Combined Particle Filter and Selective Catalytic Reduction Catalyst for Diesel Engines

Silicon carbide has many outstanding properties. It is an extremely hard and tough material with a high thermal and chemical stability, in addition to being an important semiconductor material. Silicon carbide macro-, micro- and nanostructures can be tailored to fit specific needs, making them ideal for multiple applications like high power electronic devices, heating elements, abrasive materials and cutting tools. Porous silicon carbide is suitable for electrode and catalyst support material as well as hot gas filter units or a combination of these.

The automotive industry demands new and better solutions for exhaust purification systems, and porous silicon carbide has superior characteristics for this purpose. The continuously increasing requirements for low emission levels of both toxic and polluting nitric oxides (NOxes) and health damaging sod particles, requires novel methods for exhaust gas purification. By combining the particulate filtration application with the application as catalyst support for NOx reduction, the low emissions standards can be met. This project was initiated as a result of the need for new and improved filters with characteristics making it suitable for exactly this.

Honeycomb shaped monolithic structures of porous silicon carbide, with accessible porosity of no more than 50% and pore sizes in the micrometre range, are usually obtained by recrystallization of the cubic polymorph of silicon carbide (β-SiC) at temperatures exceeding 2200°C. It has always been assumed that additives, like aluminium, create a eutectic with silicon carbide, which permits it to acts as a diffusion agent for the recrystallization at high temperatures. The role of aluminium as solely a liquid phase sintering agent is questioned in this present work, where a method is presented for obtaining mechanically stable silicon carbide monoliths with unusually high accessible porosities of ~65% and average pore sizes of 18μm by addition of aluminium to the starting mixture.

The present work investigates the intrinsic physical and chemical mechanisms attributed to aluminium, using several relevant material- and surface-characterization techniques. From these investigations it is found that the elemental aluminium added to the wet mixture, prior to extrusion into honeycomb monoliths, contributes to the reaction forming of a porous β-SiC microstructure and to the subsequent recrystallization and inherent conversion to hexagonal silicon carbide (α-SiC) assisted by an aluminium nitride intermediate phase. The resulting microstructure, of individual platy hexagonal interconnected crystals, constitutes the macroporosity of the product. The mechanical and microstructural properties of the end-product are extremely sensitive to alterations in either of the many parameters involved in the production process.

By systematically varying the many different variables, it is found that aluminium *does* act as a liquid phase sintering agent, but primarily, the advantageous effects of aluminium are attributed to crystal-structural similarities between aluminium-containing components and the silicon carbide. Likewise, the role of nitrogen, especially in combination with aluminium, and the effect of adding trace amounts of copper to the starting mixture, was also scrutinized. A new and improved filter was in this project developed on the basis of the research results concerning copper as partner additive. In comparison to filters produced with aluminium as sole additive, these new filters exhibit enhanced mechanical stability, enhanced microstructure and controllable surface oxidation of the silicon carbide crystals, ideal for catalyst adhesive layer. The silicon carbide filter, produced with trace amounts of copper, still fulfills the requirements for macroporosity and accessible porosity in excess of 50%, and is thus superior for the purpose of combined diesel particulate filter and catalyst support.