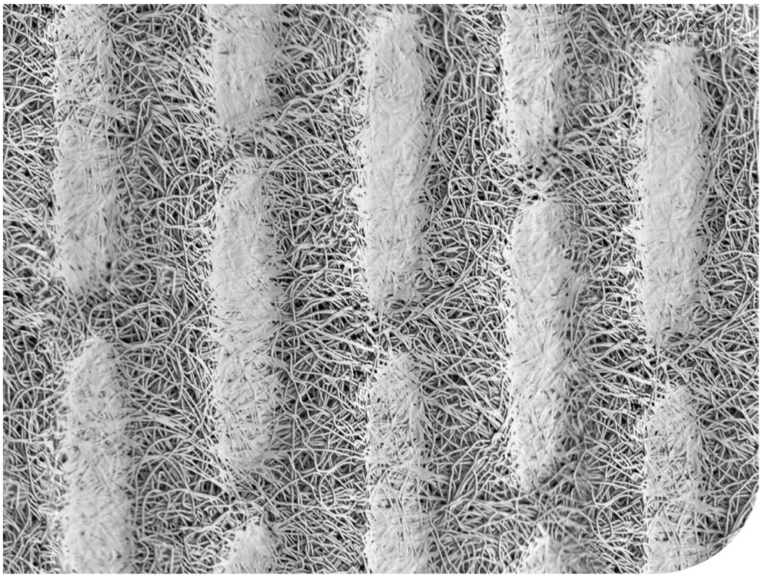

Working in a cleanroom environment not only requires the use of cleanroom consumable materials but also of special wipers. We refer to them here as cleanroom wipers. With these, particles as small as a diameter of about 2 µm and pasty and liquid contaminants can be removed relatively well from smooth surfaces. In cleaning by wiping processes – as is often the case in physics – the phenomena follow different principles in the extreme ranges than in the normal ranges.

Particle Release by Cleanroom Wipers

The Labuda Fulling Simulator Mk1

Win Labuda
Clear & Clean - Research Laboratory

While known contaminants in the macroscopic range can be efficiently removed from surfaces, this is much more difficult when the masses to be removed are in the ultramicroscopic orders of magnitude.

To expand the knowledge base in this application segment, better simulation and measurement methods are needed if cleaning by wiping is to keep pace with the requirements of modern technologies.

What is a cleanroom wiper?

The term "cleanroom wiper" is so far not protected by law. In principle, any wiper manufacturer, importer or distributor may call his product "cleanroom wiper". This is one of the reasons why the provider market for "cleanroom wipers", has become so incalculable over the years. The users are confused that the differences between cleaning wiper and cleanroom wiper are not defined.
Uncertainty also arises from the fact that foreign wiper manufacterers and domestic importers

assign their cleanroom wipers to the ISO cleanroom classes although such classes for cleanroom consumables do not exist. With the parameter particles per m³ of indoor air, the standard ISO 14644-1 only refers to airborne particulate cleanliness and not at all to the cleanroom consumables.

Cleanroom wipers must be constructed so that with their help a maximum amount of contaminants can be removed from an object surface in a very short time, without leaving large amounts of the constituents of the wiper on the surface. This requires different constructions for the various applications of the cleaning wipers (see images of the wiper surfaces, Fig. 2-5).

The existing specifications

With regard to testing particle release from cleanroom wipers, the American and Asian wiper manufacturers usually recommend two specifications:

Specification IEST-RP-CC004.3.

Institute for Environmental Sciences and Technology, Rolling Meadows, Illinois, USA: In this

