Photo: Gerhard Labudda

Fig. 1 Thanks: Win Labuda during his 80th anniversary lecture on 30 June 2018 in the *Gemeinnützige zu Lübeck*.

Win Labuda

Our Contribution to the Purity of Technical Systems

40 Years of Clear & Clean – 80 Years Win Labuda

Illustrated anniversary-lecture in the large hall of the "Gemeinnützige" in Lübeck on 30 June 2018

Fig. 2 Win Labuda (80),
Clear & Clean company founder.

History of the accomplishments by Clear & Clean

1973	Siemens-Munich requests procurement of “TEHKSVIEPÄH”
1973	Visit to TEXWIPE’s Ed and Florence Paley in New Jersey, USA
1973	Win Labuda is an independent distributor for Texwipe in Germany until 1981
1979	Win Labuda founds Clear & Clean GmbH in Lübeck, Germany
1981	First Clear & Clean products presented at the Productronica trade fair
1985	High-temperature cleaning device developed for Siemens
1985	Participation in the guideline committee for wiping agents VDI Guideline 2083 Sheet 4
1986	Clear & Clean supplies Siemens Regensburg with consumables
1987	Development of a particle probe together with Lodevicus Hermans
1987	Labuda Ball-Hammer Test Device for high-tech wipers presented
1988	Win Labuda purchases a 3 acre company property in Lübeck
1989	First special nonwoven gloves manufactured by Clear & Clean
1990	Labuda founds the Clear & Clean Research Laboratory
1991	Start of testing-device-development with Klaus Schöttle
1991	Labuda/Schöttle present the Linear Wiping Simulator MK I
1991	First edition of Clear & Clean Test Methods published
1994	Rotation Simulator MK II presented by Labuda / Schöttle
1994	Patent for Magnetic Card Reader Cleaning Card obtained by Labuda
1995	Patent for Part-Lift Particle-Collector obtained by Labuda
1997	Laser formatting developed together with Reiner Boes
1997	Clear & Clean defines itself as a manufacturer of high-quality special cleaning-products
1998	Production of first high-tech knitted fabrics for Simec Dresden
1999	Patent for glove-wipers obtained by Labuda
2000	Patent for the indicator plate obtained by Labuda
2003	Win Labuda (65) hands over operational management to Yuko Labuda
2008	Rotation Simulator MK III presented by Labuda / Schöttle
2009	Participation in the VDI guideline committee for VDI Guideline 2083 Sheet 9.2 until 2016
2016	Labuda test method for the determination of impurities in textile materials
2017	Microlite particle visualisation by oblique illumination
2017	New laboratory and production cleanrooms at the Lübeck plant
2018	Labuda's 40th article published
2018	Labuda test method for determination PES- and PA-oligomers in textile materials
2018	Win Labuda moves to the Baltic seashore with his wife Yuko

Tab. 1 Company Timeline

Principles based on experience from Clear & Clean Materials Research

1 - In a purity-dependent system, purity is determined by the level of contamination that, if exceeded, compromises system functionality.

2 – In principle, there is no correlation between particulate air purity and surface purity
[see also Fissan-Opiolka, VDI 693].

3 - In a clean manufacturing environment, only the contamination that demonstrably contributes to the reduction of the process yield is process-relevant.

4 - Particle presence, adhesion, emission and release are phenomena that do not affect the process objective of planned manufacturing processes, apart from catastrophic failures.

5 - In production environments with increased environmental purity, neither the resting places nor the propagation paths of particulate or film contamination can be regularly predicted or traced.

6 - The term process-specific contamination barrier [see also literature by Labuda] symbolises the effective inhibition of all active factors against the process-specific spread of contamination. These include process isolation measures (SMIF), laminar air flow, regular cleanroom surface maintenance, rinsing and cleaning processes and many more.

7 - The simulation of the use load for the purpose of a material test must be carried out in such a way that the type and intensity of the stress correspond within narrow limits to the real use load (e.g. +/- 20 %)

8 - Due to the variety of applications and the non-modifiable nature of the raw material, some consumables in clean technology cannot be specified and certified for some parameters of importance in clean technology (e.g. cleaning wipers, gloves).

9 - The metrologically relevant reference point for each surface purity determination before and after wiping is the object surface and not the wiping agent.

10 - The specification of application-related test methods and contamination limit values for cleanroom consumables is currently only possible on the basis of comparative methods of quality assessment.

11 - A certification of consumables of pure technology is only permissible if there are no objections on the part of the experts against the test methods on which the certification is based and the manufacturing companies are subjected to at least one unannounced successful inspection per year.

12 - A causal relationship between consumable-induced contamination and process yield could not be found in the reference literature.

13 - In connection with the application of cleanroom consumables, by experience about less than 5% of the users have a need for special knowledge that is not covered by existing testing technology in the Clear & Clean research laboratory. A modification of the recommended specification structure [VDI 2083-9.2] is not practicable and only led to pointless bureaucratic expenditure, increase of the testing costs and obstruction of the free movement of goods. For some test methods, however, there is a need to adapt to the current state of technology.

14 - The use-induced particle release from the cleanroom consumable surfaces is determined both by the physical work of the surface deformation (in joules) and by the particle adhesion and environmental conditions affecting particle adhesion.

15 - The selection of cleanroom consumables should be process-specific and should take comparative methods into account.

16 - The real use-induced particle release of cleanroom consumable surfaces must always be seen in connection with their filmic impurity.

