Rechargeable batteries bridging the gap between future *Smart Grids* and electrical vehicles

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There is nowadays general consensus that due to global warming electricity generation will, in the future, take place in a decentralized rather than centralized way in large power plants. Obviously, solar, wind and bio-mass will contribute significantly to decentralized electricity generation in the near future. Due to the unpredictable nature of these fluctuating energy sources it has been identified that local electricity storage will play a dominant role. Rechargeable batteries will indispensably take up this role. Interestingly new battery materials have recently been discovered, making a new generation of rechargeable batteries very attractive with respect to energy density, power density and materials availability. However, the cost aspect still plays a dominant role and currently forms a limiting factor for wide-spread domestic storage.

Simultaneously, another interesting development takes place in the transportation sector, inducing the transformation from rather inefficient internal combustion engines to much more efficient electrical engines. Considering the overall efficiencies of both systems, electrical transportation appears to be at least two times more efficient and has many more additional advantages, such as no local pollution or even absent pollution when electricity is generated in a sustainable way, silent driving, *etc.* This high performance is, among other things, related to the extremely high efficiency of electrochemical conversion in rechargeable batteries, which do not suffer from the inefficient Carnot cycle. In contrast to domestic storage, mobile storage is more cost-effective.

Obviously, in order to charge electrical cars, these have to be connected to the electric grid. Charging will mainly take place overnight at low rates but it has been shown that this can also occur rapidly within 20 minutes using fast-charging equipment currently under development for automotive applications. It is clear that when many cars are connected to the grid these create an interesting buffer for electrical energy, which can also be used to deliver electricity back to local buildings and/or the grid in periods of serious shortage. Assuming that the management of the various distributed energy flows takes place in a coordinated and controlled way, the building environment and electrical vehicles will become connected to the future, so-called, *smart grid*. The efficiency chain of electric transport will be compared to that of conventional driving. The new materials developments and the impact on rechargeable batteries will also be addressed.

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Peter H.L. Notten joined *Philips Research* in 1975 till 2010. While working at these laboratories on the electrochemistry of etching of III-V semiconductors he received his PhD from the *Eindhoven University of Technology* in 1989. Since then his activities have been focusing on the research of hydride-forming (electrode) materials for application in rechargeable NiMH batteries, switchable optical mirrors and gas phase storage, and Lithium-based rechargeable battery systems. Since 2000 he has been appointed as professor at the *Eindhoven University of Technology* where he is heading the group *Energy Materials and Devices*. He recently has also been appointed as *International Adjunct Faculty* at the Amrita University, Coimbatore, India (2014) and at the *Forschungszentrum Jűlich*, Germany (2014).

His main interest includes the development of (*i*) advanced battery and hydrogen storage materials, (*ii*) new battery technologies, (*iii*) modelling of energy storage materials and complete rechargeable battery (NiMH and Li-ion) systems and (*iv*) the development of sophisticated Battery Management Systems (BMS), enabling accurate and adaptive State-of-Charge and State-of-Health determination, to be applied in *e.g.* electrical vehicles in connection to the *Smart Grid*. He is member of the Editorial Board of *Advanced Energy Materials* and *International Journal of Electrochemical Science*. He has published as (co)author about 250 scientific papers and contributions to scientific books and owns about 30 patents.