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On-Line Measurement of Particle Size and Composition

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Abstract

The Particle Technology Group at Delft University of Technology is developing an instrument for on-line, real-time measurement of size and chemical composition of individual aerosol particles. Particles are sampled from an aerosol by using aerosol beam techniques. Collimated by the beam generator system the particles enter the ionization chamber of a time-of-flight mass spectrometer. There they are detected by the use of a photomultiplier when travelling through the beam of a small He-Ne laser and thereby scattering light. The photomultiplier signal is also used to trigger a Q-switched YAG laser which is vaporizing and ionizing the same particle. Analysis of the generated ions provides information on the chemical composition of the particles and the photomultiplier signal contains the particle size information.

Keywords

Chemical; instrumentation; single particle analysis; time-of-flight mass spectrometry

Introduction

Aerosols continue to play an important part in numerous fields of science. For example, since substructures are still getting smaller in the semiconductor industry, even sub-micron particles can cause an electronic circuit to fail. It is therefore of the utmost importance to prevent the emission of particles and to reduce their concentration as much as possible. One method to determine the origin of a particle is to measure its size **and** chemical composition. Another application for such a measurement device would be atmospheric processes. Natural and anthropogenic particles can play a major role in atmospheric chemistry, acting as catalyst or reactant. To gain insight in the processes occurring in our atmosphere it would be very helpful to have an instrument capable of measuring particle size and chemical composition in real-time. Until now no commercially available instrument is developed. At the Particle Technology Group at Delft University of Technology a program whereby such a instrument is developed is in progress. The size of the particles is measured through light scattering. The chemical composition is determined with laser-induced time-of-flight mass spectrometry.

Experimental set-up

The instrument as described by Marijnissen *et al.* (1988) consists of a number of components (figure 1). By expanding an aerosol through a nozzle into a vacuum chamber an aerosol beam is formed. Because the particles have a much higher inertia than the gas molecules they continue to travel at straight lines, while the gas is removed by the vacuum pumps. For further details on the beam generator see Kievit *et al.*, 1990.

Collimated by the beam system the particles enter the ionization chamber of a time-of-flight mass spectrometer. The particles are travelling through the beam of a He-Ne laser. The scattered light is measured and gives an indication of the particles size. Furthermore the scattering signal is used to trigger a second laser within 100 ns. This second laser is a Q-switched Nd:YAG laser, which generates pulses of 10 ns length containing 1200 mJ of energy (wavelength 1064 nm). By using frequency doubling crystals the output can be

converted into a multi-wavelength pulse, containing green light (wavelength 532 nm) and UV light (wavelength 266 nm).

The described laser pulse vaporizes the particle and ionizes the fragments. An electric field accelerates the ions into the flight tube of a time-of-flight mass spectrometer. The mass spectrometer detects the arrival of ions at the end of the flight tube. The signal is recorded by a digital oscilloscope and transferred on-line into the memory of a connected computer. Because the laser can fire with a maximum rate of 5 Hz, the data of 5 mass spectra per second has to be transferred, processed and stored. In addition the signal of the photomultiplier has to be recorded and transferred to the computer simultaneously to get the desired information of the particle size.

Figure 1 set-up in principal

Planned data processing

It is planned to use the instrument for classification of different kinds of particles. The idea is to implement a learning algorithm. Such algorithms have to be trained. In this case several spectras of for example two classes of particles have to be classified manually. Those known spectra are used as a training data set. After the training phase the algorithm should be able to classify particles into the trained classes.

Several learning algorithms will be implemented and the results will be compared.

If possible classes are not known a priori a cluster analysis shall be used to find groups/classes of particles (for examples from the same origin).

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