

Can Nano- and Ceramics Technology help to solve the challenges of the 21st century in energy consumption

Ceramic Materials and Technologies for Energy Supply Systems

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The penetration of daily life with electronic devices is still rapidly progressing. One important side effect is the demand for reliable and efficient energy supply systems. Especially decentralized and portable energy systems are needed. Materials innovation including nano-materials technology plays a dominant role to come up with new concepts for novel power supply micro systems.

Due to their broad spectra of favourable properties high performance ceramic materials offer enormous potential for such kind of product innovation. For example, the joint application of structural and functional ceramic technology platforms allows for unique combination and integration of electronic, ionic (electrochemical) and mechanical properties enabling for development of new highly integrated micro- and nano-electro-mechanical systems (MEMS, NEMS).

We illustrate this approach for fully integrated fuel cell systems which are well suited for both, portable and small stationary, decentralized power generation. For this, we apply hybrid and multi layer ceramic technologies such as LTCC (low temperature cofired ceramics) and HTCC (high temperature cofired ceramics) processes. These technologies are already wide spread in electronic circuit integration. However, the application of these technologies for micro system integration is still in its beginnings. We present a new fully integrated PEM (polymer electrolyte membrane) fuel cell system completely manufactured in LTCC technology. This PEM unit delivers power in the sub-Watt range and can for example be used as a battery charging device for a large variety of handheld devices. One big advantage of LTCC technology is its compatibility with Si-technology. For instance, the coefficient of thermal expansion of LTCC materials and Si match well allowing for a direct integration of microchips into these electrochemical microsystems. This allows for cost effective integration schemes.

For higher power applications in the kW range ceramic SOFC (solid oxide fuel cell) systems can be used. For cost effective production of these high temperature fuel cell systems HTCC technology is used. Whereas, PEM systems can be operated with pure H₂ only, SOFC systems can be operated with conventional hydrocarbon fuels such as propane, natural gas, gasoline, diesel or sustainable energy sources (biogas) using a simple pre-reforming process. Therefore, SOFC systems are the preferred choice for APU (auxiliary power supply) or CHP (cogenerated heat and power) applications. Both fuel cell types, PEM and SOFC are currently close to commercialization and can significantly contribute to solve the challenge of the 21th century energy consumption issue.