solutions for these technologies is one that medtech companies are eager to solve. This article highlights one specific design option, that is, high energy lithium metal oxide batteries and showcases the advantages they present.



Working prototype of a miniaturized, wireless, 12-legged capsule and power module used for controlled locomotion throughout the GI tract.

When it comes to medical product design, smaller is better.

Advanced microprocessors and miniaturized circuitry are enabling medical devices to become more compact, lighter, and ergonomic. As design footprints shrink, and medical devices become more feature-rich, design engineers must respond with increasingly intelligent power management systems that effectively reduce size and weight without compromising product functionality.

The ongoing trend towards miniaturization has significantly impacted the design of portable, handheld medical devices that are either held or worn by the surgeon and powered through a wiring harness, or worn by the patient to track movement, monitor vital signs, or deliver medications.

At first, many handheld medical devices were powered by alkaline batteries, which are bulky and short-lived. Over time, more and more portable handheld medical devices incorporated rechargeable batteries that deliver a more convenient and cost effective long-term solution. However, even today's relatively more advanced rechargeable lithium batteries have performance shortcomings related to low energy density, short shelf life, and a relatively narrow temperature range, making them unsuitable for high temperature autoclave sterilization procedures.

Tadiran TLM Series batteries deliver high rate power within a miniaturized package, enabling portable and handheld medical devices to become smaller, lighter and more ergonomically designed.

Breakthrough Battery
A growing number of single-use medical devices require high rate power to operate, such as swallowable robotic capsules, disposable drills and power tools, and cauterizers. To address the unique power management requirements of single-use medical devices, engineers at Tadiran [1] developed the TLM Series, a family of lithium metal oxide batteries that feature high rate power and fast activation with low weight and volume.

First introduced in 2007, TLM batteries are constructed with a carbon-based anode, a multi metal oxide cathode, and an organic electrolyte. In response to customer requests, a more powerful version of the battery is being introduced this year, including a AA-size cell with a discharge capacity of up to 1,100 mAh. TLM batteries feature an open circuit voltage of 4 V and are capable of handling 5 A continuous current and 15 A pulses. Additional product features include a glass-to-metal hermetic seal, exceptionally long storage life, and a wide temperature range of -40 to 85°C. These batteries also feature a unique voltage curve that allows for an endof-life indication, enabling devices to be programmed to issue a low battery status alert prior to being fully discharged.

TLM Series batteries are also extremely safe, with non-toxic, non-pressurized solvents and anode materials that are less reactive than other lithium cells. These batteries conform to UN 1642 and IEC 60086 standards for resistance to crush, impact, nail penetration, heat, over-charge, and short circuit, and can be shipped as non-hazardous goods.

Following is a real-world example using this novel high energy lithium chemistry.

Pill-Sized Wireless Capsular Endoscopy
A team of engineers and physicists at the Scuola Superiore Sant'Anna [2] in Pisa, Italy recently developed a working prototype of a pill-sized and swallowable 12-legged wireless capsule used for locomotion through the gastrointestinal (GI) tract. The robotic capsule features a novel, patented slot-follower/lead screw mechanism that powers 12 miniature legs that retract when swallowed, then emerge once in the GI tract to generate 0.63 N average propulsion force at each leg tip, enabling the capsule to travel at 5.0 cm/min, permitting surgical and/or diagnostic procedures in approximately the same time it takes to complete a standard colonoscopy.

Replacing standard GI endoscopy with a swallowable capsule is a novel concept designed to improve patient comfort and safety, as the new procedure involves less indignity, less discomfort associated with insufflation (air), and reduced risk of damaging colon walls, thus increasing the number of people willing to undergo this less invasive procedure.

Earlier versions of a swallowable robotic capsule relied on GI peristalsis for locomotion, the natural muscle activity that moves food through the digestion process. Reliance on peristalsis is highly problematic for diagnostic purposes because the process does not allow the endocrinologist or technician to control speed, stop, or reverse direction, making it impossible to properly inspect the interior surface of the colon or large intestine without inflating the device. Devices that rely on muscle activity also do not provide effective motion control in deflated colon tissue.

Designing a robotic capsule to navigate the small and large intestines was no simple feat, as human intestines are highly compliant and non-linear, made up of highly viscoelastic material with up to 2.0-mm thickness of lubricating mucus, resulting in a coefficient of friction that is extremely low.

Once swallowed, the retractable legs are powered by two miniature DC brushless motors. The device also contains microcontrollers, a wireless bi-directional interface, and custom MOSFET drivers. Future prototypes will incorporate a human-machine interface, a commercial pill camera that offers real-time streaming video capabilities, an error exchange dialog box that enables feedback to the user in case of malfunction, and devices capable of performing biopsies and/or delivering treatment.

The initial prototype for the 12-legged capsule utilizes a wire connection to a separate power module, which is also swallowable. The power module contains a TLM-1030 battery (10 x 30 mm) that operates at 3.3 V with a total capacity of 100 mAh. Based on an average operating current of 184 mA, the TLM-1030 battery has plenty of capacity to complete a 30 minute colon transit.

The introduction of a more powerful version of the TLM battery could result in future models becoming even more miniaturized, including possible integration into a legless version of the capsule that "swims" through the GI tract.

Conclusion
This case history demonstrates how a new generation of lithium metal oxide batteries is delivering high rate power and fast activation with low weight and volume, leading to smaller and more ergonomically designed medical devices.

Dr. Thomas Dittrich is the manager of applications engineering at Tadiran Batteries GmbH. He is responsible for developing battery solutions that are optimized to customer requirements. Dr. Dittrich can be reached at 800-537-1368 or sales@tadiranbat.com *[3].*

Links:
[1] http://www.tadiranbat.com/
[2] http://www.sssup.it/
[3] mailto:sales@tadiranbat.com