17 - The higher the ISO air cleanliness class of a production environment, the lower the percentage of cleanroom consumables in the amount of particles present in the cleanroom. Just over 50% of the particles released in an ISO Class 4 cleanroom are released by the people working there and their clothing - less than 2 % by cleaning wipers and gloves [see the Labuda literature].

18 - The testability of consumables or their raw materials in roll form is only given at the accessible end of the roll when rolled up. However, the material defects are often located in the middle of the roll.

Company History 1979 - 2018

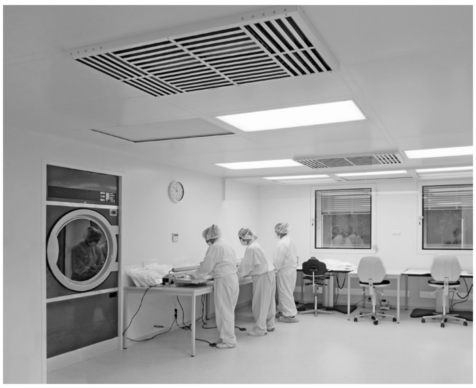


Fig. 3 Laying room at Clear & Clean – ISO class 5 cleanroom.

Fig. 4 Visual inspection and packaging of our high-tech knitted wipers in the cleanroom.

Fig. 5 ISO class 5 cleanroom at the Lübeck plant.

80th ANNIVERSARY-LECTURE by WIN LABUDA

Distinguished guests, dear employees of Clear & Clean,

First of all, I would like to thank my esteemed co-speakers Professor Dr Dr h c Detlef Junker, Professor Dr Heinz Fissan and Dr Jan Michels for their lectures, which have considerably expanded our knowledge in three areas: Atlantic Alliance, Breathing Air and Underwater Fauna.

The following lecture is dedicated to the purity of technical systems and the history of the company Clear & Clean - Werk für Reintechnik, and at the same time it is my 80th anniversary lecture after 54 years activity of entrepreneurial and 40 years of research activity.

Eighty years are a long time. And many of you have accompanied me part of the way, some with good advice, others with astonishment, some with envy, others didn't like me very much because of my outspoken and piquant remarks. But now, on the occasion of my 80th birthday, almost all of us have come together to hear about Clear & Clean and the purity of technical systems.

I have divided my lecture into six parts:

I	*Company history 1979 - 2018*
II	*The development of test equipment*
III	*The Labuda Test Methods*
IV	*The Clear & Clean Research Laboratory*
V	*The technical essays*
VI	*Thanks*

The colourful history of the company Clear & Clean GmbH actually begins in 1973 when my unforgotten friend Hans Zerle from Siemens AG in Munich called me and asked me the following in Bavarian: „You, I need some *Feetzen* from the U.S. – they're made by TEHKSVIEPÄH. Do you know how to get the stuff?" I didn't know what it was all about at all, but I answered the question in the affirmative. A hunch told me that something important was about to happen here. But first I had to get some information: That's how I found out that "Feetzen" in Bavarian means rags or cleaning cloths. "Tehksviepäh" is not a common Bavarian word. So I called the American Chamber of Commerce. They found out that it was probably Texwipe Inc., then a small company with 1-10 employees that manufactured industrial cleaning products in New Jersey.

I arranged a visit, flew to New York to Edward Paley – Texwipe's founder - and his charming wife Florence. He explained his hypothesis about the future structures of the high-tech industries such as semiconductor, PCB hybrid circuits,

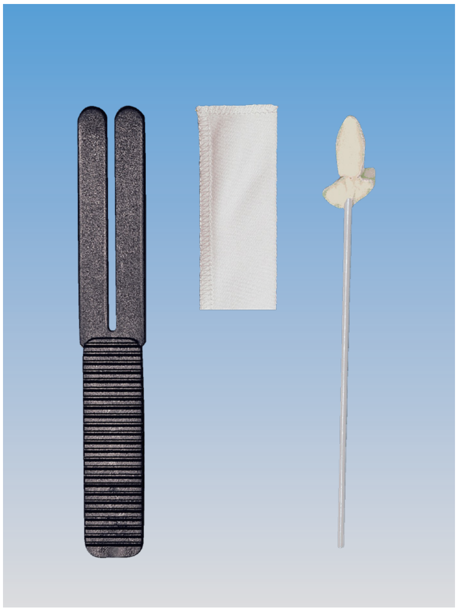


Fig. 6 DISC-O-GRIP™, Cuff holder, first Clear & Clean products for cleaning Siemens hard disc-drives in 1980.

opto-electronics, laser technology and others. These industries would steadily reduce the size of their structures over decades. Natural contaminants such as dust and grease, on the other hand, would basically remain unchanged. This fundamental difference in structure would result in large industries such as the construction of cleanroom installations, measuring instruments, a specialized clothing and filter industry and, last but not least, factories for cleanroom wipers such as Paley owned. The purity of the technical systems would become one of the most precious assets of the 21st century.

Paley‘s remarks were so intriguing that I decided to make the purity of technical systems into my professional life theme, and I have never regretted that decision. For a period of eight years I was then a German Texwipe distributor but in the end Texwipe still did not want to give me an agency contract and I decided to set up my own manufacturing company. There was perhaps a little bit of grudge in the game but also a certain brightness on the horizon that makes such experiments attractive in the best years of a man’s life.

