Fraunhofer ITWM versus Corona

The year 2020 will always be inextricably linked with the Corona pandemic. The new kind of virus shook all areas of public life. Its worldwide spread was declared as a "public health emergency of international proportions". The pandemic changed people's everyday lives and suddenly presented companies, the economy and the global economy with unexpected challenges. Fraunhofer immediately initiated the "Fraunhofer vs. Corona" action program in order to make scientific findings applicable as quickly as possible in the fight against the pandemic. Fraunhofer ITWM contributed to the fight against the virus with mathematical methods and is one of the institutes with the most anti-corona projects.

Using Mathematics Against COVID-19

In the fight against the Covid-19 pandemic, our experts have been involved in various research projects from the very beginning. They are supporting society and industry in a number of ways and in different areas in coping with the Corona crisis using mathematical methods. A selection of our activities at a glance:

EpiDeMSE – Support for decision-makers

Providing decision-makers at the local level with the best possible support in planning measures – that is the goal of the EpiDeMSE project (Epidemiological Modeling, Simulation and Decision Support). In April 2020, researchers within the framework of the Fraunhofer-Gesellschaft's Anti-Corona Program began working on a tool that provides forecasts of epidemic progression straight away. The model uses time-varying parameters that are estimated from the collected case numbers and compared with other statistical data. In this way, the effectiveness of the measures on the infection rate can also be assessed.

Site planning for vaccination centers

Even before a vaccine against the SARS-CoV-2 virus was available, researchers at Fraunhofer ITWM were already working together with the Robert Koch Institute and Technical University of Kaiserslautern on the site planning for vaccination centers. Answers to questions with many unknowns had to be found: How many vaccine doses are available? Who will be vaccinated first? Where should vaccination take place? In their publications, the researchers looked at different location scenarios and evaluated, among other things, the number of physicians needed, the distance of the population to the vaccination centers, and the number of locations.

Cooperation with the DFKI

Pooling expertise to achieve more together: Together with the German Research Center for Artificial Intelligence (DFKI), researchers at Fraunhofer ITWM have developed a model that simulates and examines possible opening scenarios. EpiDeMSE was used for this purpose. The result is a clear and easy-to-understand visualization of the infection situation and a forecast of future regional developments.

