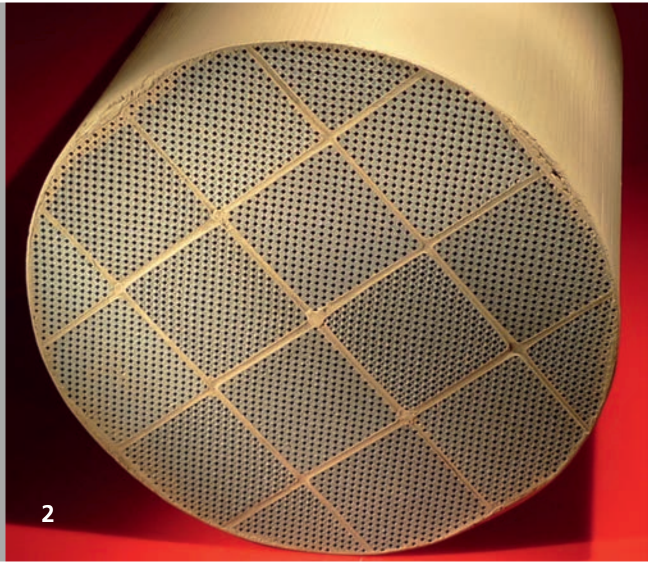

1


2

MECHANICAL AND AUTOMOTIVE ENGINEERING

DIESEL PARTICULATE FILTERS WITH OPTIMIZED PRESSURE DROP AND FILTRATION EFFICIENCY

Dr. Uwe Petasch, Dipl.-Krist. Jörg Adler

Diesel particulate matters are known to be harmful to human health and environment. Nowadays, diesel particulate filters are widely applied as the state-of-the-art technology for the safe and effective reduction of diesel engine exhaust gases. The filters have to satisfy the following basic functional requirements:

- Separation of soot particles from exhaust gases with adequate filtration efficiency
- Low initial pressure drop and back pressure during soot filtration
- Very good resistance against thermal shock and high temperatures during filter regeneration

In the past few years, ceramic wall-flow filters for soot particulate filtration have already enjoyed a high level of development. However, due to the tighter emission standards and the demand for more energy efficient vehicles, it is essential to have future developments of particle filters that focus on lowering the pressure drop and increasing the soot filtration efficiency.

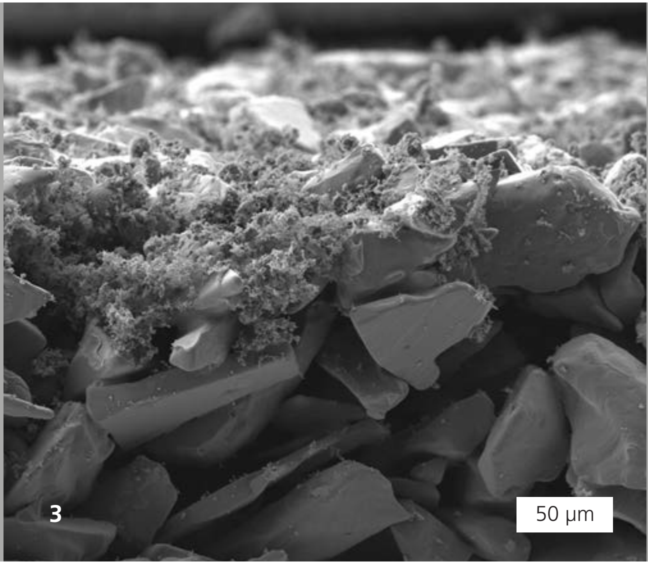
Liquid-phase sintered silicon carbide (LPS-SiC) was developed at Fraunhofer IKTS as a porous material for the application in soot filtration, and was transferred to industrial scale production, mostly for filters in off-road applications. The advantage of LPS-SiC lies not only in its excellent thermal properties but also in the reproducible and adjustable porosity controlled by the SiC grain sizes. In an attempt to further optimize the pressure drop and the filtration characteristics, experimental studies were carried out to identify the role of the material porosities on the properties of the particulate filters.

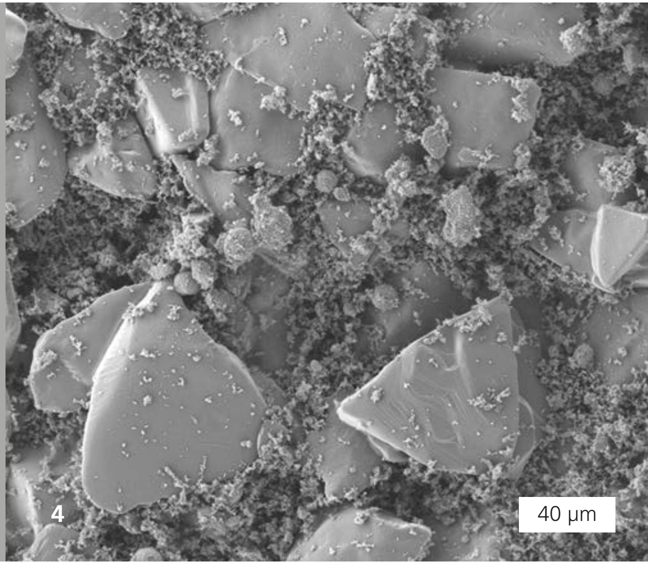
Pressure drop and filtration efficiency of disc-shaped specimens and extruded honeycombs made from porous SiC material were investigated by means of reproducible soot loading experiments on a special laboratory test bench (Figure 1). As a result, changes in filter properties of porous materials with pore sizes between 10 and 20 µm as well as their influence on the characteristics of the real filter structure were independently evaluated.