With the increase in importance of the pure technologies in the high-tech industries, more and more cleanrooms and, naturally, more manufacturing and trading companies for the so-called cleanroom consumables emerged wordwide starting in the 1980s. These product groups essentially include: gloves, cleaning wipers, pure paper, pure packaging material and cleanroom clothing. In the English-speaking countries, the industry developed under the generic term Contamination Control. The suppliers were - and are - mostly import distributors or sales subsidiaries of foreign manufacturers who maintain a warehouse here in order to be able to deliver faster.
In this environment, Clear & Clean as a German domestic manufacturing company always had a special position among the users.

In 1979, I had been an entrepreneur for 15 years. After importing microwave and radio tubes in 1964 and importing electromechanical components in 1971, I now wanted to have some experience in building and managing a manufacturing operation. For this I founded Clear & Clean GmbH on my birthday in 1979 and started selling our products instead of Texwipes in the German market in 1981. However, I have all my life retained a high esteem for Ed and Florence Paley. The first three products were cotton cuffs, a cuff holder and a cleaning rod with foam head (Figure 6). The material was used for the cleaning of storage plates, which were then about 40 cm in diameter and had to be cleaned at regular intervals. Siemens AG bought the material from us and delivered it all over the world. But disks got smaller over time, did not need cleaning at the end, and eventually this business ended.

At the same time as Clear & Clean - in 1979 - Ingo Moschner registered Dastex GmbH and in 1982 Jacobus Bartels followed

Fig. 7 Win Labuda and Thomas von Kahlden in the 80s during committee work for the VDI Guideline 2083 Sheet 4.

with the foundation of Basan GmbH and Robert Matzi with IAB-Reinraumprodukte GmbH. Over time, these companies became competitors of Clear & Clean for standard cleanroom consumables such as cleanroom wipers and cleanroom paper. Later, the American laboratory supplies giant VWR also got a taste for it, initially setting up a branch in Germany and buying Basan GmbH from Jacobus Bartels in 2012. Today, in 2018, the cleanroom consumables industry has a worldwide revenue of around 10 billion US dollars.

In 1985, we were in luck - as the saying goes. Siemens Gerätewerk in Munich was looking for a high-tech cleaning element for cleaning high-temperature selenium drums in high-speed toner printing machines. So we developed a silicone oil-soaked mat made of needled Teflon felt, which was fixed between two temperature-resistant hard paper rolls for fixing. After we presented some prototypes, our proposal was accepted and so we supplied this product to Siemens for over 15 years until 2001, when the Teflon cleaning felt was replaced by the cheaper Nomex material from the U.S. This positive business development associated with the felt deliveries later gave us the opportunity to pay for the property in a Lübeck industrial area.

In the same year 1985 Mr K. G. Müller from the VDI-Düsseldorf asked me to collaborate on the VDI Guideline 2083-Sheet 4. There in the VDI working group of the chairman Edgar Sirch I met Thomas von Kahlden (Fig. 7), with whom I soon developed a friendship that has now lasted 33 years. Thomas again brought us into contact with some employees of the Fraunhofer Institute IPA, where he was still working at the time. This again resulted in interesting discussions, which were then also reflected in one or the other product development.

Clear & Clean's entry into the German semiconductor industry as a manufacturer and supplier of consumable products in 1986 goes back fundamentally to one man - the physicist Lodevicus Hermans (Fig. 8). He had made the decision that Siemens-Regensburg would use gloves and cleanroom paper from Clear & Clean in the new MEGA plant in Regensburg.

Fig. 8 The physicist Lodevicus Hermans, Siemens AG, Regensburg, decided in 1986 that Clear & Clean would become a consumables supplier.

However, Hermans had attached conditions to his first order of 200,000 wipers: He had prescribed setting up a testing laboratory, a separate cleanroom with a clean bench and a Climet particle counter. He also encouraged us to invest in a future-oriented knowledge expansion for this material group. Our first (and so far only) sales representative at that time was Mr Jeremy Frederick. He was an excellent salesman, and we have long regretted that he withdrew so early into private life. After word got around among the users that we supplied Siemens Regensburg and also manufactured our products in Germany, we very quickly received orders from all major German cleanroom operators.

At the beginning we hardly knew how to cope with the situation and recruited a number of Polish employees from a nearby transit facility who were awaiting their immigration to Canada. The delivery date for the first order was 1 January 1986. Our busy Poles worked over Christmas 1985 and actually completed the 200,000 wipers for Siemens Regensburg on time. In any case Louis Hermans deserves thanks and recognition above all for the many good technical suggestions, which we received in the course of the time from him. Sometimes I jokingly say that he is also the only one who reads my essays. In 1986 Siemens AG was our only major customer. In the course of time, all the companies shown here (Fig. 9) eventually became Clear & Clean customers. In addition, there are quite a few of those present here, from whom we have received less than 4 complaints despite monthly deliveries over a period of 35 years – and from some of them no complaints at all.

At that time some users urged us to include cleanroom paper in our portfolio. We looked around and found the Japanese company Sakurai, which was responsible for international

Fig. 9 Past and present business relationships (as of 2018, excerpt).

Fig. 10 Exhibition at the *Productronica* in Munich 1987, on the right the future company director.