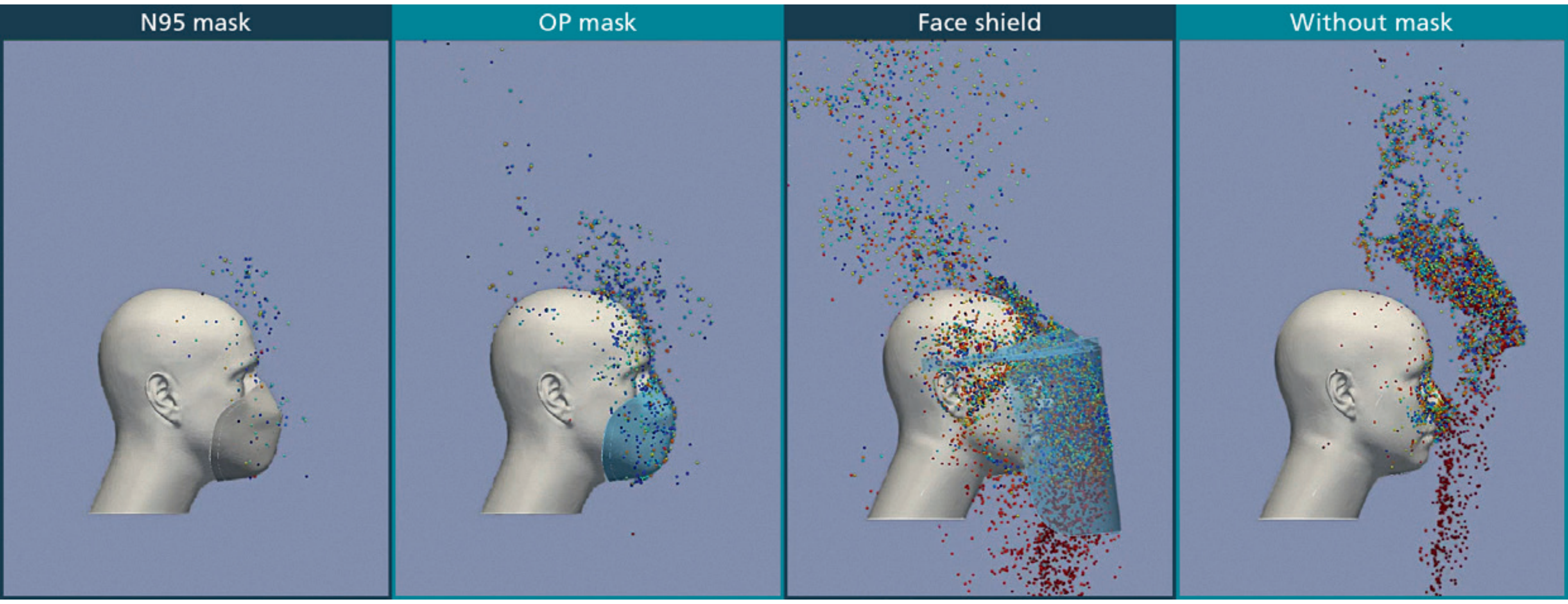
Scatter plot: Blog and podcast

Since the beginning of the pandemic, the statistics blog "Streuspanne" has been devoted to questions and statistical parameters that have shaped the discussion about Corona. In addition to a three-part mini-series on Corona testing, blogging mathematicians and statisticians Dr. Sascha Feth and Dr. Jochen Fiedler also address mutant Corona viruses and conspiracy theories. In the podcast of the same name, the two scientists can also be heard making statistics understandable for laypeople.

More information at www.itwm.fraunhofer.de/itwm-vs-corona

All social media activities under the hashtag #ITWMvsCorona

AVATOR – How Do Aerosols Spread Indoors?



Different types of protective mouth-nose coverings prevent the spread of aerosols to varying degrees.

The Covid-19 pandemic has made many people aware that infectious aerosols play a major role in the spread of disease. In the project “AVATOR” (Anti-Virus Aerosol: Testing, Operation, Reduction), several Fraunhofer institutes are investigating ways to assess the risk and reduce the danger of infection by aerosol-borne viruses. For this purpose, an interdepartmental team at ITWM is developing a multiscale simulator which calculates the aerosol propagation in indoor environments.

Contact

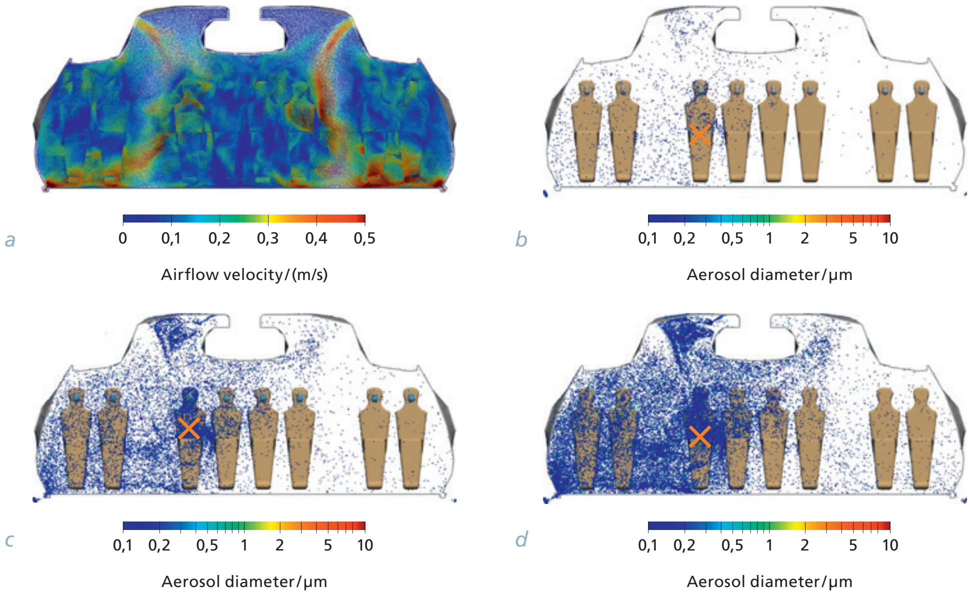
Dr. Ralf Kirsch
Team leader “Filtration and Separation”
Phone +49 631 31600-4695
ralf.kirsch@itwm.fraunhofer.de