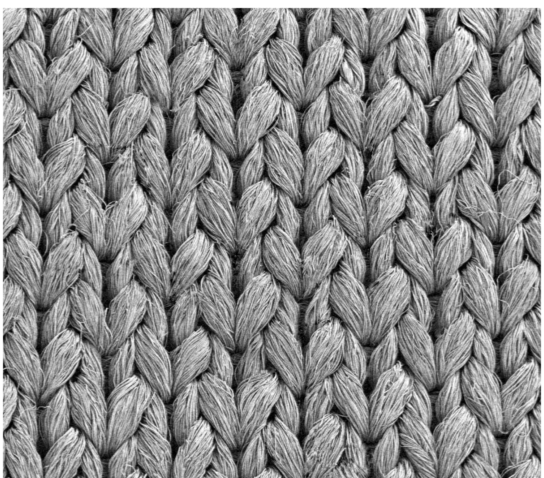

Fig. 2 Cleanroom wiper for fine cleaning

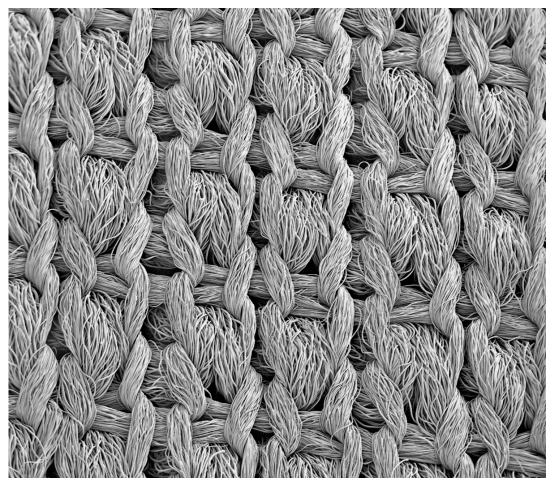

Fig. 3 Cleanroom wiper for cleaning rough surfaces

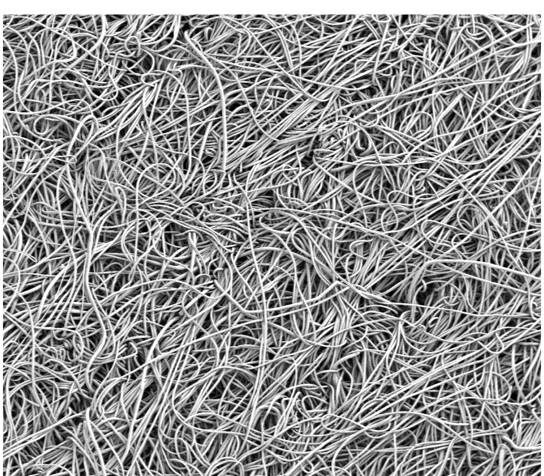

Fig. 4 Cleanroom wiper for wiping up liquids

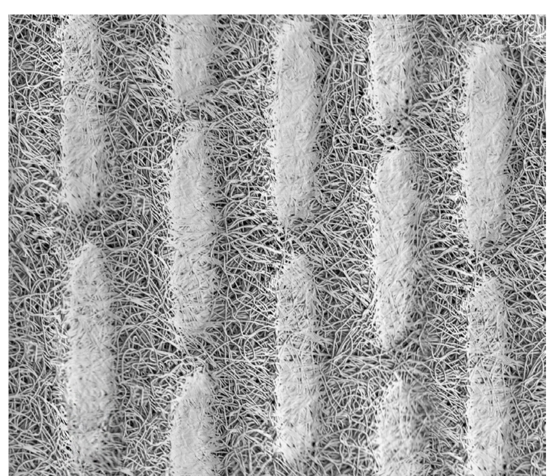

Fig. 5 Cleanroom wiper for floor cleaning

method the sample is immersed in DI water and then moved back and forth in the water. The particles and fibre fragments released into the water are counted and then classified according to size.

"Gelboflex-Test" or Specification ISO 9073-10:2005-03 Textiles – Test Methods for Nonwovens - Part 10: Lint and other particles generation in the dry state."

In the initial position of the simulator, the sample (cleaning wiper) is wrapped around two cylindrical discs at a given distance from each other and affixed to them. At a given distance from the sample, a probe is mounted which counts the airborne particles. By counter-rotational movement concurrent to a lifting motion the sample is twisted on the discs (rotated against each other). Thus, particles and fibre fragments are released from the textile body, which are then picked up by the probe of an airborne particle counter and then counted and classified.

After conducting the last mentioned test (Gelboflex) and obtaining the test results, the users of cleanroom wipers can at least determine whether and how many airborne particles are shed by the tested cleanroom wiper when used in a dry state. From the test result according to the specification IEST-RP-CC004.3, however, no meaningful information can be gained. The transfer of particles into a liquid medium does not correlate with anything and particularly not with the quantity of particles on the object surface after a wiping procedure.

However, actually the user is only interested in the condition of the surface, namely:

- the particulate cleanliness of the object surface following a cleaning procedure.
- the remaining contamination on the object surface, in particular the ion contamination
- the time needed to obtain the required state of cleanliness.