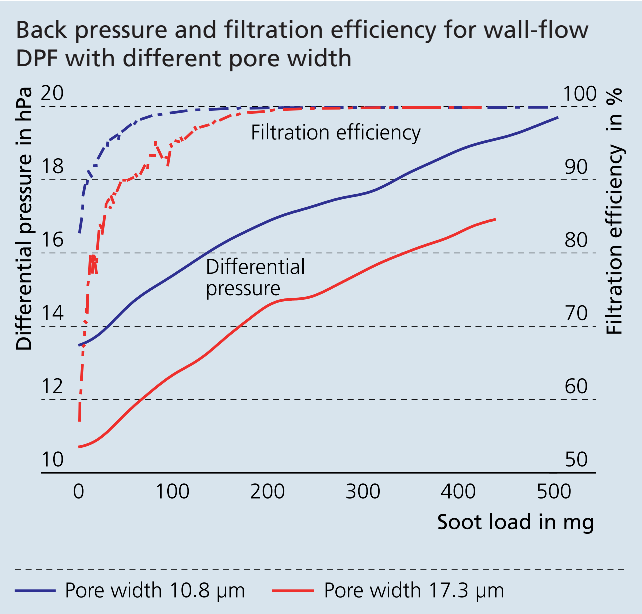
All tested materials showed a two-stage filtration behavior that is typical for wall-flow DPF: The starting depth filtration was followed by a formation of a soot layer resulting in cake filtration (Figure 3). The soot collection efficiency at the beginning of the deep-bed filtration stage ranges between 60 % and 85 % depending on the pore size of the filter material and increases to > 99.5 % due to cake filtration.

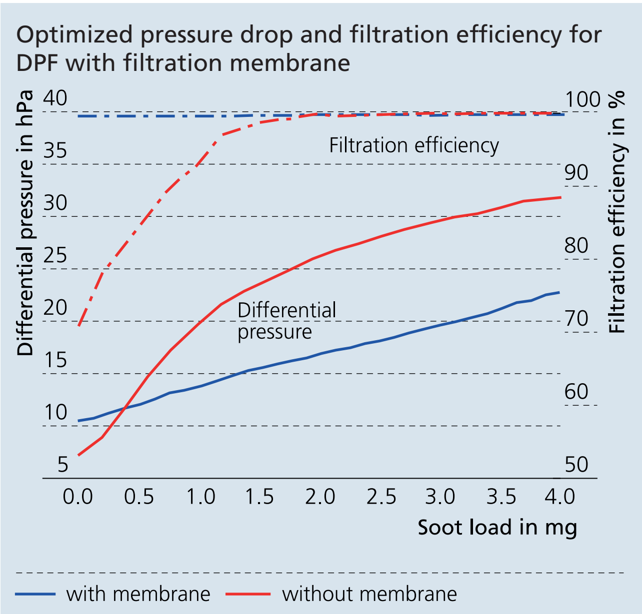
Filters with increased pore sizes of the filter wall have advantages in decreasing the initial pressure drop and the back pressure during soot loading. However, particle filters with smaller pore sizes show higher filtration efficiency since their relative inefficient deep-bed filtration phase is less pronounced.

Another approach for increasing the filtration efficiency is to use an additional fine porous filtration membrane on the filter wall. However, this method not only influences the filtration efficiency but also the back pressure of the filter. In cooperation with Fraunhofer ITWM, microstructure simulations based on experimental and analytic results of soot particulate deposition on porous LPS-SiC materials were used for a further development of optimized filters. The results of the simulation









were applied in the design and experimental development of filter membranes. An optimal balance between filtration efficiency and back pressure was obtained for filter materials whose top pore layers were filled with additional fine porous ceramic material (Figure 4). The initial pressure drop of such a filter material was only slightly affected. In contrast, the back pressure offset caused by soot deposition is lower than the value for conventional filter materials since the depth filtration step was completely avoided. The filtration efficiency stays at approximately 99 % during the overall filtration process.

Services offered

- Design, development and optimization of diesel particulate filters
- Application-oriented characterization of filter properties

1 Soot loading and pressure drop test bench.

2 Wall-flow diesel particulate filter.

3 Cross-sectional area of a DPF wall after soot loading.

4 Filtration membrane on DPF for optimized pressure drop and filtration behavior.

Contact Dr. Uwe Petasch • Phone +49 351 2553-7616 • uwe.petasch@ikts.fraunhofer.de