Ventilation to fight Corona? SARS-CoV-2 can be transmitted via aerosols – airborne droplet nuclei smaller than ten micrometers. This is also possible in certain situations over greater distances, for example when many people congregate in insufficiently ventilated indoor spaces.

Digital twins simulate situation and form basis for concepts

Against this background, distance, the number of people in rooms, and indoor air hygiene and ventilation are important building blocks in the pandemic. Especially for educational institutions, hospitals, care facilities, hotels, airplanes or trains and offices as well as production facilities, the researchers in the project are looking for answers to hygienic questions as well as practical solutions to prevent the spread of aerosol infections.

In indoor environments, aerosols do not simply disappear, but spread throughout the room over time. In addition to cleaning technologies for indoor air, AVATOR also investigates the spread of aerosols and derives hygiene concepts for specific applications. The researchers are modeling the dispersion mechanisms using ITWM simulations



Simulation scenario airplane – How do aerosols disperse in the interior? Aerosol dispersion starting from the marked person with different masks: a. Airflow velocity; b. N95 masks; c. OP masks; d. without masks

ITWM expertise of many years helps with implementation

Dr. Ralf Kirsch, team leader "Filtration and Separation" of the "Flow and Materials Simulation" department, adds: "In our work, we at ITWM benefit greatly from the fact that we can draw on a broad spectrum of expertise – in this case, our many years of experience in the field of modeling and simulation of filters are very helpful."

Multiscale approach takes several somponents into account

The multiscale approach also incorporates fine details into long-term observations – such as the type of individual protective equipment. Which mouth-nose covering protects how? The researchers then use the simulation results to derive a risk assessment that can be used to compare different indoor air concepts for each scenario.

In parallel to the simulation-based assessment procedures for air dispersion, the participating institutes are developing various air purification technologies. These findings are finally tested in laboratory environments as well as validated in real environments. The project results will then lead to new concepts for reducing the risk of infection with SARS-CoV-2.

In this way, sensible hygiene measures can be developed and the effectiveness of existing ones validated. AVATOR is part of the Fraunhofer Society's "Fraunhofer versus Corona" program and runs until September 2021.

Detailed information about the project including simulation videos
www.itwm.fraunhofer.de/avator_en

Contact

Dr. Christian Leithäuser
Department "Transport Processes"
Phone +49 631 31600-4411
christian.leithaeuser@itwm.fraunhofer.de

Meltblown: Less Clouds in the Simulation Sky

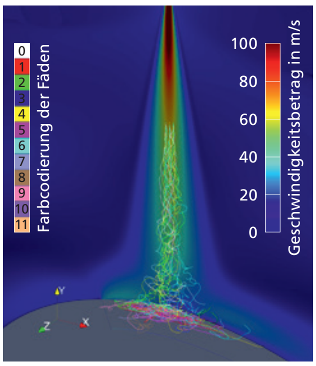
Nonwoven production is getting more attention than ever from the general public in Corona times, because nonwovens are crucial for infection control. Mouth guards, disposable bed linen, surgical gowns, wound protection pads and compresses are just a few examples. The ultra-fine nonwoven products are manufactured in so-called meltblown processes. ITWM simulations help to better understand the production processes and design them more efficiently. Researchers of the "Transport Processes" and "Flow and Material Simulation" departments provide support with their expertise.