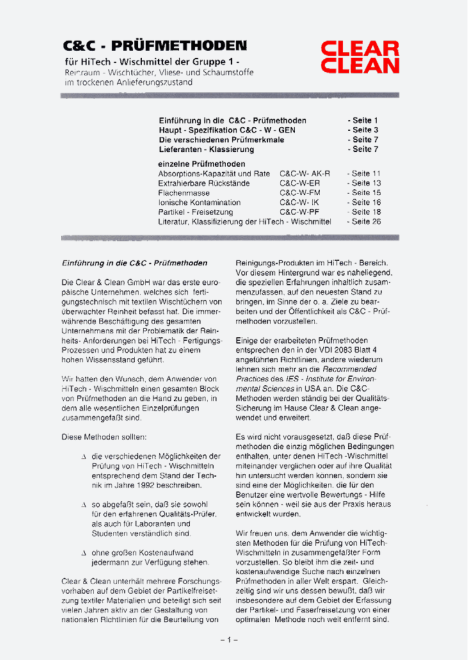
distribution for a paper mill in Japan. We then exclusively sold the Japanese paper of the STACLEAN® brand in the German-speaking area for 4 years. Then there were differences with Sakurai regarding our sales exclusivity. We terminated this business relationship and – with an experienced European manufacturer of long-fibre paper – developed our double-coated, low-ion, special-purpose GALAXY® paper to Clear & Clean specifications.

This is what our company management looked like in 1987, as can be seen in the picture on the right (Fig. 10). On the right you see the future CEO Yuko Labuda in the prime of her life next to a somewhat exhausted company founder. Both of them had just completed a night of stand construction, on the left, Mrs. Elke Schwab, our former sales assistant.

To this day I am grateful to the first customers of that time: Semikron, Fritz Martin's Nuremberg company for power electronics, and next Werner Tomberger from Siemens Villach chose Clear & Clean as their consumables supplier. Intermetall in Freiburg, IBM Sindelfingen, Robert Bosch GmbH at several locations and later Texas Instruments in Freising also opted for Clear & Clean products in the early years.

Also the following year 1988 was significant for us. We bought a 3 acre property and thereby created the opportunity to prepare the company spatially for the necessary expansion.

Fig. 11 The 3 acre Clear & Clean company site. Photo: Herbert Jäger



C&C - PRÜFMETHODEN

für HiTech - Wischmittel der Gruppe 1 -

Reinraum - Wischtücher, Vliese- und Schaumstoffe
im trockenen Anlieferungszustand

CLEAR CLEAN

Einführung in die C&C - Prüfmethoden

Die Clear & Clean GmbH war das erste europäische Unternehmen, welches sich fertigungstechnisch mit textilen Wischtüchern von überwachter Reinheit befasst hat. Die immerwährende Beschäftigung des gesamten Unternehmens mit der Problematik der Reinheits- Anforderungen bei HiTech - Fertigungs-Prozessen und Produkten hat zu einem hohen Wissensstand geführt.

Wir hatten den Wunsch, dem Anwender von HiTech - Wischmitteln einen gesamten Block von Prüfmethoden an die Hand zu geben, in dem alle wesentlichen Einzelprüfungen zusammengefaßt sind.

Diese Methoden sollten:

- die verschiedenen Möglichkeiten der Prüfung von HiTech - Wischmitteln entsprechend dem Stand der Technik im Jahre 1992 beschreiben.
- so abgefaßt sein, daß sie sowohl für den erfahrenen Qualitäts-Prüfer, als auch für Laboranten und Studenten verständlich sind.
- ohne großen Kostenaufwand jedermann zur Verfügung stehen.

Clear & Clean unterhält mehrere Forschungsvorhaben auf dem Gebiet der Partikelfreisetzung textiler Materialien und beteiligt sich seit vielen Jahren aktiv an der Gestaltung von nationalen Richtlinien für die Beurteilung von Reinigungs-Produkten im HiTech - Bereich. Vor diesem Hintergrund war es naheliegend, die speziellen Erfahrungen inhaltlich zusammenzufassen, auf den neuesten Stand zu bringen, im Sinne der o. a. Ziele zu bearbeiten und der Öffentlichkeit als C&C - Prüfmethoden vorzustellen.

Einige der erarbeiteten Prüfmethoden entsprechen den in der VDI 2083 Blatt 4 angeführten Richtlinien, andere wiederum lehnen sich mehr an die *Recommended Practices* des *IES - Institute for Environmental Sciences* in USA an. Die C&C-Methoden werden ständig bei der Qualitäts-Sicherung im Hause Clear & Clean angewendet und erweitert.

Es wird nicht vorausgesetzt, daß diese Prüfmethoden die einzig möglichen Bedingungen enthalten, unter denen HiTech -Wischmittel miteinander verglichen oder auf ihre Qualität hin untersucht werden können, sondern sie sind eine der Möglichkeiten, die für den Benutzer eine wertvolle Bewertungs - Hilfe sein können - weil sie aus der Praxis heraus entwickelt wurden.

Wir freuen uns, dem Anwender die wichtigsten Methoden für die Prüfung von HiTech-Wischmitteln in zusammengefaßter Form vorzustellen. So bleibt ihm die zeit- und kostenaufwendige Suche nach einzelnen Prüfmethoden in aller Welt erspart. Gleichzeitig sind wir uns dessen bewußt, daß wir insbesondere auf dem Gebiet der Erfassung der Partikel- und Faserfreisetzung von einer optimalen Methode noch weit entfernt sind.

– 1 –

Fig. 12 First C&C test methods in 1991.

The picture (Fig. 11) roughly corresponds to the company in 2008.

