

# Innovative filter media by means of integrated nanofibers

Irema-Filter GmbH has applied for a patent an innovative process to integrate nanofibers into synthetic filter media resulting in enhanced filtration efficiency for ultra fine particles at low pressure drop and excellent service life in air filtration.

*Wolfgang Rupertseder, Thomas Ertl  
IREMA-FILTER GmbH, Postbauer-Pavelsbach/Germany*

For more than 30 years Irema-Filter GmbH has been engaged in the manufacture and development of synthetic filter media with the main focus on the production of pleatable and pleated filter media for the last 15 years. The filter media is used as automotive cabin-air filters, where the company holds a marked share of approximately 30 %. Also in the field of industrial applications Irema-Filter products are well-established.

## Requirements regarding future air filtration media

The central requirement for future air-filter-media is an improved efficiency, especially for particles smaller than 1  $\mu\text{m}$ . Therefore, all well-known manufacturers of synthetic filter media are working hard on improving the filtration efficiency by applying nanofibers to their materials. At the same time filtration media may provide an extra long service life and create only little air resistance of which the latter is strongly required especially in times of high energy costs.

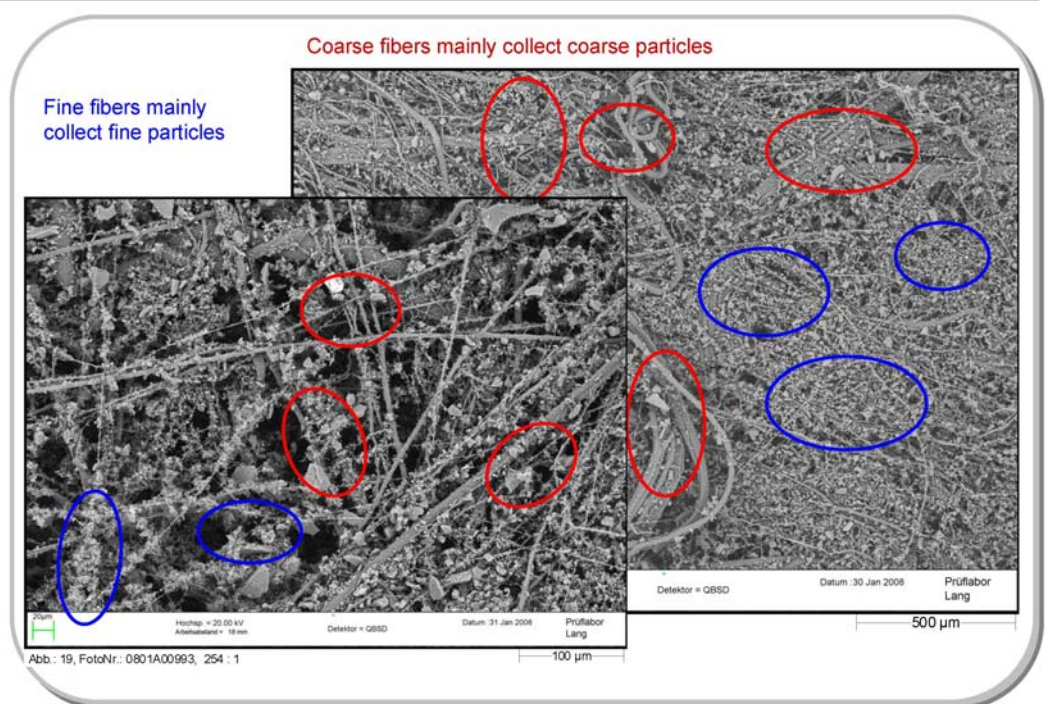
At this stage two questions arise: is the actual favored nanofiber technology the key to solve all three above mentioned requirements and what should such a filter medium look like?

## Capturing finest dust particles

In 1965 Paul Dutch already explored the influence of the fiber diameter on the filtration efficiency of differently sized particles. It has been shown that the bonding forces between the fiber and the dust particle reach highest values whenever the fiber diameter is in the same range of the dust particle size [1]

To verify this effect Irema-Filter GmbH microscopically analyzed different media charged with varying particles (e.g. NaCl, ISO-dust and Ashrae-dust). All samples clearly showed the evidence of the above mentioned correlation. (picture 1)