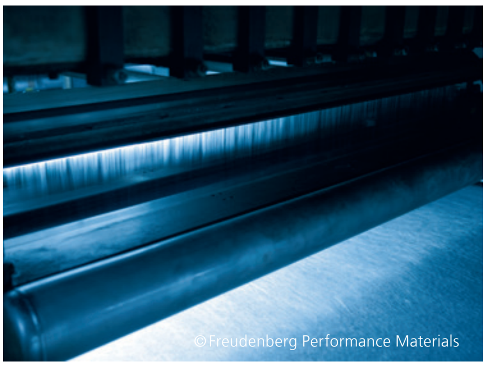
For example, in the Fraunhofer-internal project "ProQuIV", the entire production chain of infection protection is optimized in this way. The abbreviation stands for "Production and Quality Optimization of Nonwoven Infection Protection Clothing". This is because bottlenecks in the production of these materials were observed at the beginning of the crisis. For the class of meltblown nonwovens, increasing the efficiency of production is particularly difficult because these processes react very sensitively to fluctuations and material impurities.

Digital twin optimizes meltblown process

"Meltblown" is the name of the industrial production process whose ultra-fine fiber nonwovens are responsible for providing the crucial filter function in face masks. In this process, the molten polymer is forced through nozzles into a forward-flowing, high-speed stream. It is dispersed and cooled in a highly turbulent air flow. This is how the individual fibers (filaments) are formed. They swirl under the air flow, entangle and stretch, and fall more or less randomly onto a conveyor belt, where they solidify further as they cool.

In this process, a key factor is the behavior of the filaments in the turbulent, hot and fast air flow. The filaments' properties are affected by this air flow. "The complex process poses a great challenge in simulation," explains Dr. Walter Arne of Fraunhofer ITWM. He has been working at the institute for years on the simulation of various processes related to filaments, threads, and fibers. "This is because the quality of the filaments, and thus in the end of the nonwovens, is influenced by many factors. For example, by an aspect we call cloudiness." In the graphic on the right, it is clear what is meant by this: How homogeneous is the nonwoven? "Product quality can be greatly improved if non-uniformity is optimized. Our simulation helps with figuring out how to do that," the researcher adds.

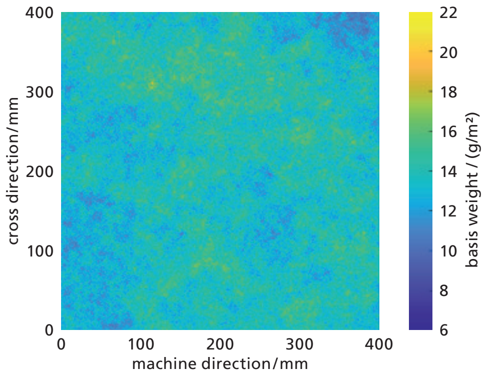




Left: Simulation of filaments in the meltblown production process. Right: Production of nonwovens using the meltblown process in Kaiserslautern.

Top: Quality control of a meltblown material in the clean room area. Bottom: Cloudiness: How homogeneous is the nonwoven? Simulated basis weight distribution as a measure of the homogeneity of the nonwoven.

This is where ITWM software comes into play. "With our Fiber Dynamics Simulation Tool FIDYST, the movements of the fibers, their stretching, their falling, and the orientation with which they land on a conveyor belt are predicted. Depending on the process settings, specific turbulence is created and thus nonwoven qualities that differ, for example, in structure, cloudiness, basis weight and strength," explains Arne.



Simulation across the entire process chain

Digital twins and calculations from Fraunhofer ITWM help to simulate and better understand the processes. The production of technical textiles thus not only becomes more efficient, but the nonwovens can be developed virtually without having to realize this in advance in a test facility. In this way, production capacities can be increased while maintaining quality. Simulations save experiments, allow new insights, enable systematic parameter variations and solve upscaling problems that can lead to bad investments in the transition from laboratory to industrial plant.

