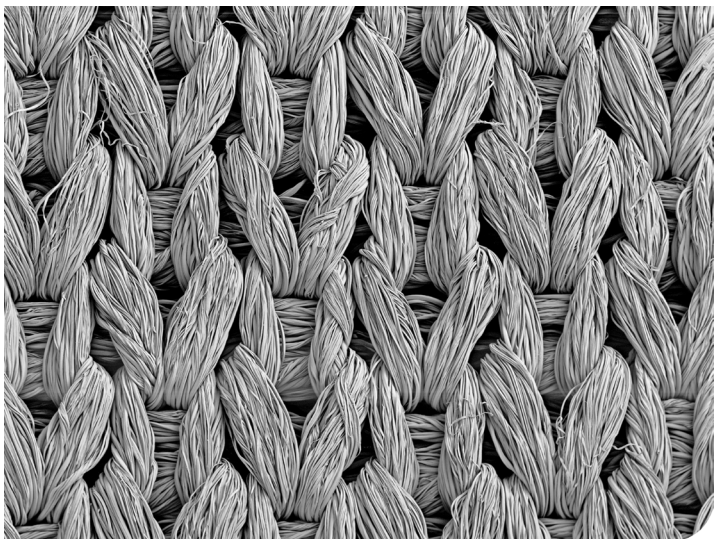

In the semiconductor, pharmaceutical, optical and space industries, cleaning critical surfaces with HiTech-wipers in the production environment has proved to be especially effective. Cleaning procedures are time intensive and are thus a considerable operational time cost factor. Therefore the composition of such HiTech-wipers should ensure that in the shortest possible time the largest possible portion of the contaminants is taken up by the wiper. In many cases, the contamination on the surfaces is invisible. Often the contaminants are particle- or layer-formed deposits in a thickness range < 1 µm.

HiTech-Wipers

Precision tools of a modern production culture in the year 2000

Win Labuda
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The success of a precision cleaning operation is therefore normally measurable neither with the naked eye nor without special effort. Experience shows that a supplier market develops quite varied qualities for all products which have not yet been specified comprehensively and multinationally. The same is particularly true for HiTech-wipers. In this essay the product, the state of technology around the year 2000, and its field of application will be described in more detail.

The cleaning by wiping

During the process of cleaning by wiping a transfer of mass takes place: the contamination is transferred from a surface into the wiper. At the same time, however, small amounts of the mass of the wiper are deposited onto the surface which is to be cleaned. They remain there as undesirable residue, usually consisting of fibre abrasion, meso-particles, submicron particles, oil residue from yarn production, or surfactant or ionic residue from the production process of textile raw materials. During normal cleaning procedures, for example at home or in a workshop, such

contaminant residue from the wiper rarely has a significant effect on the resulting surface cleanness. In highly developed industrial processes, however, such residue from previous cleaning procedures even in the µg range can have a considerable effect on the process result. Since about 1970, for this reason, an industry has developed which offers appropriate wipers for the tasks of precision cleaning.

Classification of the contaminants

The contaminants of surfaces in the HiTech-environment can roughly be divided in two categories. The first group is comprised of such contaminants that essentially consist of organic and non-organic micro-objects. Except for fibres, fragments and skin rub-off, these are all in the microscopic size range. In essence, we are dealing with:

1.1. Fibres, fibre fragments
1.2. Meso-particles < 10 µm
1.3. Submicron particles < 1 µm
1.4. Bacteria < 1 µm
1.5. Virus from < 0.1 µm
1.6. Pollen < 100 µm
1.7. Skin abrasion up to 1000 µm

Besides the particulate contaminants, there are also layer-formed contaminants:

2.1. Fingerprints
2.2. Oil layers
2.3. Grease layers, pastes
2.4. Polymer layers
2.5. Crystallizations
2.6. Paint and lacquer layers
2.7. Gels
2.8. Surfactant layers
2.9. Residues from precipitation
2.10. Liquids

Such layers can range in size from one atomic layer to 500 µm in thickness. Seldom do the contaminants appear singly in layer form or particle form but instead are usually found on surfaces in combination with each other. A HiTech-wiper must be capable of taking up a large bandwidth of contaminants and bonding them securely until they can be disposed of. The bonding of the particles to the wiper fibres ensues principally by means of the Van der Waals forces; the bonding of the layer-formed contaminants ensues by means of adhesion. In moist wipers, on the contrary, the capillary forces bond the solvent which the particles and other contaminants are in.