Against this background, the focus in the development of new simulators should no longer be exclusively on the cleanroom wiper, but rather mainly on the cleanliness of the object surface.

However, this is not to say that knowing the ion content of a cloth is therefore meaningless. Because naturally only such ions from a cloth can reach the object surface if they are contained in the cloth. And if the accurate measurement of ion contamination of a surface is only possible at very high cost, then it may be necessary to agree on an auxiliary parameter until the status of technology has found a more cost effective solution.

Modern test equipment

It is an empirical fact that even semiconductor technologists do not want to take a closer look at the procedures of cleaning by wiping, when the product cleanroom wiper poses no danger to the process yield. Obviously this is no longer the case – and has not been for a long time. Already back in 1994 the defect density engineer Rainer Hiller from Erfurt from X-Fab Semiconductor Foundries had examined 5000 chips for noticeable form factors with reference to textile structures and came to the result that the defects due to textile form factors amount to less than 0.3 % of the total defects. The experience is consistent with the statement of defect density engineers from the Infineon Group. Furthermore, a change has taken place in the causes of defects in semiconductor technology over the years: Particle defects are less significant, but molecular and ion contamination has increased in defect relevance.

If we at Clear & Clean continue to invest in the study of particles during cleaning by wiping processes, then simply out of the sheer joy of a researcher in finding out whether certain new wiper constructions show advantages during application. In addition, particle deposits are of increasing importance in digital photography, copying-systems, medical technology and other systems.

During the past 35 years, Clear & Clean has developed test instruments for cleanroom wipers that are especially oriented on the most important use properties.

Fig. 6

Fig. 7

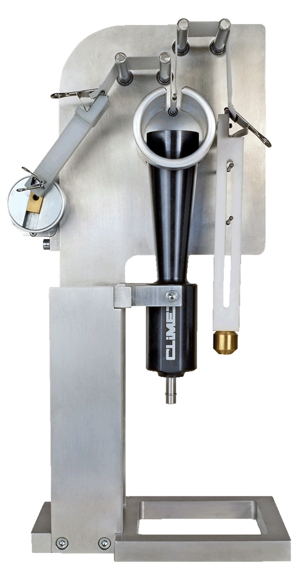

Fig. 8

The new Labuda Fulling Simulator - Mk1

With the "Labuda Fulling Simulator Mk1" (Fig. 8) it is possible to simulate the specific particle release of cleanroom wipers when they are being handled in the dry state. For this purpose, a piece of cloth with the dimensions 220 x 80 mm and with a defined tensile load is wrapped around a rotating shaft and moved back and forth several times. The rotating shaft is mounted above the isokinetic probe of an airborne particle counter. The particles released in the moving process are fed to an airborne particle counter, counted, recorded as data and classified according to the Feret diameter. The device is thus an alternative to the "Gelboflex-Tester".

In this device, the updating of the status of technology is based on the insight that particles are released into the environment from a textile structure that is wrapped around a rotating shaft. This procedure is intended to simulate the mechanical process of crumpling and folding, without this leading to uncontrolled changes in the distance relative to the particle probe.

With this testing technique it is possible to classify cleanroom wipers according to the parameter "specific airborne particle release in the dry state". Apparently plausible differences can be discerned between the thus obtained test data, with reference to the different cloth constructions and products (see diagram, Fig. 11). This speaks first of all for the satisfactory simulation and measurement techniques. What is surprising is the wide range of variation.

The advantages and disadvantages of the Labuda Fulling Simulator Mk1 in comparison to the Gelboflex simulator are the following:

+ Fixed distance between probe and cloth = higher measurement reliability

+ Fewer faulty measurements due to handling caused by particle and fibre abrasion on the sharp edges of the fastening elements