The Poles who had helped us so diligently in 1985 received some times later the visa for their emigration to Canada. We organised a small farewell party for them which ended with my wife Yuko - a professional pianist by training - performing Chopin‘s Etude opus 10 No 1 by candlelight. Everyone cried. To say goodbye, they solemnly presented us with a farewell gift with the words „this is our most precious possession". We unpacked it carefully: It was a calendar with 12 pictures of Pope John Paul II.

In the 1990s we realised that we needed a connection to the scientific institutions if we wanted to make use of the technological developments of our time, especially in our field, and to study and apply these in depth and benefit from them. In 1985, we first received valuable suggestions from Dr Peter Ehrler from the Institute for Textile Technology and Process Engineering in Denkendorf – a little later from Professor Heinz Fissan, he held the chair of Process and Aerosol Measurement Technology at the University of Duisburg-Essen, and from around 1992 onwards to a large extent from Professor Eckhard Schollmeyer, director of the DTNW - German Textile Research Centre North-West in Krefeld. Our sincere thanks go today to the above-mentioned scientists of these institutions and their staff.

In 1991, I formulated our first Clear & Clean test methods for high-tech wipers and published a brochure with five test methods (Fig. 12). The tests related to the parameters liquid absorption capacity and rate, extractable residues, surface mass, ionic contamination, particle release and methods of classifying wipers. In these test methods we had listed 9 different object surfaces in a matrix for the first time and recommended suitable wiper constructions for cleaning them. In the 2nd edition of the test methods published on 1 August 2007, tests for a larger number of parameters were described. The 3rd edition is currently in preparation.

Fig. 13 1991: Production of Interfold wipers for dispenser, one-hand and single wiper removal.

In the same year, 1991, we saw an interesting market in the high-tech industries for Interfold nonwovens (Fig. 13), which were folded into one another in such a way that the operator would no longer accidentally pick two or three wipers at the same time from a flat-laid pile, but only one at a time from a wall-fixed special container (Fig. 14). The Robert Bosch team in Reutlingen, led by dynamic team leader Thomas Beck, was the first to install the wall dispenser system, followed by Siemens Villach. Siemens Dresden and others later opted for the wall or mobile dispenser as well.

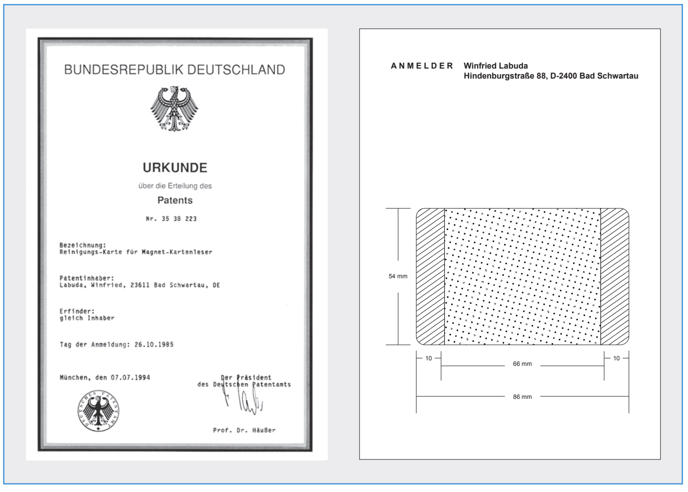
One small oddity from this period: In 1994 I had obtained a patent (Fig. 16) for a smart cleaning card for magnetic card

Fig. 14 Portable dispenser and wall dispenser for the orderly removal of single nonwoven wipers in the cleanroom.

readers. At that time, ATMs had established themselves in the big cities and each of these ATMs had to be cleaned monthly. We alone had the card (we thought). We expected millions of orders from the product. However, the rosy outlook quickly faded when I received a revocation from the Patent Office, telling me that a Japanese had invented the same card the day before. When I asked if the Japanese had applied for a patent for the card, they told me he didn't, but he was willing to conjure up the earlier invention date. He took his oath and I lost my patent.

In 2000 and 2002, we held a symposium on clean technology in the lecture hall of the Institute for History of Medicine and Science Studies at the University of Lübeck (Figs. 17 and 18). In the 2002 symposium, practically the entire industry came to give lectures or listen to them. Gerhard Rauter, then CTO at Infineon, gave the highly acclaimed introductory lecture „The future of cleanroom technology". AMD, Bosch, ELMOS, Fraunhofer GmbH, Infineon Dresden, Infineon Regensburg, Infineon Villach, Micronas, University Duisburg-Essen, and MPI Golm attended, and partly held lectures as well.

Fig. 15 Dispenser bucket with saturated knit wipers. Advantage: The solvent can be replenished as required.



BUNDESREPUBLIK DEUTSCHLAND

URKUNDE

über die Erteilung des

Patents

Nr. 35 38 223

Bezeichnung:
Reinigungs-Karte für Magnet-Kartenleser

Patentinhaber:
Labuda, Winfried, 23611 Bad Schwartau, DE

Erfinder:
gleich Inhaber

Tag der Anmeldung: 26.10.1985

München, den 07.07.1994

Der Präsident
des Deutschen Patentamts

Prof. Dr. Häußer

DEUTSCHES PATENTAMT

ANMELDER Winfried Labuda
Hindenburgstraße 88, D-2400 Bad Schwartau

54 mm
10
66 mm
10
86 mm

Fig. 16 Oddity „Cleaning card for magnetic card reader"
Patent granted, but later revoked.

