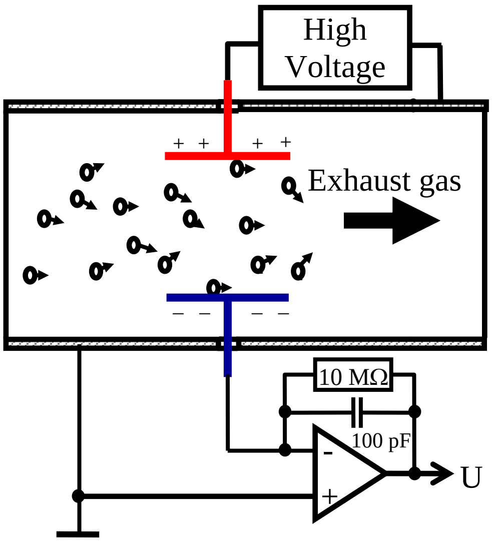
Smoke Particulate Sensors for OBD and high Precision Measuring

Prof Dr G. Hauser
Fachhochschule Wolfenbüttel
Salzdahlumer Straße 46 – 48
D-38302 Wolfenbüttel
Germany
g.hauser@fh-wolfenbuettel.de

Poster Presentation at 9th ETH-Conference
on Combustion Generated Nanoparticles
15th – 17th August 2005

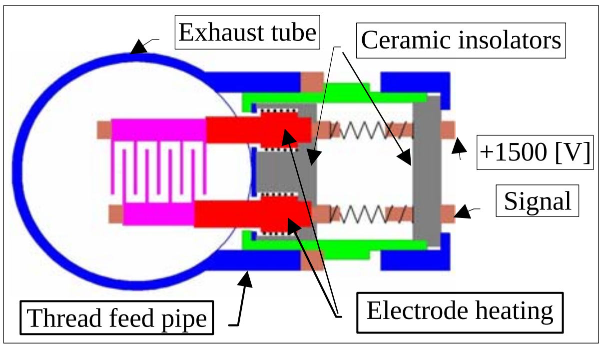
1. Methodology of Operation



The property of carbon, leading electrical current, is used for the transportation of electrical charge. Therefore a high electrical field is implemented inside the exhaust gas tube by means of capacitor blades with a distance of 3 [mm] and a high voltage of 1500 [V]. Whilst the particulates pass this capacitor they are attracted by Coulomb forces on to the blades and, during statistically touching them, they will be charged. As they have then the same polarity as the electrode itself they move away following the exhaust gas flow. The charging procedure and the transportation of charge is measured by a DC coupled charge amplifier. The RMS value of this voltage is the measure of the quantity of particulate. At low gas flow the quantity of charge exchanges is much higher than at a high gas flow. Therefore the gas flow must be known in order to calculate the smoke concentration of the Exhaust gas.

After the combustion process the smoke particles have a more or less individual electrical charge, which has no effect to the measuring results because the electrical field is extremely low in comparison with the field inside the capacitor.

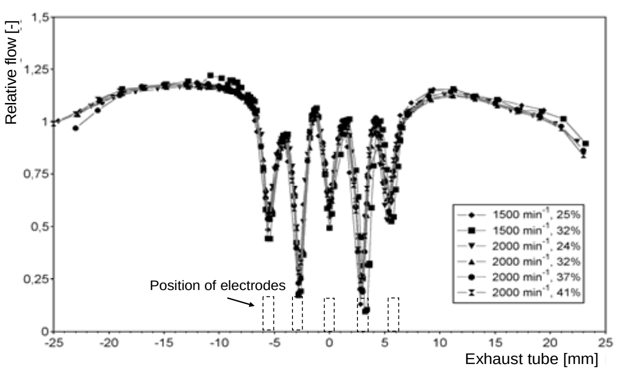
2. Construction principle of the Charge- Sensor



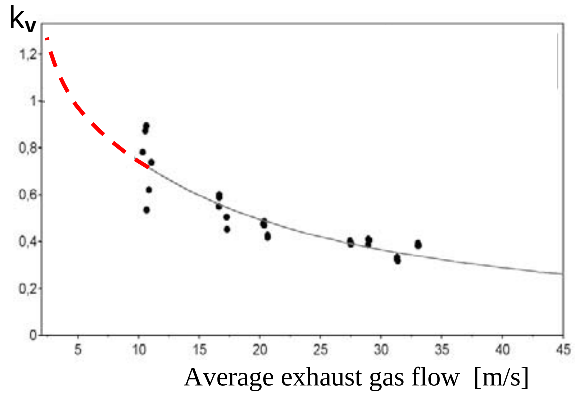
The most important part of the sensor construction consists of the electrode shaft heating. It is necessary to keep the isolation resistant within the range of 100 [MΩ].