- Cloths must first be cut to fit

- Method is not well known

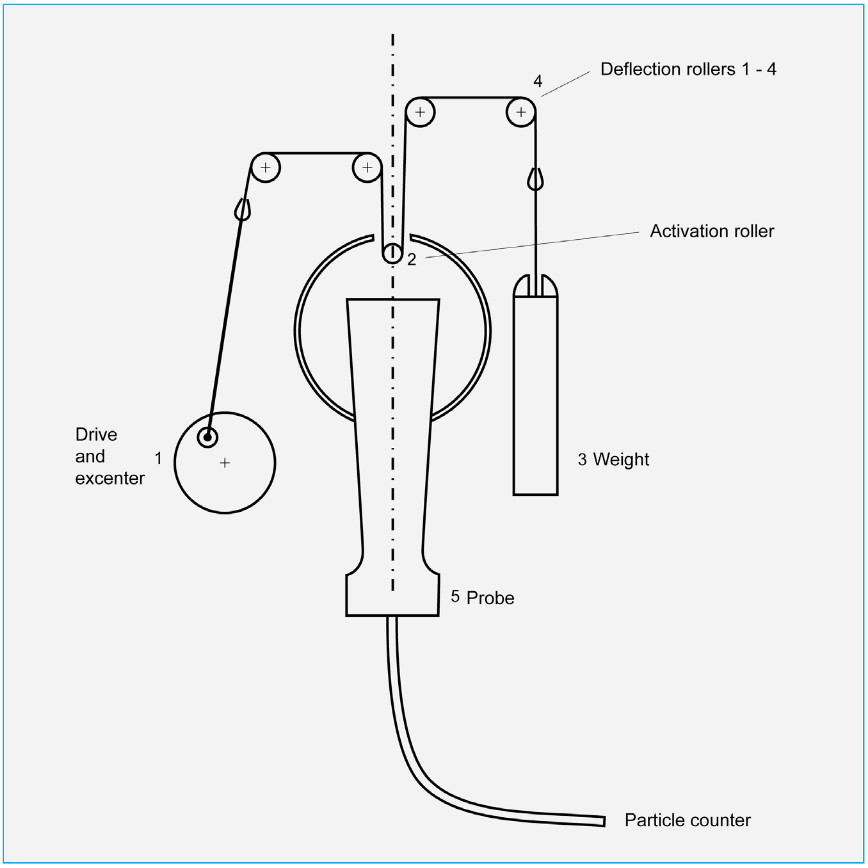

Fig. 9 Schematic diagram of the Labuda Fulling Simulator Mk1

Various Simulators developed by the author since 1990

Particle and fibre attrition
With the "Labuda Rotation Wiping Simulator MkII" the particle and fibre attrition during the wiping process can be simulated on various rough surfaces. (Fig. 6)

Dynamic liquid absorption
With the "Labuda Linear Wiping Simulator MkII", the dynamic liquid absorption during the linear wiping process can be simulated, and the liquid residue on the surface can also be determined.

Specific cleaning efficiency and time
With the "Labuda Rotation Simulator Mk III" with the aid of laser fluorescence it is possible to measure both the specific cleaning time and the cleaning efficiency of each cleaning wiper. (Fig.7)

Particle release in the dry state
With the "Labuda Fulling Simulator Mk1" the particle release of cleanroom wipers in the dry state can be simulated, and with an airborne particle counter can be recorded and classified. (Fig. 8)

Particle deposits on surfaces
With the "Part-Lift" particle collector it is possible to remove and analyse the particle deposit on surfaces before and after a cleaning by wiping procedure.

Equivalence of application and simulation work

Many test instruments for assessing particle release from cleanroom consumables consist of a combination of a simulation module and a measurement module. (Gelboflex ASTM F 392, IEST-RP-CC004.3, ASTM F51M, Helmke Drum etc.) In the simulation module a mechanical process is simulated in practice, which is then converted to a measured value in the measurement module. As an example we choose here the twice folding of a dry cleaning wiper after taking it out of the package and the resulting airborne particle release. In the process of folding the wiper twice, the mechanical work W = F · s is carried out, which induces a release of n particles into the environment. With maximum simulation accuracy of the system, exactly the same mechanical work will be done in the simulator as measured in practice, so that the same particle amount is released. This requirement of simulation accuracy is not always followed in many simulator

Fig. 10 Particle release into the environment through crumpling and moving about

developments – unfortunately including those of the author. If the practical work that was performed did not yield sufficient quantities of particles, then previously the component

