Portable Device for Simultaneous Measurements of Nano- to Micrometer Particles and its Agglomerations at Workplaces

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Introduction

The GRIMM Mini-WRAS for the workplace measurements of nanoparticles and agglomerates of larger sizes has been developed in the frame of the project NANODEVICE.

This portable instrument enables real-time measurements of wide range particles: It measures from10 nm to 35 µm in 41 size channels. From the particle sizes and numbers, the data analysis software calculates masses, surfaces and volumes. Results are displayed online.

A control and evaluation software has been developed to run the measuring hardware wirelessly and remotely from a Windows based PC. The separation of control system from measurement hardware provides great flexibility, as the device can be exposed to sites in health-endangering environments.

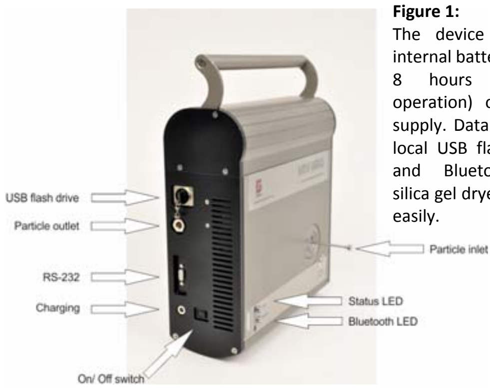

Figure 1:
The device is powered by internal battery (for more than 8 hours of continuous operation) or 220 V power supply. Data storage supports local USB flash drive, RS-232 and Bluetooth. Integrated silica gel dryer can be changed easily.

Instrumentation

Optical Sensor

The optical sensor is a newly designed particle spectrometer to detect individual particles and to classify their sizes (Single Particle Counting).
The light source is a laser diode with a wavelength of 660 nm and an output of approx. 100 mW. An internal pin diode monitors the constant power of the laser diode. It generates the detection signal at highest reliability and performance. The number of particles is determined by the number of scattering light pulses per period. The particle size is determined from the scattered light amplitude. These measurements require a constant flow rate, precisely controlled via pressure sensors. The flow is at regulated 1.2 l/min. The optical sensor is calibrated with latex and dolomite particles compared to a reference OPC.

Electrical Sensor

The electrical sensor consists of three main components, a unipolar corona charger, a precipitation electrode and a Faraday Cup Electrometer (FCE).
Once the aerosol particles (each single particle) are counted and classified by the optical sensor, they pass on to the electrical sensor through a short tube where all nanoparticles are reliably detected by the FCE: Initially the particles gain a unipolar charge (positively) in the electric sensor by a positive corona charge. The particles are separated according to the electrical mobility in the subsequent collecting electrode. A portion of the aerosol stream passes through the collecting electrode and is recorded in the Faraday Cup Electrometer (FCE). Based on the current measured by the FCE, the volume flow, the geometry of the sensor, and the charge efficiency of the particle sizes are determined.

Internal Data Acquisition and Data Transfer

The measurements of both sensors are combined internally and stored on USB flash drive. The storage capacity is enough for numerous measurements and easily accessible from the outside of the GRIMM Mini-WRAS. Additional to internal storage of the measurements all data are transferred online either via a RS-232 or Bluetooth interface. The wireless Bluetooth connection, also used for system control, allows remote measurements in hazardous or difficult to access areas. Special measurement conditions are diagnosed online, signaled by status LEDs and documented in the data protocol.

First Measurement Results

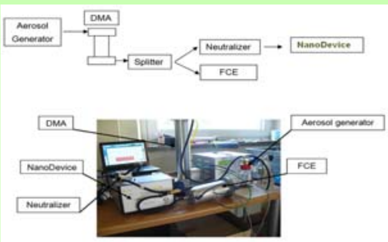

Figure 1: Calibration with NaCl-generator and SMPS

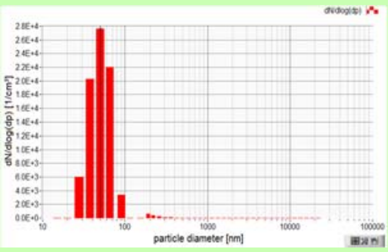

Figure 2: Background size distribution measured at workplace

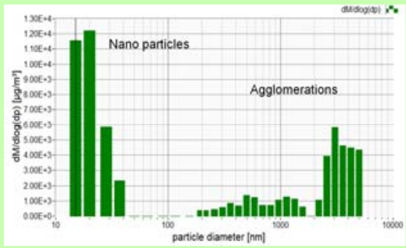

Figure 3: Mass contribution during soldering

Figure 4: Number concentration during soldering

Conclusions

Measurements have proven the importance of an accurate calibration of the Mini-WRAS. Thus initial calibration procedures for both, the electrical and optical sensor have been established for stable and reproducible results over months. Comparisons to reference technologies have shown good accordance to SMPS and OPC.
For workplace measurements, first the background concentrations are to be determined in order to observe the later increase of nanoparticle concentrations due to certain workplace activities. For example during a typical soldering process the workplace nanoparticle concentration increases from ca. 10,000 p/cm³ to more than 350,000 p/cm³.