Picture 1: Coarse fibers – coarse particles, fine fibers - fine particles



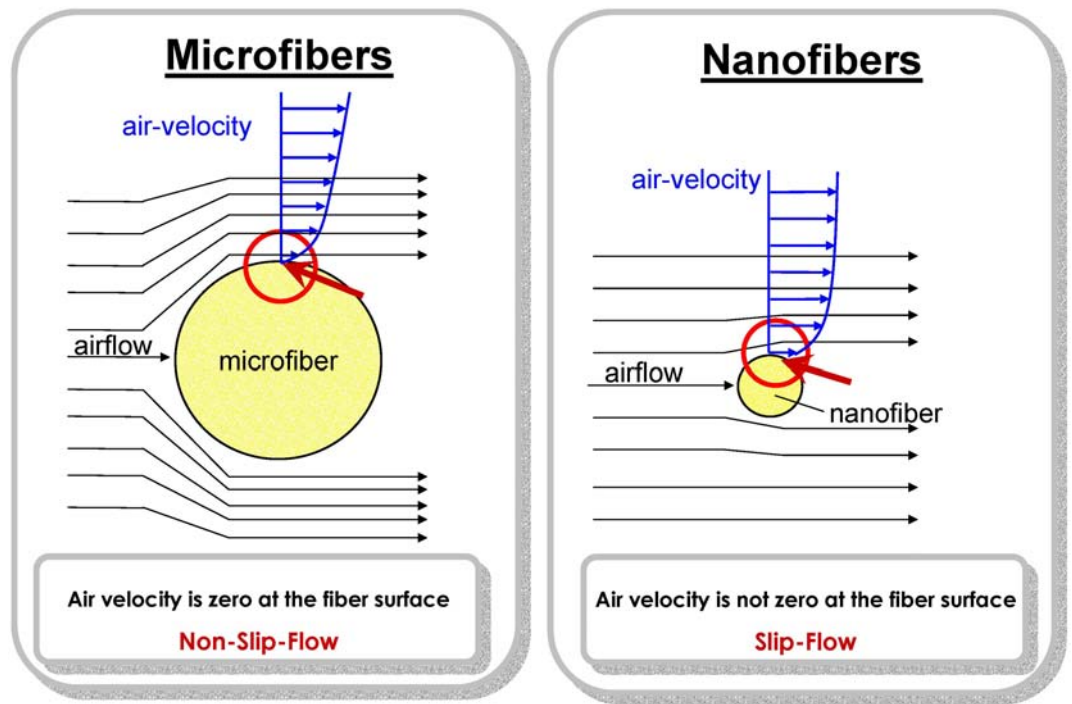
In order to most efficiently deposit finest particles the use of nanofibers is essential. The probability for very small particles to be caught by fibers in the air stream increases with the number of fibers. However, the weight of nanofibers in the filtration medium is negligible. Thereby, it is worth considering that by applying the same amount of material it is possible to produce 10,000 nanofibers with an average diameter of  $d = 100 \text{ nm}$  instead of one microfiber with a typical diameter of  $d = 10 \text{ }\mu\text{m}$ .

### Slip-Flow effect

Beside separation efficiency filter media are also characterized by their pressure drop. Entering the world of nanofibers and nanoparticles, physical effects emerge having a positive impact on the air resistance of filter media.

Regarding the airflow around a microfiber the airflow velocity at the fiber equals zero, thus, resulting in a respective high airflow resistance. However, with nanofibers exhibiting diameters of less than 500 nm the so called slip-flow-effect arises which accounts for a non-zero airflow velocity at the nanofibers surface. In consequence airflow resistance of nanofibers is considered to be very low. [2] (picture. 2)

Picture 2: Slip-Flow effect



### Manufacturing of filter media containing nanofibers

Today, three main processes are commonly used for the production of synthetic nanofibers:

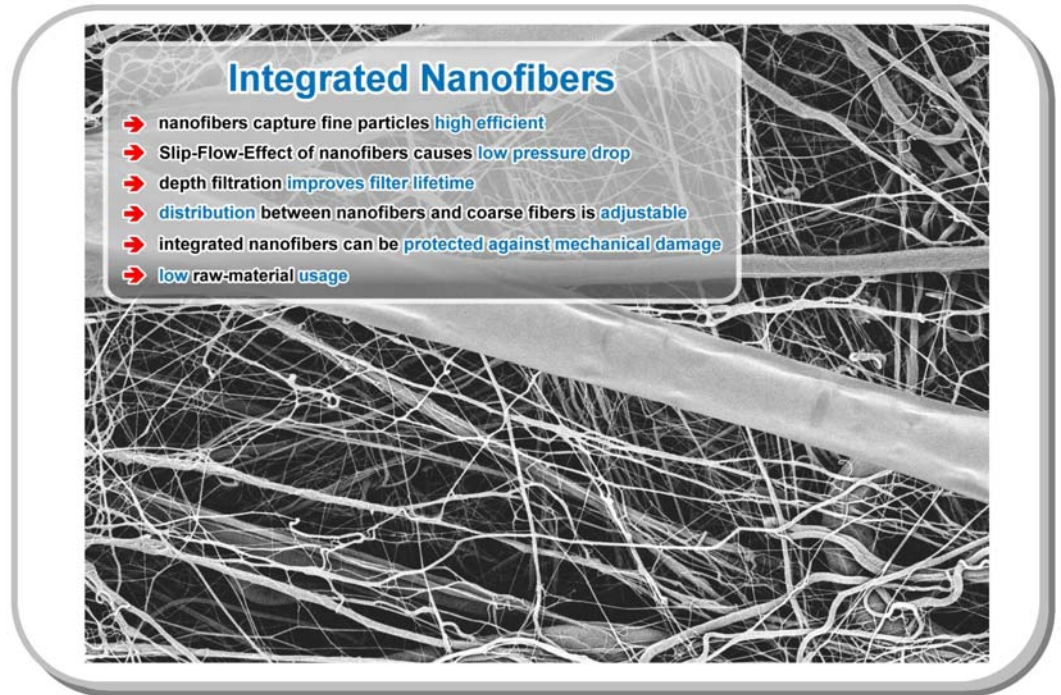
1. Electrospinning
2. Island in the Sea
3. Meltblown process