The classification of HiTech-wipers

HiTech-wipers must be suitable for both, the contaminant to be removed and the surface to be cleaned. With that in mind, the objective should be to remove all contaminants equally well with the smallest spectrum of wiper types. Considering these circumstances, the following allocation between areas of contamination and HiTech-wipers can be established (see Fig. 1).

The use of solvents

Most cleaning tasks in a cleanroom are not carried out with dry wipers, but with wipers soaked in solvents. That can speed up the cleaning process, and in many cases it can make cleaning possible at all. In a cleanroom, solvents for use in cleaning by wiping are composed principally of a mixture of *isopropyic alcohol* and *deionized water*. Sometimes Aceton is also used. For some cleaning procedures in the plasma-etching field of the semiconductor production, isopropyic alcohol and deionized water are used separately.

Type of contamination	Type of HiTech-wiper
contamination on openly accessible cleanroom surfaces (tables, cleanbenches, cleanroom furniture)	standard cleanroom wipers of a polyester/cellulose mixture or of pure viscose fibres
contamination on the machines (inside surfaces of equipment)	equipment wipers of high-quality, multiply decontaminated polyester knit with sealed edges
contamination of optical lenses, mirrors, and ultra-smooth surfaces	optic-wipers of high-density microfilament knits
contamination of the floors	floor-cleaning wipers of abrasion-resistant polymer fibres with high liquid absorption

Fig. 1

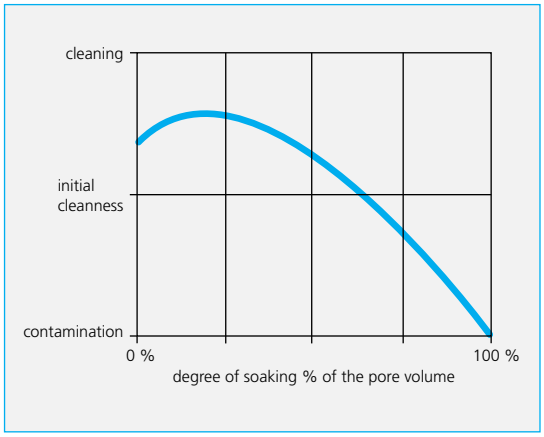

Fig. 2 Efficiency of cleaning by wiping with solvent-soaked wipers

Soaking the wipers with a solvent is normally done manually with a spray pump. By doing that in this manner, the wiper is moistened very thoroughly in those spots or places where the solvent stream hits. In the places which are moistened through and through, however, the cleaning capacity of the wiper is strongly reduced or not present (see Fig. 2 and Ref. 1). It is therefore meaningful to use wipers which have been homogenously soaked and are packed correspondingly.

The cleaning efficiency of HiTech-wipers

The user of HiTech-wiping supplies is not as interested in their purity as in their *cleaning efficiency*, which tells what percentage of the original contamination is still present on the surface after one standardized wiping procedure. This feature determines how long a cleaning process takes and thus how high the costs are for it. The cleaning efficiency of the HiTech-wipers of different manufacturers varies greatly (see Fig. 3).

Unfortunately only one (European) manufacturer identifies the cleaning efficiency of its products (for thin grease layers). Among the cleanroom wipers known worldwide, the cleaning efficiency varies for ultra-thin grease layers on glass surfaces between 15 and 75 percent, depending on the manufacturer and the type of wiper. Figures 4, 5, and 6 show the surface structure of three different models of wipers. Fig. 7 shows the cleaning efficiency of these three wipers in this context. The cleaning efficiency for submicron particles can be measured according to a method by Schmidt, Opiolka, and Kück [Ref. 2] or according to Klumpp [Ref. 3]. For measuring the cleaning efficiency for liquids and pasty contaminants, the gravitometric or ellipsometric method is appropriate [Ref. 4].

Particularly in the precision cleaning of surfaces with a roughness < 10 µm Rz, the points of contact between a surface, the mesh curvatures per cm² wiper (papilla) and their particular forming are determining factors for the cleaning efficiency of a wiper.

Measurement and testing methods

The success of a cleaning procedure with the aid of HiTech wipers is usually not visible to the naked eye. One is therefore dependent on reliable measuring methods for recording and documenting the quality of HiTech-wipers based on their application.

