Silicon Filters for Environmental Analysis

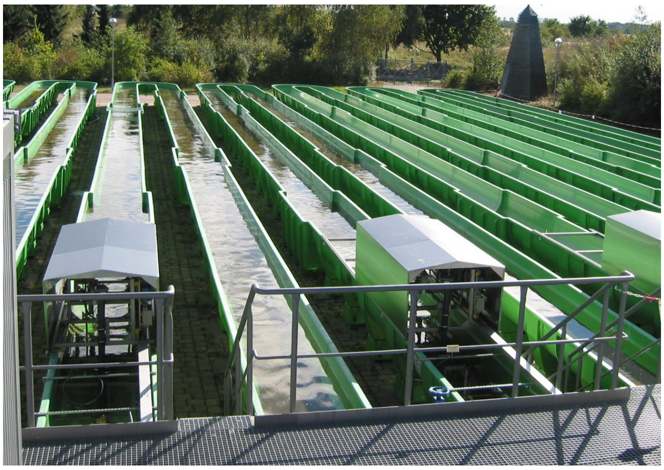
Microplastic Analysis: Smart Filter Systems and Machine Learning

Problem

The introduction of microplastic particles – i.e. plastic particles less than 5 millimetres in size – into our ecosystem is becoming increasingly problematic. But how does microplastics get into water, air and soil? And how can it be investigated and detected there? [1]

Task

For the systematic investigation of sources, transport routes, accumulation and effects in the environment, procedures for efficient and reliable sampling are currently lacking. In particular, selective filters for microplastic rapid analysis are needed.



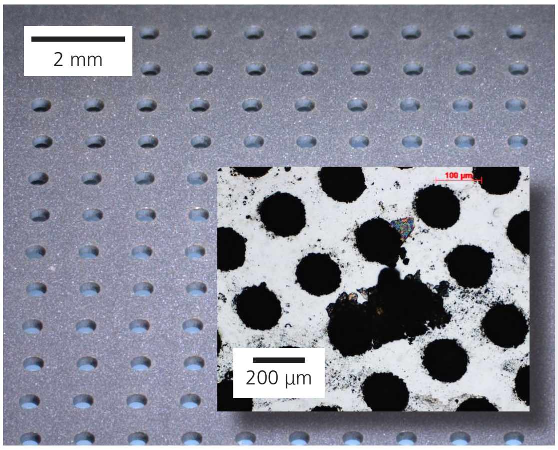
Flowing Water Facility.

Solutions – Filters

The Fraunhofer Center for Silicon Photovoltaics CSP in cooperation with SmartMembranes GmbH offers filter systems (pat. pend.) for rapid microplastic analysis based on silicon and alternative materials (Al_2O_3, glass). The »Smart Sampling« filters are suitable for subsequent rapid microplastic analysis to determine particle sizes and types of plastic.

Solutions – Machine Learning

The classification of microplastic materials is reliably achieved by machine learning algorithms. The data analysis concept is designed to be applicable to any spectral imaging technique.



Background: Large-area Si filter, foreground: Si filter with microplastic particles shimmering in rainbow colors under the microscope.

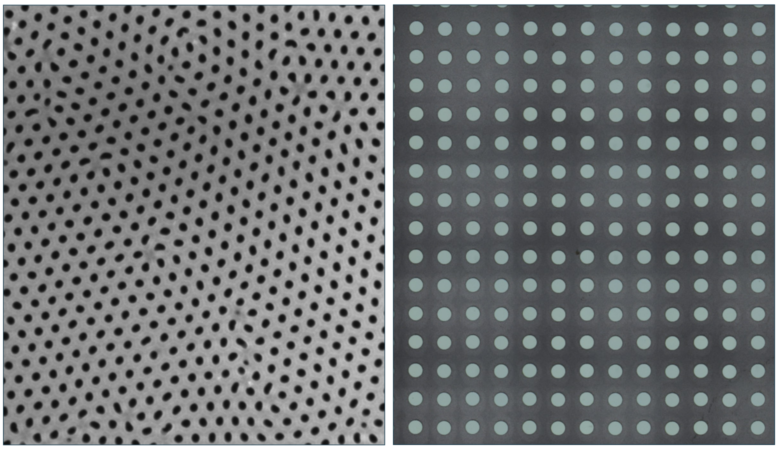
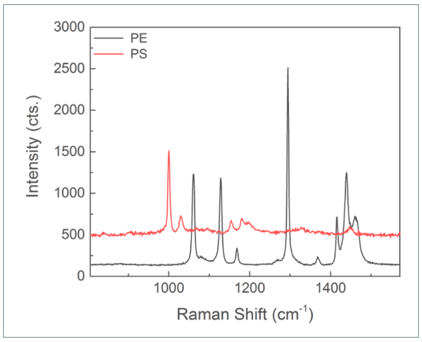


Fig. left: Al_2O_3 filter with hexagonal pore arrangement and pore diameter approx. 20 nm. Fig. right: Si filter with square pore arrangement and 700 µm pore diameter.

Applications

- Use in laboratory and in mobile environmental analysis
- Application in filter systems for sampling in water and air
- Together with chemical treatment of waste water
- Versatile for liquids and gases
- For spectroscopic polymer analysis in transmission and reflection spectroscopy (e.g. FTIR, Raman) [2]]



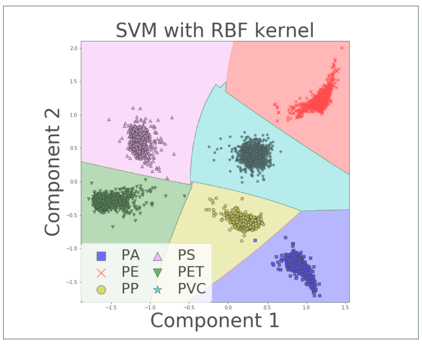
Each imaging pixel in Fig. 1 contains complete spectral data: Raman spectrum of microplastic samples – Polyethylene (PE) and polystyrene (PS) were identified.

Technical Data

- Materials: Si, Al2O3, glass
- Dimensions: 10-700 µm (thickness) x 5 cm (diameter)
- Pore arrangement: square/hexagonal
- Pore distance: 10-1000 µm
- Pore diameter: 1000 µm, 500 µm, 100 µm, 50 µm, 10 µm, 5 µm, 1 µm, <1 µm
- Broadband anti-reflective coating
- Chemically resistant

Data Analysis – Machine Learning

- Algorithms developed for spectral imaging techniques, e.g. Raman spectroscopy, hyperspectral imaging
- Material classification using support vector machines, neural networks



Classification: Support vector machine model for six plastic materials based on hyperspectral imaging data.

Kundenspezifische Lösungen

- Special design:
  - Any geometries up to 200 mm (diameter)
  - Pore size and arrangement on demand
  - Functional coatings
- Analysis of the filter cake with Raman and FT-IR.
- Particle statistics
- Special filter holders, e.g. for mass spectrometric analysis methods

[1] VDI, Plastik in der Umwelt – Quellen, 2015 Senken und Lösungsansätze

[2] Käppler et al., Analytical and Bioanalytical Chemistry (2015) 407:6791–6801

Contact

Dr. Paul-Tiberiu Miclea
Diagnostics & Metrology
Tel. +49 345-5413
Fax +49 345-5999
paul-tiberiu.miclea@csp.fraunhofer.de

Fraunhofer CSP
Otto-Eißfeldt-Sr. 12
06120 Halle (Saale)
Germany
www.csp.fraunhofer.de