A challenging route towards 3D-integrated all-solid-state batteries

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Micro-batteries are expected to become more and more important in numerous small-sized devices, like medical implants, biosensors, hearing aids and autonomous network devices. Characteristic for these electronic applications is that they have to operate autonomously and reliably. Due to these requirements the thin film power source needs to be rechargeable, mechanically stable for a long period of time and hence reveal an extremely long cycle life. As the average energy consumption of these future devices will be rather small, this opens up the possibility to integrate all-solid-state rechargeable batteries, enabling a high degree of IC integration.

It has been reported that all-solid-state, Li-based, rechargeable batteries can be charged and discharged more than 10,000 times without significant degradation. These thin-film batteries are, however, planar-structured, resulting in a relatively low energy density. By depositing the complete battery stack in a 3D etched substrate, obtained by for example physical or wet-chemical etching of mono-crystalline Silicon-wafers, the effective energy and power density can be tremendously increased. Moreover, utilizing novel battery anode materials with a very high storage capacity comprising of thin films electrodes are highly beneficial. Our new 3D-integrated battery concept will be highlighted together with the challenging electrochemical properties of the new class of Si-anode materials[1,2].

The thermodynamic and kinetic properties of Silicon thin films will be presented in detail. Employing a variety of electrochemical measurement tools, trends in various parameters will be shown depending on, for example, the degree of Li-intercalation. In addition, the use of a thin film configuration allowed us to study the morphology of the Solid Electrolyte Interface (SEI) at the electrode surface and its influence of the electrode cycle-life in much more detail. Strikingly, the use of solid-state electrolytes has a high beneficial effect of this SEI formation.

References

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