It was found out, that a temperature of 250 [°C] is sufficient to keep the insulators clean of smoke particulates.

3. Gas flow profile through electrode blades



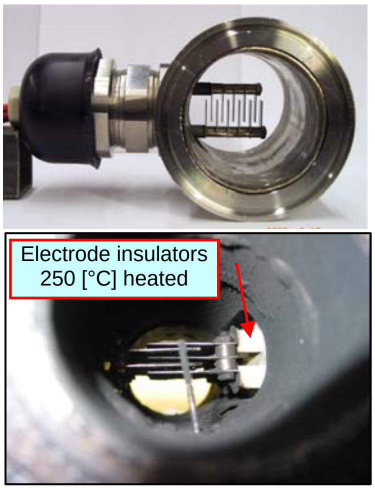
The exhaust tube of 50 [mm] diameter was scanned across for a range of engine speeds and engine loads. The measured results had to be normalized in order to see the profile at different gas flow speeds. Even at the positions of the electrode blades inside the tube the profile stays constant. This is the necessary condition for on board measurements of high accuracy.

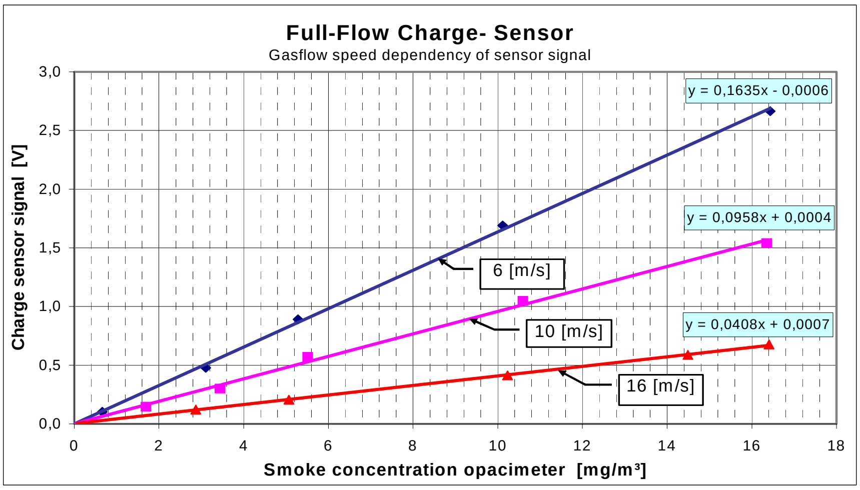


The gas flow speed has to be derived from the air intake mass flow, the fuel mass flow, the exhaust tube diameter and the temperature at the sensor position.

If the other parameters are kept constant and the gas flow speed varies against the particulate concentration the curve shows the shape of an e-function. Later experiments with bypass measurements and controlled gas flow speeds down to 1 [m/s] have result in the red line.

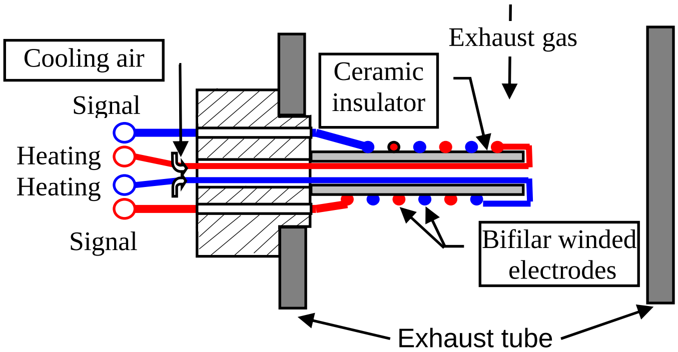
4. New design of a full flow application of the charge sensor without corona