Plausibility test of particle release for standard nonwovens (not cleanroom wipers) Labuda Fulling Simulator MK 1					
		$\bar{x}$	VK	Last Measurement	Number of measurementes
Polyester cellulose nonwoven	Grey scale value	2.45			
	Measuring value	**458.9**	26.69	18. Dec 2012	20
Viskose standard nonwoven	Grey scale value	8.5			
	Measuring value	**6354.45**	18.41	18. Dec 2012	20
Viskose microfibre nonwoven	Grey scale value	2.6			
	Measuring value	**10124.65**	15.57	13. Aug 2012	20
Parameter:		Particle Shedding			
Measuring device:		Labuda Fulling Simulator and MetOne Particle Counter			
Load:		100 grams			
Velocity:		72 strokes / min (6 V)			
Sample width and length:		50 x 200 mm			
Edge cut:		mechanical			
Sealing of the cut edges:		none			
Particle size:		0,3 µm			
Measuring time:		120 sec			

Table 1

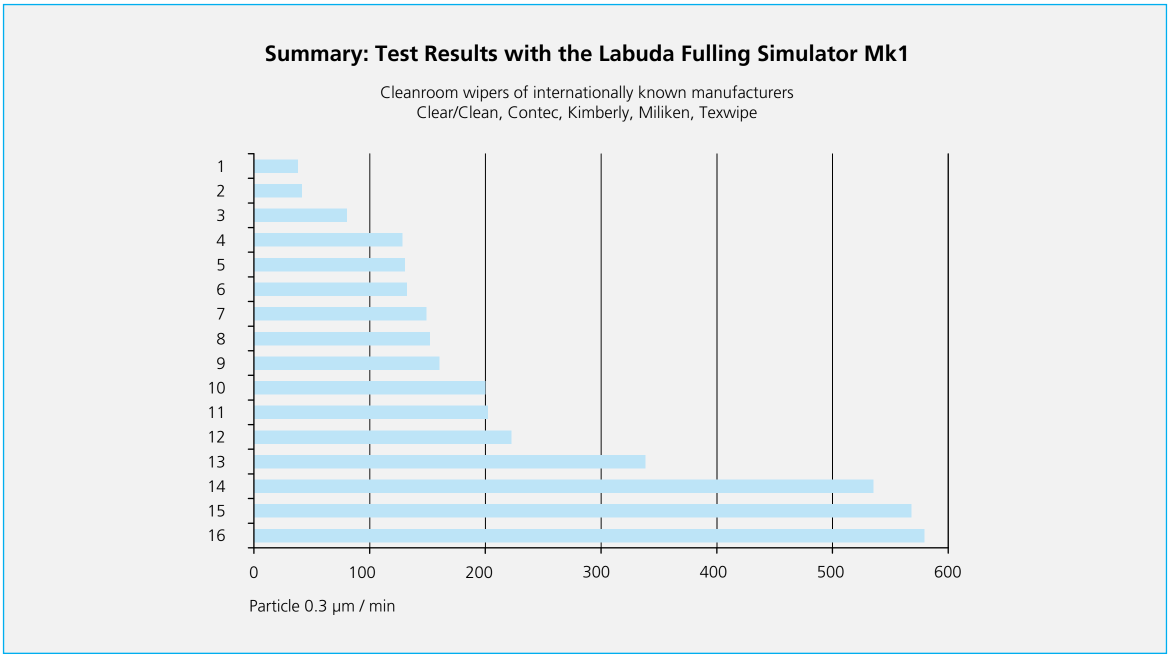

Fig. 11 Test results of the particle releaseof cleanroom wipersof diverse manufacturers

"work" in the simulator model was increased until finally significant amounts of particles were released. The test results were thus unconsciously modulated. If no particles can be measured this however, could mean that there are not any particles. With this in mind, it is necessary to reconsider the basic premises of the known test methods for cleanroom consumables. This would also be a good hint to the various guidelines committees: First, reconsider the test methods and then formulate the guidelines and not vice versa.

- SEM images © Yuko Labuda
- Translation: Carol Oberschmidt

Reference list

[1] „Surfaces" in the sense of this papers are all kind of surfaces encompassed by the athmosphere.

[2] englisch: ISO 14644-1:1999 Cleanrooms and associated controlled environments - Part 1: Classification of air cleanliness. (Die Meßgröße ist: Partikel pro Volumeneinheit Raumluft).

[3] T. Textor, T. Bahners, E. Schollmeyer "Evaluating wiping materials used in cleanrooms and other controlled environments." 41st International Detergency Conference, WFK Krefeld, S. 289-298, Publikationen DTNW 2003, Nr. 2011