Fig. 17 2nd *LRTS* Symposium for Clean Techno-logy 2002 at the Institute for History of Medicine and Science Studies, Lübeck.

Fig. 18 2nd *LRTS-Symposium*, front left Profes-sor Dr Heinz Fissan, right Dr Peter Ehrler.

Fig. 19 Laser formatting from the roll to the wiper.

Siemens AG had built another semiconductor factory in Dresden under the name SIMEC, which went into operation in 1995 and soon became the largest cleanroom consumables user in Germany alongside AMD. From the very beginning, we worked there with the chemist Detlef Mitrach as a clean-room contractor. Today he advises our research laboratory very efficiently in questions of trace analysis, for which we are very grateful to him. Two years later Siemens wanted to use high-purity cleaning wipers made of polyester knit for part of the production. Other users also signalled to us that VHT (very high-tech) and UHT (ultra-high-tech) wipers could be a pro-mising, albeit very small, market for the future. Nevertheless, we built a completely new production facility for this in Lübeck. This included the production stages of laser formatting, wet decontamination and low-particle drying. We had already int-roduced laser formatting (Fig. 19) in our production in 1997. This means that our knitted wipers made of PES/PA yarns are automatically cut from a knitted roll into individual wipers using laser technology. In the course of this process, the edges of the fabric are sealed by the laser. Thus, hardly any partic-les or fibre fragments occur in the edge area. However, Simec remained undecided for years and we were left practically without orders for a long time.

However, 1997 was also a key year for Clear & Clean in other respects. The system of full-supply concepts, coming from the USA, also gained popularity in Germany. Full-suppliers are companies that supply the entire demand of a company for a product group, such as cleanroom consumables, and promise price advantages for the user. Basan and Dastex - both trading companies and therefore highly sales-oriented - immediately jumped on this bandwagon and now outbid each other in the market with price concessions.

That year we had to decide whether we wanted to follow this path or not. In the end we decided to remain a manufacturer of high-quality special cleanroom consumables. We wanted to expand both the special product development area and our research laboratory and not become the third full supplier in Germany. However, this also meant a reduction in the size of the company in the long term, less profit expectations and a concentration on intensive technical and scientific work which would perhaps only pay off after decades or even never. I made this entrepreneurial decision rather impulsively, but the market rewarded it in the end. We at Clear & Clean have never had a loss-making year since 1986 - in 2017 and 2018 we struggled with a production capacity utilization of over 100% and were unable to serve a number of prospective customers.

Shortly before the turn of the millennium, however, the semiconductor industry was generally unsatisfactory. Siemens spun off its semiconductor business and created Infineon AG specifically for this purpose. The company was floated on the

Fig. 20 The German-Japanese Yuko Labuda, a member of the management board of Clear & Clean GmbH since 1994, took over as managing director of the operative division in 2003 and successfully managed the company with a steady hand according to the motto „concordia domi foris pax" (harmony within and peace to the outside world). This is also the motto that decorates the Holstentor in Lübeck in golden letters.

stock exchange on 1 April 1999 and six months later its share value had fallen by 45%.

Over the years, Infineon FABs had become the main Clear & Clean customer, accounting for over 50% of revenues. Infineon – in difficulties at the time – recruited a purchasing manager from the automotive industry and assigned a number of specialist buyers to him. One of them confronted us with prices from Southeast Asia that were 50% lower than ours. He threatened to cancel all orders immediately if we did not undercut the Asian prices. At first we were shocked. After all, we delivered 2 million wipers p.a. to Infineon at the time. That means we had a stock of half a million wipers, material for 200,000 pieces in the pipeline from the USA and ongoing purchase contracts for the raw-material for another 1 million pieces.

After three days, I regained my composure, called my staff together and explained that I wanted to end the business relationship with Infineon. Nobody was enthusiastic. However, I wrote a letter to the relevant purchasing officer in which I advised him to terminate the business relationship. Until then, however, we had to comply with his price expectations in order not to sit on raw material for 1.7 million wipers. But after the purchasing manager in question and his followers had all left Infineon, business relations with most locations returned to normal.

The Development of Test Devices

When we started with the production of cleanroom consumables, there were only the test methods of the paper and nonwoven industry for the product cleaning wipers, according to which we could test the quality of our products or compare them with competitor products. It was not until 1987 that the IEST Institute for Environmental Sciences and Technology in the United States issued the IEST RPs, the first methods for evaluating wipers for use in cleanrooms and other controlled areas. But these methods were essentially based on the particulate washout state of the wiping agent and not on the surface purity that could be achieved with it, which was actually the required key parameter. At that time there were certain purity specific parameters which we could not determine according to the test methods existing at that time. In addition, some standard wipers were as a matter of principle unsuitable for testing in cleanrooms.

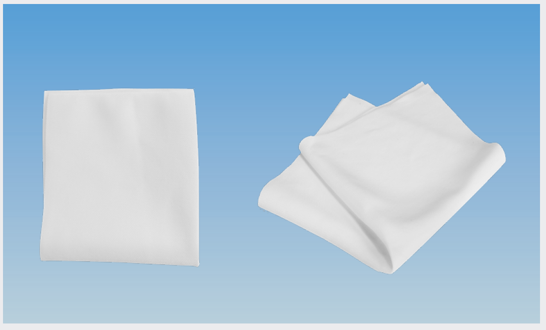


Fig. 21 Knitted wipers.