For a long time it did not seem possible to evaluate the quality of HiTech-wipers meaningfully and reproducibly. Technically sound testing methods and the corresponding equipment were lacking. The consequence was often the choice of not very well suited but cheapest possible wipers - to the disadvantage of the user. The results are unnecessarily long cleaning times and a high degree of contamination residue on the „cleaned" surfaces. The testing methods of the US-based *Institute for Environmental Sciences* or *IES*, an institute sponsored by the American industry, such as the immersion method and the twist method (*biaxial-shake method* (IES-RP-CC-004.2) and

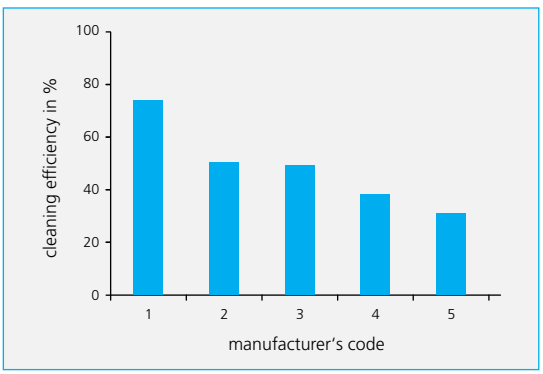

Fig. 3 shows the cleaning efficiency of the 2 most efficient wipers of 5 manufacturers (1 to 5) for thin oil layers on glass substrate

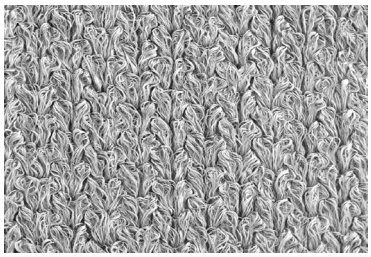

Fig. 4

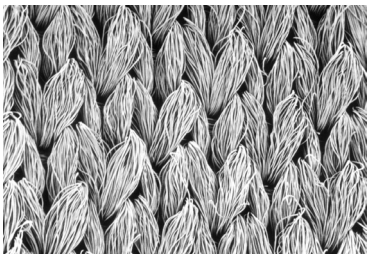

Fig. 5

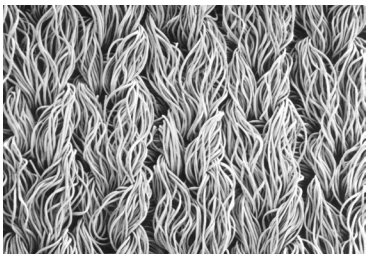

Fig. 6

dry „flex" test) are based on faulty reasoning and have contributed and continue to contribute to the general confusion. For certain reasons, the American wiper manufacturers persist in refusing to accept more meaningful testing methods. European specialist essays are not cited there on principle. Since 1990, however, a European company in the field has developed practically applicable testing methods which are now generally available.

The most important test parameters of HiTech-wipers are:

1 - Cleaning efficiency for different contaminant categories

Complementary aid: fibre and particle abrasion when wiping over specified surface-structures

2 - Liquid residue on the surfaces after moist wiping procedures

3 - Solvent absorption and distribution speed during the wiping procedure

Today there are meaningful testing methods for all of the test parameters listed above. Besides the test parameters mentioned particularly, there are additional parameters which can be tested using relevant DIN-ISO methods. A problem in this context is that the testing methods frequently require special equipment, which is not available to the cleanroom engineer at his own location. In Europe there is a laboratory for the analysis of HiTech-wipers. However, its capacity is rather booked. It would hence be desirable, if easy-to-handle, economical testing equipment could be developed, in order to make comparison quality evaluations of HiTech-wipers at the user's place of application.