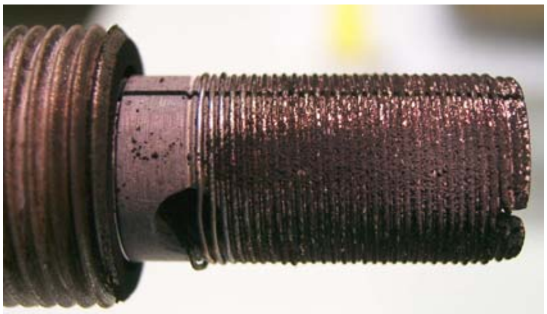




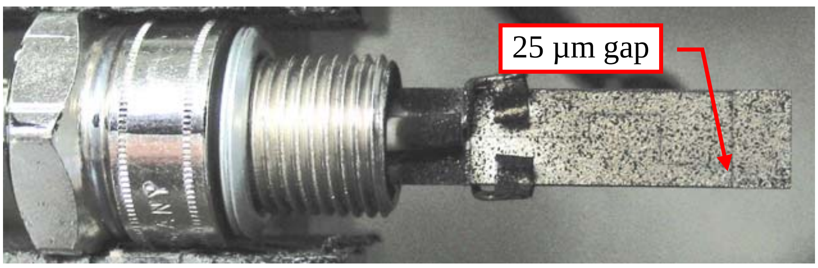
The photos show also the long-time operation behaviour of the charge sensor and the linear measuring results depending on the gas flow speed .