In all three processes nanofibers are placed on and bonded to a carrier in form of a single layer preferably downstream-sided. In practice it is difficult to bring enough nanofibers on the carrier in order to ensure high filtration efficiency for particles  $< 1 \text{ }\mu\text{m}$  and without creating a negative impact on service life. And: the larger the amount of applied nanofibers the more effort regarding bonding will be necessary which results in a high airflow resistance of the medium. By virtue of this problem Irema-Filter GmbH has developed an innovative technology which enables the integration of nanofibers in the three dimensional framework of the air-filter. Increased amount of nanofibers can thus be integrated within the whole depth of the medium.

### Integrated nanofibers

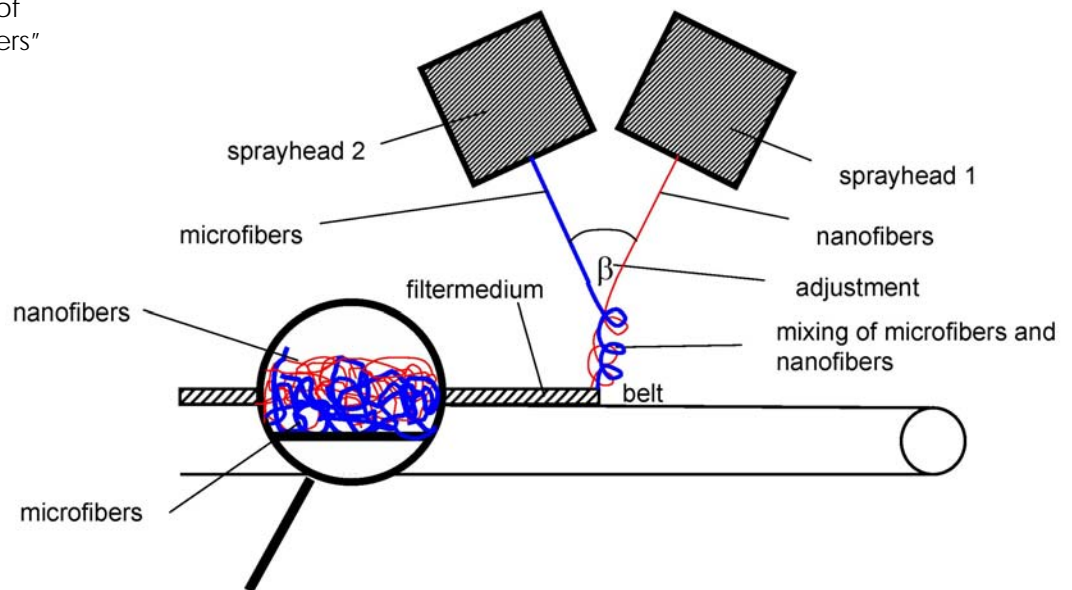
The innovative process of Irema-Filter GmbH is based on a modified meltblown process allowing the simultaneous manufacture and entangling of micro- and nanofibers in a single process step in order to fabricate high-performance filter media. The use of several different and separately controlled spinning devices allows adjusting the concentration of different fiber diameters within the cross sectional area. Hereby every spinning device is dedicated to a specific task depending on product requirements: coarse fibers for stability, microfibers for coarse and fine filtration and nanofibers for fine and finest filtration. (picture 3)

Picture 3: REM:  
Integrated  
Nanofiber



By means of this new technology it is possible to integrate high concentrations of nanofibers in the filtration medium without subsequent bonding. The high flexibility of the process enables the development of customized filter media with highly improved filter characteristics. (picture 4)

Bild 4: Manufacture of  
"integrated nanofibers"



### **First outcomes**

For Irema-Filter GmbH the novel integrated nanofiber technology opens new prospects regarding the development of high performance air filtration media. Several of these innovative filters are already successfully used in automotive cabin air filtration applications. For industrial employment serial production started particularly in the area of HEPA filtration media (H10 and H11). All products are tested and certified by the independent institute fiatic according to DIN EN 779, EN 1822, ASHRAE standard 52.2 and common automotive test-specifications.

### **Literature:**

- [1] National Air Filtration Association: NAFA GUIDE TO AIR FILTRATION, 4<sup>th</sup> Edition, 2007
  
- [2] Graham, K., Ouyang, M., Reather, T., Grafe, T., McDonald, B., Knauf, P.:  
Polymeric Nanofibers in Air Filtration Applications, Donaldson Co. Inc.  
Presented at the 15<sup>th</sup> Annual Technical Conference & Expo of the American Filtration and Separation Society, Galveston, Texas, April 9-12, 2002