The costs of cleaning by wiping in a cleanroom operation

In large cleanroom operations with, for example, a demand of > 1 million wipers per year, cleaning by wiping is an important cost factor. In the past, it was rarely realized that the use of 1 million wipers per year also means that a person takes a wiper into his hands one million times and cleans with it on the average of 45 seconds in duration. One such standard cleaning procedure costs the semiconductor industry about DM 2.10 [Ref. 5]. The material costs for the wipers make up 8.7 % of the total costs of cleaning by wiping; the costs of the cleaning time comprise 84.8 % and the costs of scrap caused by the use of wipers comprise 6.5 % of the total costs. Considerable savings are therefore most possible in the area of the handling of the wiper (cleaning time). The following possibilities of taking cost-reducing measures present themselves:

1 - Prevention of multiple withdrawals of stacks of wipers by the use of suitable individual dispensers and boxes

2 - Reduction of searching, bringing and disposing times by increasing the accessibility of the wipers in the production environment

3 - Use of wipers with a proven higher efficiency

4 - Use of wipers which leave less liquid residue on the surface after the moist wiping procedure

5 - Use of wipers which are delivered in as-received condition already pre-saturated in solvent

The Market for HiTech Wipers

The world market for HiTech-wipers is worth about 240 million U.S. dollars in material value. Because the cost segment *wipers* comprises only 8.7 % of the total cost of *cleaning by wiping* in a high-tech operation, the quality of the HiTech-wipers influences the cleaning-related cost segment *handling* in the magnitude of about 2.35 thousand million U.S. dollars and besides that influences a cost segment *production rejects* in the magnitude of about 180 million U.S. dollars.

A number of specialized companies share the market among themselves. Two of them, one in the U.S. and one in Europe do systematic research into cleaning by wiping; most companies, however, only have a more or less well-equipped quality control. In Germany, one company has produced high-tech wipers for the standard and high-end range since 1979. When considering the invoiced value globally, America is still leading. In research and in the range of high-end products, however, Europe is in the fast lane.

The field's need for impulses from industry and research is pressing. Many of those in charge of cleanrooms have not yet recognized the opportunities to reduce costs in this area. Often, the focus is on the material price instead of on the lucrative possibilities of saving in the area of handling. Technical fantasy, the will to intellectually comprehend and identify with the product, and entrepreneurial thinking are lacking as is a product image which would do justice to the erstwhile technologically high-quality product HiTech-wiper.

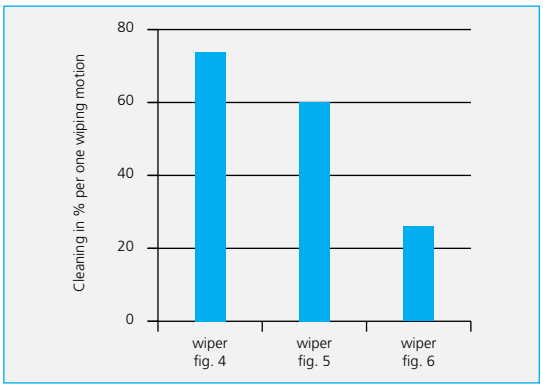

Fig. 7 Cleaning efficiency per wiping motion of selected cleanroom wipers

Market development and the future

In Germany, the market development towards individual dispensers and mobile boxes has largely been brought to a close. Only a few of the users of large quantities of wipers utilize wiper-stacks in plastic bags in production. A preview of the future gives us the following highlights:

- In the high-end range there will be entirely new forms of wiping supplies. These will be better fitted to the actual physiology of the hand than the square wipers and they will facilitate faster work performance. The cleaning efficiency of such wipers will be considerably higher than the products used up till now.

- In the precision cleaning of plasma-etching machines, in semiconductor production, and in cleaning the screens in hybrid circuit production, new kinds of HiTech-wipers without open-lying fibers, fibrils or hard cut edges will be utilized. Machine downtime and the number of production rejects will be reduced in an interesting magnitude.

- Instead of HiTech-wipers in a dry as-received condition, more wipers in the future will be utilized in a moist as-received condition. These will be made available in the production environment in hermetically-sealed boxes or sealable bags.

- There will be precision wipers of ultra-high cleaning efficiency for substrate cleaning. With them, contaminant layers down to < 1 nm will be able to be removed.

- For the parameters *cleaning efficiency* and *surface cleanness* there will soon be methods and equipment for testing that are simple, inexpensive and can be used by everyone without special training.

The author

Win Labuda is responsible for the development of high-end supplies for cleanrooms at Clear & Clean GmbH in Lübeck. Since 1979 he has developed a series of reliable testing methods for high-tech wipers and has collaborated on the VDI (*Association of German Engineers*) national guidelines for surface cleanness. In

1985 he founded a research laboratory to investigate cleaning by wiping. He is the author of fifteen essays on the subject of cleanroom supplies and has held over 100 lectures on the topic to date.

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