5. Another methodology of measuring Smoke particulates



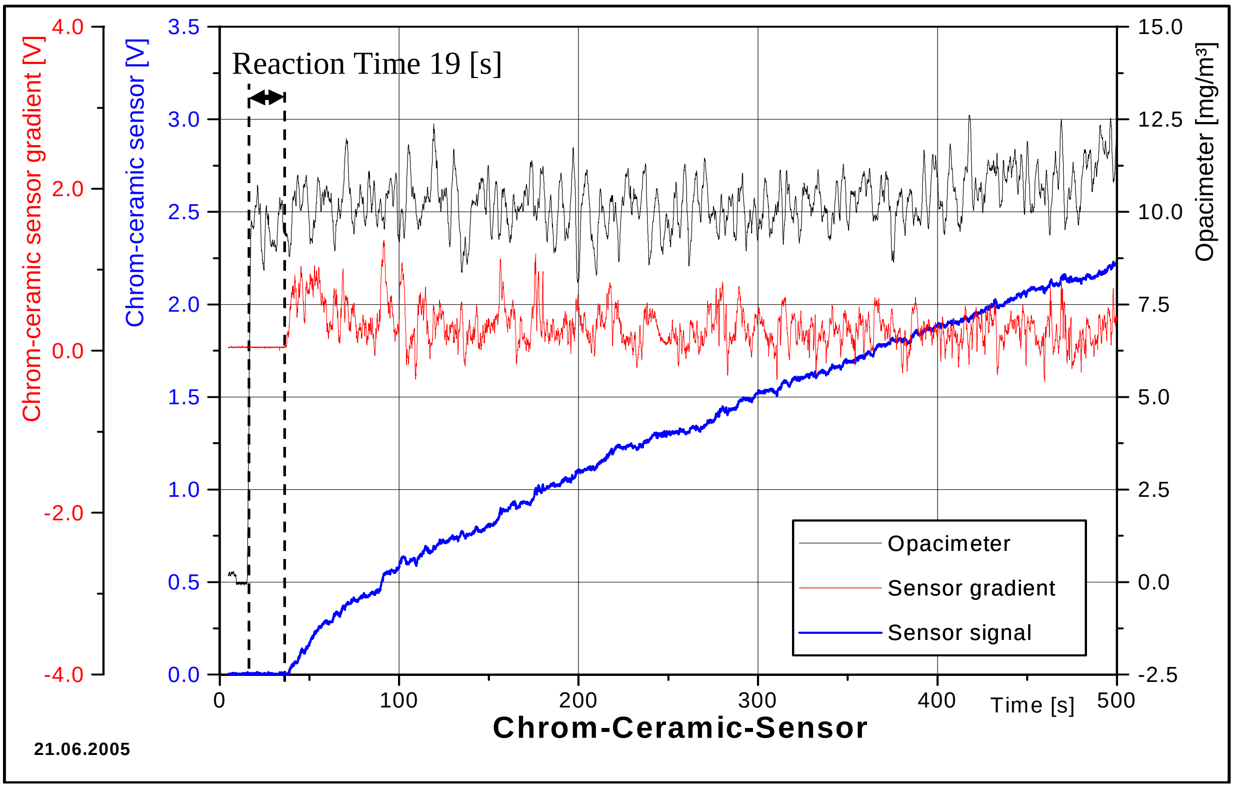


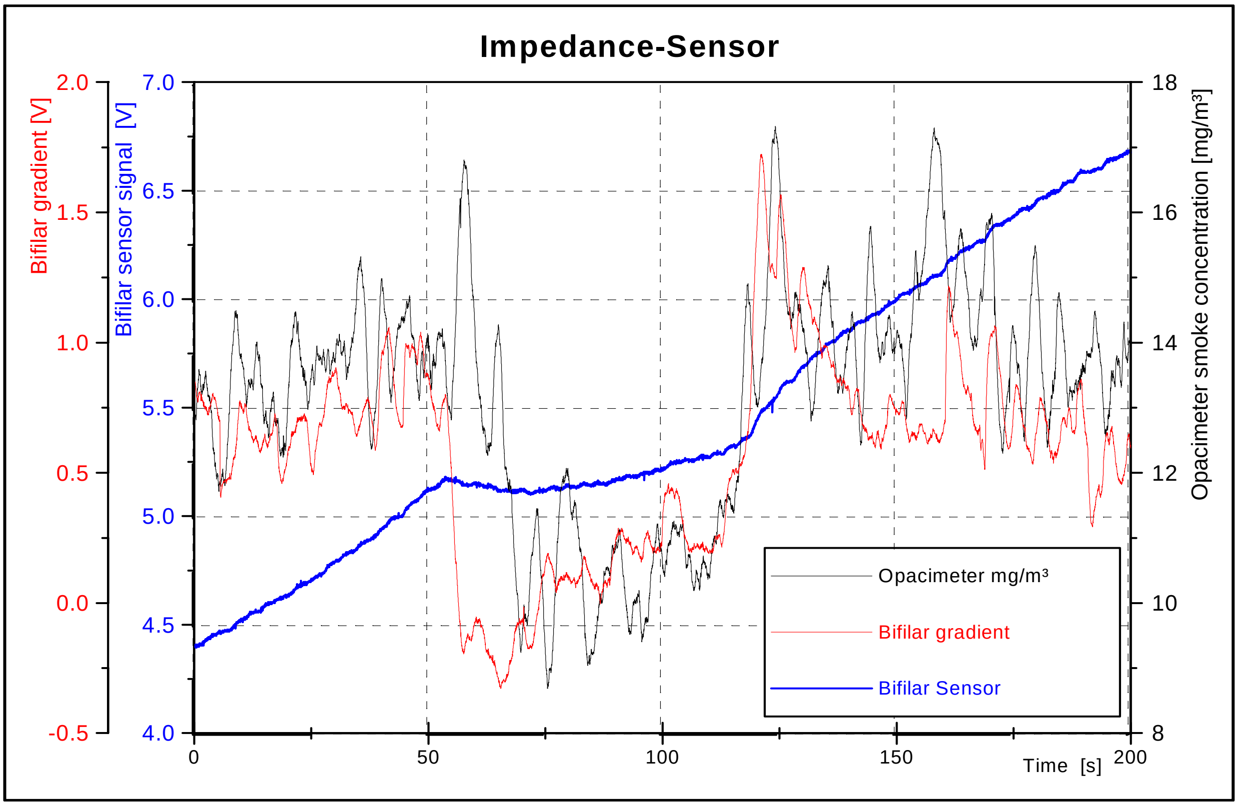
Carbon particles produce electrical resistor bridges across the electrodes and gradually reduce the isolation resistance. This principle is used as measuring device by regarding also the gradient of the resistor changing as a measure of the dynamic particulate concentration. The bifilar coil is manufactured of resistance material and by simply shorten the ends of the coils the measuring device is used as well for burning the particulates.



The smallest device is made of a spark plug with a very small electrode- gap to optimise the reaction time.

Results are shown in next diagrams.