However, the virtual implementation of the meltblown process also opens up new opportunities for optimization at other levels: In the upscaling of industrially relevant processes, such as mask production, the ITWM expertise concerning filters is also used. The "Filtration and Separation" team headed by Dr. Ralf Kirsch has been working for many years on the mathematical modeling and simulation of various filters.

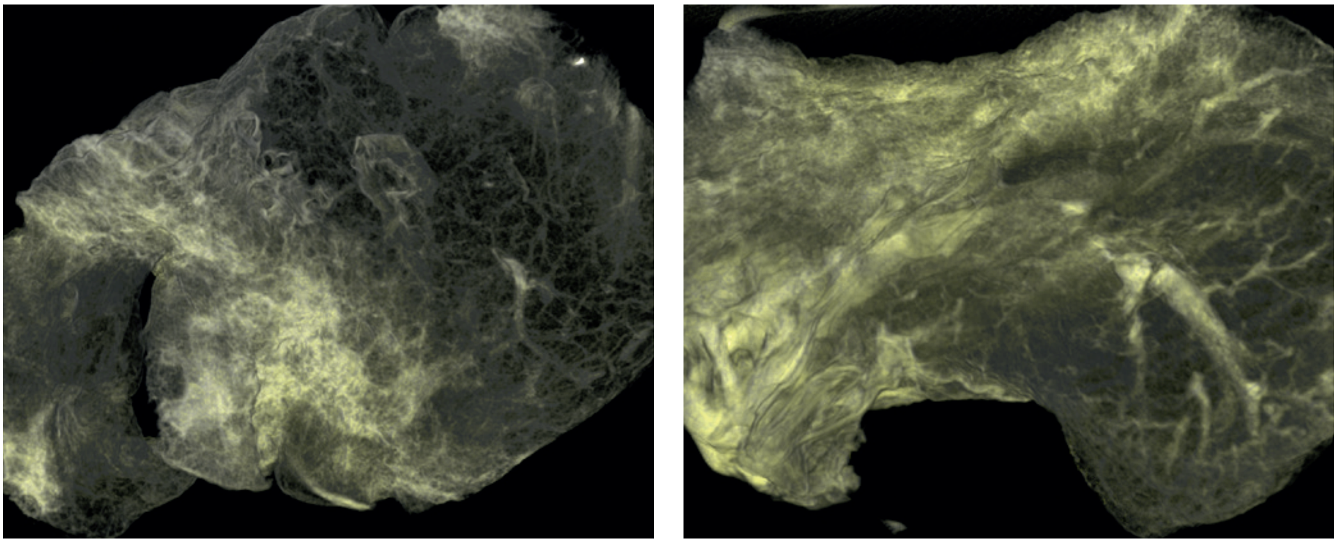
More information, including simulation video, at www.itwm.fraunhofer.de/meltblown-process-simulation

Contact

Dr. Walter Arne
Department "Transport Processes"
Phone +49 631 31600-4347
walter.arne@itwm.fraunhofer.de

Better Understanding Lung Damage from COVID-19

How exactly does the Sars-CoV-2 virus damage the lungs? To answer this question, medical researchers have looked deep into the microstructure of the lungs. Changes caused by Covid-19 can be easily detected with traditional X-rays or thoracic computed tomography. However, to understand the microstructural changes and pathophysiology of Covid-19-induced cardiopulmonary failure, they need microradiological studies. The image analysis algorithms of Fraunhofer ITWM help the Heidelberg Clinic to analyze the image data.