Precision cleaning wiper | Standard cleaning wiper

Fig. 22 Knitted fabrics have different surfaces, magnification in both images is 130x. The cleaning effectivity of these wipers is very different.

"The eye does not see everything." This statement applies in particular to the use and evaluation of wiping products. At the top right (Fig. 21), for example, we see a cleaning wiper that can hardly be distinguished from the one shown at the left with the naked eye. But in the enlarged illustration (Fig. 22) you can see how different the structures are. The left wiper is well suited for precision cleaning because it has many papillae. The papillae are the „mesh mountains" of a knitted fabric that lie on a flat object surface of low roughness during the cleaning process. The more papillae a wiper has per unit area, the more effective it is for cleaning thin organic layers and microparticles.

How cleaning wipers are used (Fig. 23) is a determining factor for the cleaning success achieved with them. This refers both to the cleaning time and to the impurity mass removed from

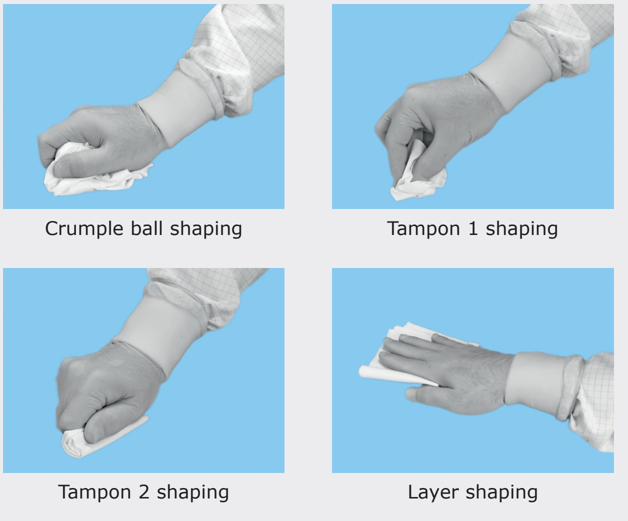


Fig. 23 Handling variants of cleaning cloths [Labuda W., Siegmann, p. „Cleaning wipers - Handling variants and effective surface for cleaning procedures", ReinRaumTechnik 1/2006 GIT/Wiley Verlag, Darmstadt].

Fig. 24 Knit wipers, vacuum-packed, printed PE packaging.

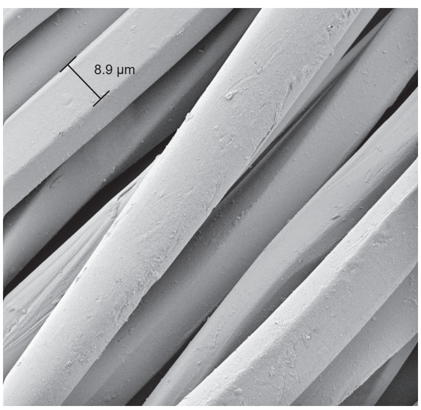


Fig. 25 PET/PA filaments after decontamination. SEM image 10000x.

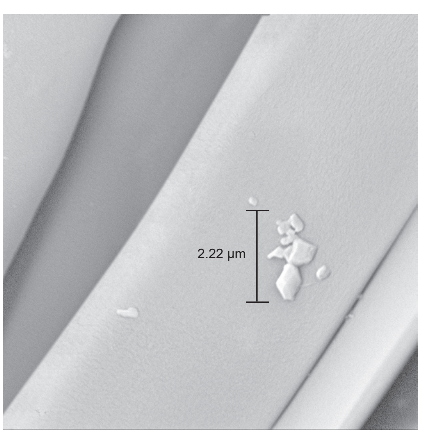


Fig. 26 PET filament with SAP particle SEM image 25000x.

the object surface and not least to the impurity residue on the surface. This is the impurity mass, which cannot be reduced by wiping and with the respective wiper. We can see in the illustration how differently cleaning wipers can be handled. The normal use of a wiper takes place by forming layers. The forming of a wiper during wiping, however, is handled differently from person to person. We show the crumple ball formation, the tampon 1 formation, up to the layer formation. But with layer forming the operator does not have the same pressure force as with tampon 1 or tampon 2 forming. Professor Fissan occasionally honoured us by giving a lecture – just like this morning and in the past at the VDI. This helped us gain deeper insight into the subject, and each of us came to conclusions for his own area. We at Clear & Clean have tried to classify any particle deposits on fibres and filaments of textile structures. At that time I differentiated the particles that are deposited on polymer fibres or filaments according to their adhesive characteristics:

WAP – weakly adhesive particles and
SAP - strongly adhesive particles

The latter mentioned I have subclassified further in

SAP-A types: Particles or fibre fragments which are attached to the textile fibre by adhesive substances (fibre accompanying substances) - and:

SAP-B types that are attached to the polymer fibre by strong Van der Waals forces and could be carried back into the atmosphere, e.g. as a result of low air drafts, to find a new resting place sometime and somewhere.

What we had not considered sufficiently at that time was the large number of oligomers, which can be found especially on the surfaces of polymer yarns and which we are still not easily able to differentiate from the particles produced by material abrasion. In 1976, the textile researchers Valk, Stein and Dugal, and later Ehrler from the Institute in Denkendorf, in particular, repeatedly pointed out the oligomer phenomenon as well as the problem of the possible connection between particles and organic substances on the filament surfaces of the yarns.