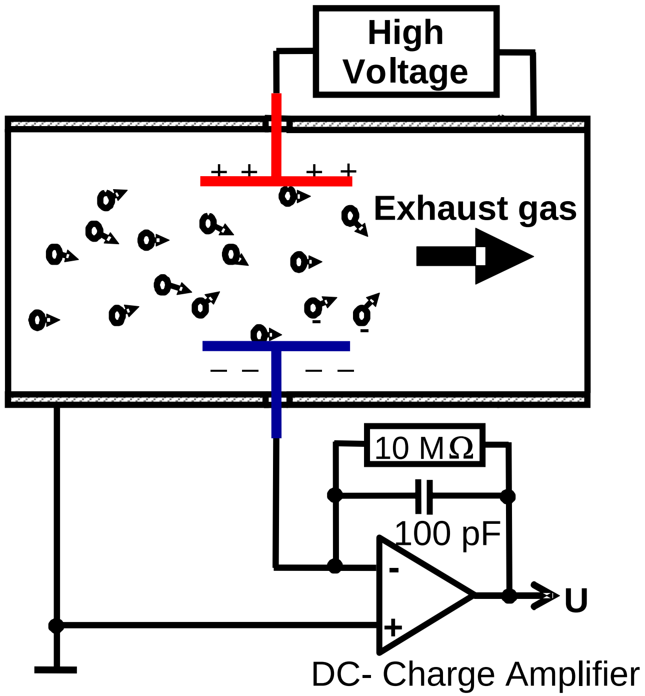


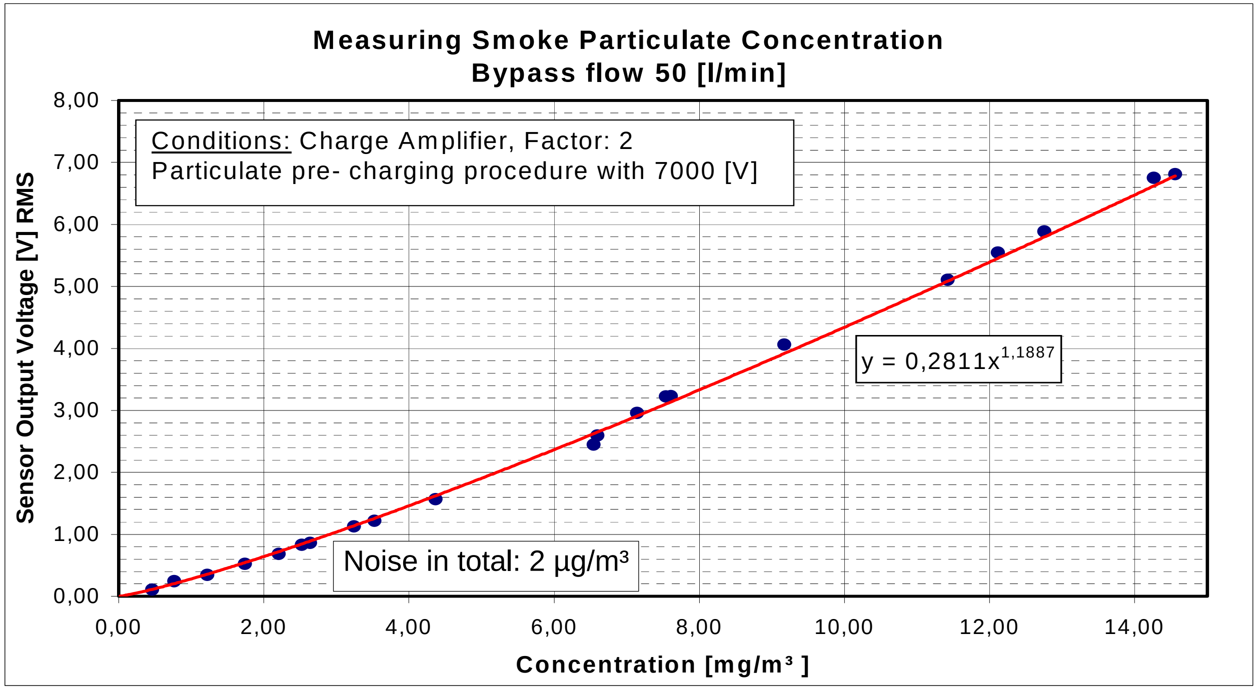


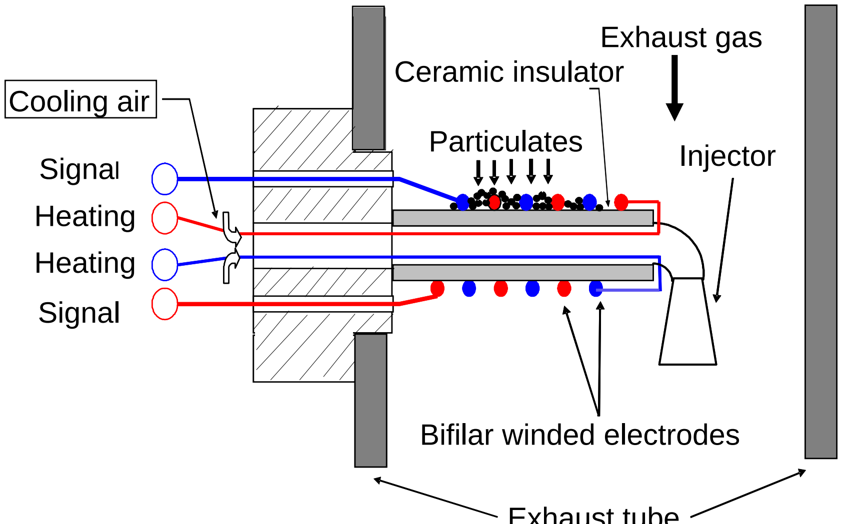
Prof. Dr.- Ing. G. Hauser
Oberer Triftweg 33
D-38640 Goslar

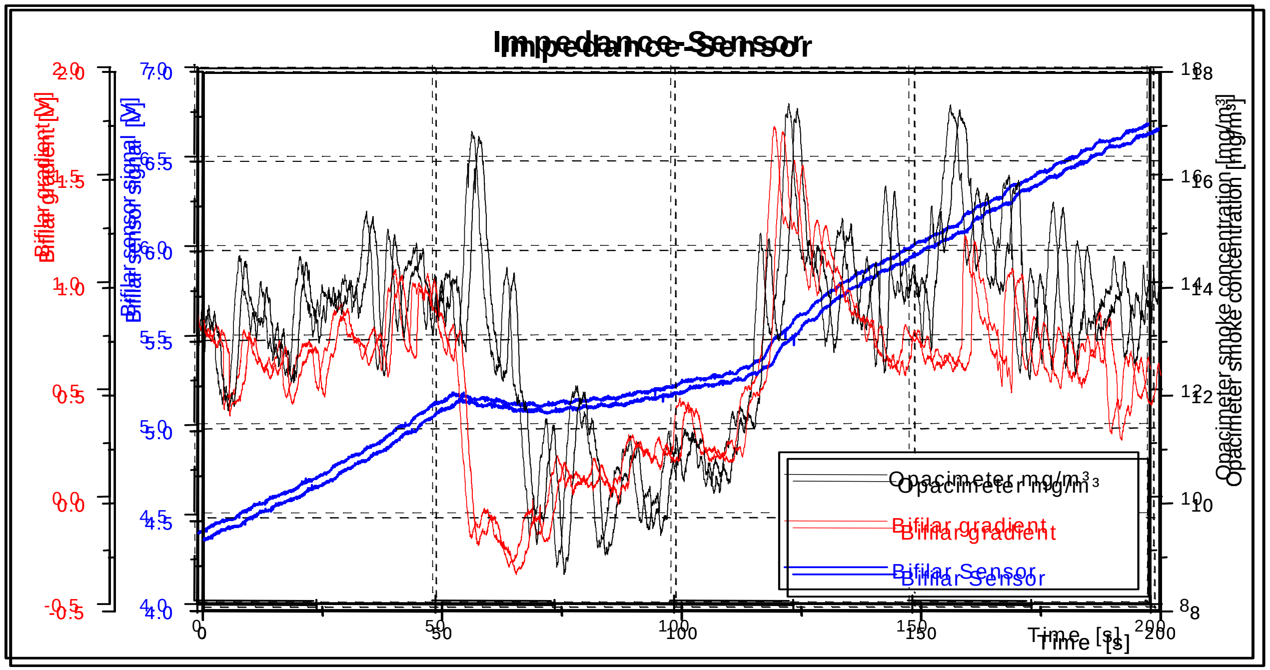
Tel. 0049 (0) 5321 23674
e-mail: g.hauser@fh-wolfenbuettel.de
Home-page: www.cle.de
e-mail: g.hauser@cle.de

Smoke Particulate Sensors for OBD and high Precision Measuring









Prof. Dr.- Ing. G. Hauser, Goslar, Germany