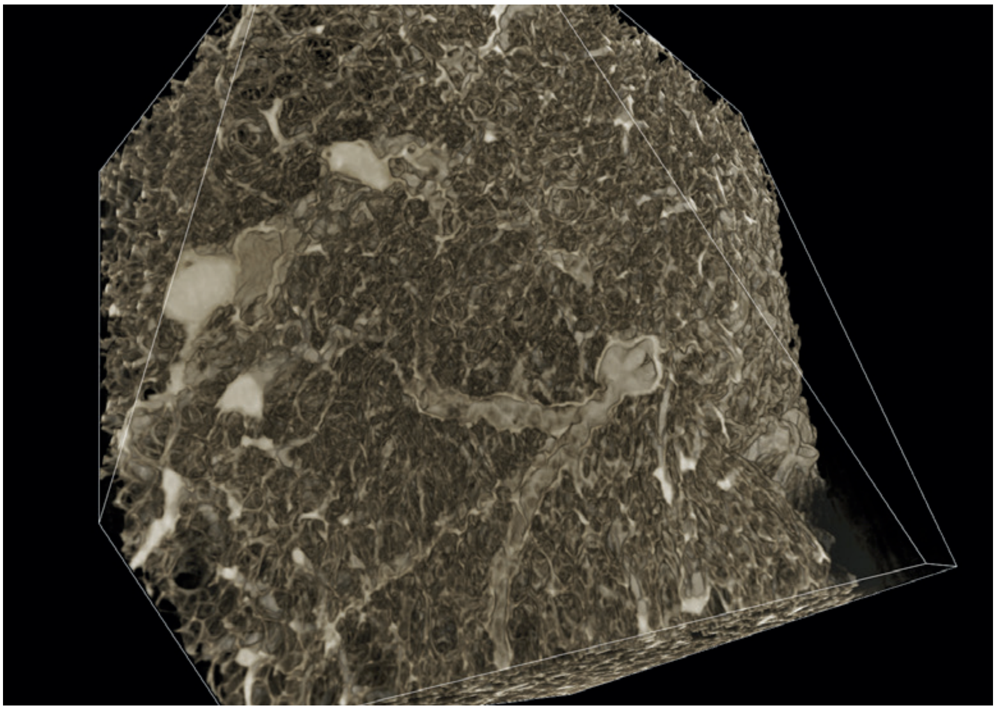


Volume visualizations from the left upper lobe of the lung; sections of size 14 cm × 14 cm × 1.4 cm are shown here.

The University Hospitals of Göttingen and Heidelberg are investigating lung tissue from patients who died of Covid-19 using computed tomography with synchrotron radiation (SRµCT). Thanks to the high resolution and good signal-to-noise ratio, capillary vessels can be visualized and analyzed in the SRµCT volume images. "However, this produces very large amounts of data on very different scales; we can analyze and interpret these with our methods," says project leader Dr. Katja Schladitz.

Similarity between mice and humans – at least in lung tissue

Years ago, the Image Processing department developed algorithms to analyze capillary vascular systems in SRµCT images of prepared mouse lungs and observed regenerative growth at different stages. Typical signs of vascular growth were detected and quantified in 3D images for the first time. In the case of Covid-damaged lungs, the goal is to uncover the



A high-resolution image section from the visualization of the lung tissue of 5.4 mm × 5.4 mm × 4.5 mm: The vascular wall system is visible; the alveoli can be guessed as pores.

causes of typical changes observed on clinical CT: Is local compaction due to tissue scarring, congestion, or hemorrhage? Does the morphology of the vessels change? Which vessels are damaged and how? The answers to these questions help to better understand the disease process and typical symptoms and specify treatment options for Covid-19-induced pneumonia.

"Fraunhofer vs. Corona"

Fraunhofer-Gesellschaft reacted very quickly to the pandemic and launched the "Fraunhofer vs. Corona" action program as early as April 2020. Experts worked, and are still working, at the forefront of the fight against the pandemic, supporting industry and society in coping with direct effects and later consequences. The focus is on anti-Corona projects in the medical and health sectors, such as vaccine development, innovative diagnostics and drug development, but also in the provision of IT capacities. Fraunhofer also provides technological support in the production of components for protective equipment. Accompanying preliminary research also paves the way to a more resilient society.

Fraunhofer ITWM successfully participated in the action program with eight project proposals – the Covid-19 analysis for synchrotron images presented here is one of the funded projects.

Contact

Dr. Katja Schladitz
Department "Image Processing"
Phone +49 631 31600-4625
katja.schladitz@itwm.fraunhofer.de