# Personal monitor for engineered nanoparticles using a MEMS cantilever balance

S. Merzsch[1], H.S. Wasisto[1], I. Kirsch[2], A. Waag, E. Peiner[1] and E. Uhde[2]

[1] Institute of Semiconductor Technology (IHT), TU Braunschweig, Braunschweig, Germany
[2]Dept. Material Analysis and Indoor Chemistry, Fraunhofer WKI, Braunschweig, Germany
Keywords: Engineered nanoparticles, personal sampler, MEMS.
Presenting author email: erik.uhde@wki.fraunhofer.de

Nanomaterials as additives have become common in the production of consumer goods and building materials. The range of application extends from daily live products like cosmetics or wall paints to special uses in high performance coatings, glues. The volume of production exceeds several 10,000 t per year (Hendren *et al*, 2011) for the nanomaterials in most widespread use. Engineered nanomaterials can thus no longer be regarded as a sparely used research object, but have become a type of industrial raw material among others.

Therefore, the production environment, where large amounts of nanomaterials are handled and substantial exposure is possible, monitoring of the air quality is an important issue in respect to further use of this technology. A demand for personal monitors to assess the exposure of workers towards these particles undoubtedly exists (Tsai *et al*, 2011). Simple collection of the particles on filters or impactors offers an affordable solution to this, but requires complex laboratory analysis and cannot provide timely warning in case of increased concentrations in the surrounding environment. Therefore a direct-reading instrument would be more suitable for this purpose. Unlike a conventional particle counter, such a device must be small and lightweight, and the sensor and the electronics must be simple enough to allow a mass production at low costs.

A MEMS (micro-electromechanical system) based approach was proposed to weigh extremely small particles. This concept was developed further to design a particle detector for use in personal monitors. A joint project (NANOEXPO) examines the possibility of using piezoelectrically and thermally excited cantilevers as sensors for ultrafine particles. The project team developed and currently tests a small personal dosimeter-like sampler that collects and weighs ultrafine particles over a work shift.

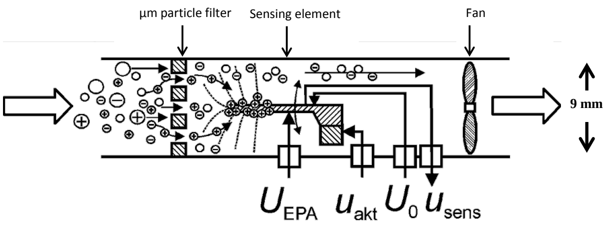


Figure 1. Schematic of the sampler. $U_{EPA}$ is the collection voltage (-480 V)

The sampler consists of a flow channel (Fig. 1) with a coarse-particle pre-filter, the sensing cantilever and a micro-fan to force air through the channel. Sub-micrometer particles are trapped on the cantilever by electrophoresis or thermophoresis (depending on the selected sampling head, Fig 2), the resonant frequency change of the loaded cantilever is then used to determine the mass of the collected particles. The device uses a variable loading phase of 1 – 15 min and reaches a typical detection limit of < 1 µg/m³. The personal sampler is validated in environmental test chambers against test aerosols generated from technical nano-particles ($SiO_2$, carbon, $TiO_2$, Ag, and PTFE).

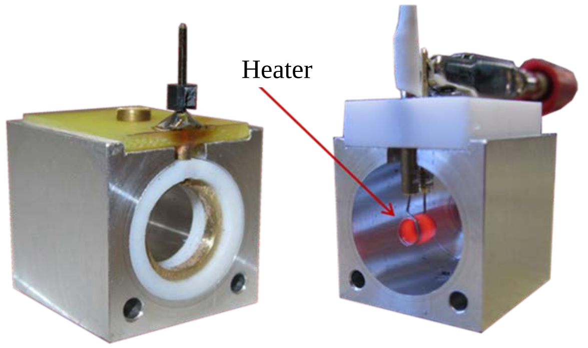


Figure 2. Electrophoretic (left) and thermophoretic (right) sampling head of the personal monitor.

At the current development stage the microbalance-detector prototypes show a mass-sensitivity sufficient to allow for 15-minute measurement cycles if the (preferred) second resonant mode is used for sensing. A mass resolution below 1 ng can be reached under typical indoor conditions, and the cross-sensitivity in regard to environmental changes (especially high humidity, temperature changes) is in an acceptable range. Since mass resolution can be improved with smaller cantilevers, but the particle collection efficiency mostly scales with the cantilever surface area, modification of the cantilever surface is currently evaluated to further increase the sensitivity of the sensor.

The authors greatly acknowledge funding by the German Federal Ministry of Education and Research (BMBF) under grant no. 03X0098A/B.

Hendren CO, Mesnard X, Dröge J, Wiesner MR, (2011) *Environ. Sci. Technol.* 45 (7), 2562-2569

Tsai CJ, Huang CY, Chen SC, Ho CE, Huang CH, Chen CW, Chang CP, Tsai SJ, Ellenbecker MJ, (2011) *J. Nanopart. Res.* 13, 4161-4172