Batteries meet SEMICONductors

How battery pack evolutions create opportunities for power electronics companies

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Abstract

The market for Li-ion batteries for e-mobility and stationary energy storage is strongly growing, driven mainly by electric and hybrid electric vehicles (EV/HEVs). According to Yole Développement estimates, for the largest Li-ion battery market segment - battery electric vehicles (BEVs) - the market value will reach almost $52 billion by 2023.
There is no big technology breakthrough expected in coming years regarding battery cells. The product differentiation will be sought on the battery pack level, by optimizing the battery pack design and its components. The existing solutions from other applications will be modified to fit the EV/HEV requirements, such as low Electromagnetic Interference (EMI) issues and vibration resistance to vibrations. The bigger changes are associated with the battery pack voltage trends towards 800V for BEVs and towards 1,500V for stationary energy storage for grid applications. The use of higher battery pack voltage will impact the choice of electronic components in Battery Management System (BMS) and in car converters and inverters and battery chargers. Silicon IGBTs or SiC MOSFETs rated at 1,200V will be used with 800V vehicle battery packs. The electrical interconnections and connectors and safety devices such as fuses and contactors must also be adapted for higher voltages. The energy capacity of battery packs will continue to increase, resulting in needs for faster charging capability. Ultra-fast chargers providing charging power up to 350kW have already been developed. The power electronic components and systems rated for high currents will enable fast vehicle acceleration. The battery pack as the key element of an electric vehicle is closely interlinked with other elements such as inverters and converters, and motors. The synergies between different sub-systems and mechatronics solutions are sought more than ever, to obtain compact, lightweight and reliable solutions and to reduce the system costs.

Biography

Dr. Milan Rosina is a Senior Analyst for Power Electronics and Batteries at Yole Développement. Before joining Yole, he worked as a Research Scientist and a Project Manager in the fields of photovoltaics, microelectronics, and LED. Dr. Rosina has more than 15 years of scientific and industrial experience with prominent research institutions, an equipment maker, and a utility company. His expertise includes new equipment and process development, due diligence, technology, and market surveys in the fields of renewable energies, EV/HEV, energy storage, batteries, power electronics, thermal management, and innovative materials and devices.

High-rate and durable Li-ion batteries by Spatial-Atomic Layer Deposition

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Abstract

The wide implementation of electric vehicles is at the moment hindered by (amongst others) the lack of intrinsically safe battery technology that could provide sufficient energy density as well as fast charging for many charge/discharge cycles. The battery industry heading towards solid-state configurations. The key challenges in next-generation all-solid state Li-ion battery technology development are related to the required energy and power densities, fast charging constraints, battery lifetime, and at the same time keeping the cost low by high-volume production. Such technology criteria require superior electrode as well as electrolyte materials (pinhole-free), and processing techniques enabling even advanced 3D designs.

We report on innovative materials and 3D architectural approaches that can disrupt current Li-ion batteries, especially combining high-capacity with fast-charging capability. However, newer architectures demand newer processing techniques. A technology researched a lot in this respect is the Atomic Layer Deposition (ALD), which is well-known for its superior material quality and layer conformality over ultrahigh aspect ratio topology. But, in applications outside the advanced micro- and nanoelectronics industry, ALD technology is impeded by the economics of the low film deposition rates. Here, the scalable atmospheric pressure Spatial-ALD (S-ALD) holds the best promise for sufficient deposition rates and large-area roll-to-roll processability, which is key to battery industry.

Presented will be the results on high-rate 3D Li-ion battery electrodes using S-ALD, which show charging rates of few minutes. Highlighted will be the development of new high-performance battery electrode materials (in-situ doped) by engineering material properties at the nanoscale. Next to it, we will present about the first-ever S-ALD based solid-state LIPON electrolyte material (<100 nm thick). More about our research and capabilities will be presented during the seminar.

Biography

Dr.Sandeep Unnikrishan is the Program manager of R&D program on Solid-state batteries at TNO-Holst Centre in the Netherlands. He has an engineering background on manufacturing technology, and later did his PhD on solid-state fuel cells. He has more than 15 years of experience in technology development for nano-engineered devices, including organic electronics, fuel cells and batteries. His current focus is on the development of innovative materials, designs as well as fabrication technologies that can enable the high-performance batteries of the future.

Towards on-chip 3D all-solid-state lithium-ion microbatteries

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Abstract
The upcoming Internet of Everything (IoE) devices demand miniaturized rechargeable batteries, who distinguish themselves through a high level of safety as well as increased energy and power density per footprint area. Thin-film all-solid-state lithium-ion batteries deposited on highly structured silicon substrates are ideal candidates to match these requirements. The technical transition to solid-state electrolytes means significant improvement of battery safety. Three-dimensional (3D) battery concepts, including deposition on structured surfaces with high aspect ratio, have been shown to improve both capacity and rate performance of all-solid-state batteries.

At Fraunhofer IPMS-CNT we are driving the development of functional layer stacks by atomic layer deposition (ALD) allowing direct integration into microsystems. ALD enables conformal, pinhole-free deposition of nanometer thin films and composition control on an atomic level. However, deposition of lithium-containing materials by ALD is a challenging task. In order to make the entire 3D battery by ALD, single layers, interfaces, and the whole layer stack have to be tailored.

For semiconductor compatible design and production we manufacture on 8 inch silicon wafers using standard industrial thin-film deposition equipment. For battery integration into silicon technology lithium-ion diffusion into the silicon substrate must be inhibited. Undesired lithium-ion outdiffusion would result in poor cycling stability and failure of neighboring devices.

In order to enable deposition on nanostructured silicon substrates, there is demand for as thin as possible non-active battery layers. In this work, lithium-containing functional layers and ultrathin lithium- ion diffusion barriers for on-chip 3D batteries were investigated.

Biography
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Atomic layer deposition of Li-containing layers for thin film batteries

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