The Labuda Test Methods

Fig. 27 Ball-hammer test device according to Labuda (1987) for particle release from textile surface structures.

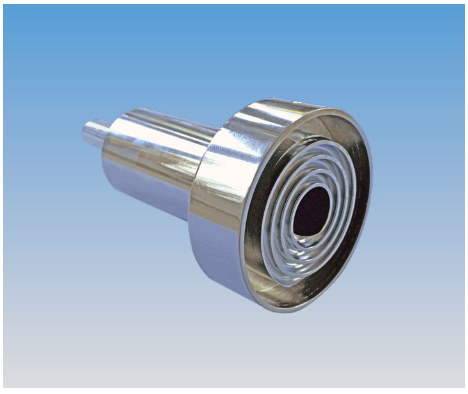


Fig. 28 Hermans/Labuda probe. Labuda had the idea of particle separation in attachable mechanical channel systems in 1987 and Hermans contributed the idea of spiral compression.

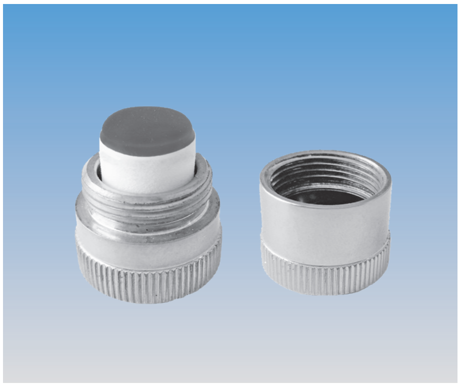


Fig. 29 PART-LIFT™ 1996 Part-Lift device for detecting the particle and fibre fragment coating on surfaces with low roughness (Labuda patent).

Let us now turn to the test methods and devices for cleanroom consumables I developed and Klaus Schöttle built at the time.

Labuda-Balk Fibre Shear Test
Our cleaning sleeves were used in the 1980s, among other things, to be rubbed over the sharp-edged read/write heads of disk storage systems in a solvent-soaked state for cleaning. This resulted in fibre abrasion. After we had separated from Texwipe, we naturally did not only find friends among the customers. Some of our opponents claimed that our cuffs released more fibres during cleaning than the competitors' cuffs. A test method had to be found. At that time, the Siemens mathematician and physicist Adolf Balk helped me out of a tight spot. He determined for the Siemens Data Technology Group that the sleeves had to be tested after the „fibre shear test according to Labuda" and we were comparatively good at this test. There was no other test method at that time.

Back in the 1980s there were still no instruments with which we could measure the use-induced particle release of a cleaning wiper. So most „experts" took the wiper in their hands, pulled and tugged at it or tore it in half over the probe of a particle counter. But of course this resulted in hardly plausible „test results". Then I tried to get some order in the simulation of the use-induced particle release of cleaning wipers by the „ball-hammer testing device" (Fig. 27) developed by me - Edgar Sirch nicknamed it „Labudator". A cleaning wiper is clamped in the head section of the device. A ball hammer will drop on the stretched cloth twenty times in free fall. The isokinetic probe of a particle counter is mounted a few centimetres below the plane of the tensioned cloth and the particles detached from the wiper during the impact of the falling ball are counted in a particle counter and classified according to size. Despite its apparent simplicity, the whole model was not a completely successful design, because the material tension varied during the clamping of the test specimens due to the design. To my knowledge, it was the only device that allowed non-destructive measurements on overalls. For example, Werner Tomberger from Infineon Villach used the device for years to test the cleanroom clothing for particulate cleanliness. However, it did not survive the times.

Labuda-Part-Lift-Collector (Patent) (Fig. 29) to collect particles from smooth surfaces. I thought at the time that somehow it would be necessary to remove the particles that were on smooth surfaces 1:1 in order to examine them microscopically. We used a cylindrically shaped elastomer rod and applied an adhesion surface to it. The whole thing was provided with a screwable housing. The elastomer rod with adhesion surface exceeded the housing plane by exactly 4 mm so that the contact pressure was always the same. For

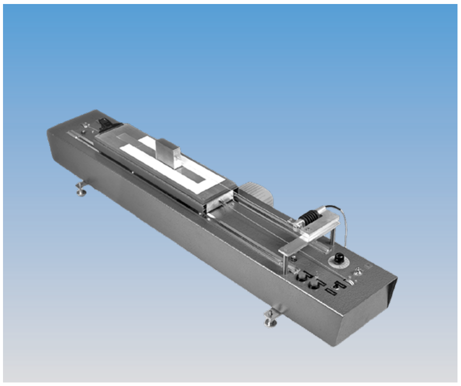


Fig. 30 Linear wiping simulator MK I according to Labuda, 1991.

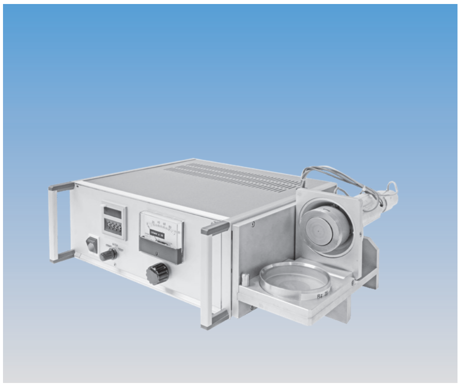


Fig. 31 Rotation wiping simulator MK I according to Labuda-Schöttle.

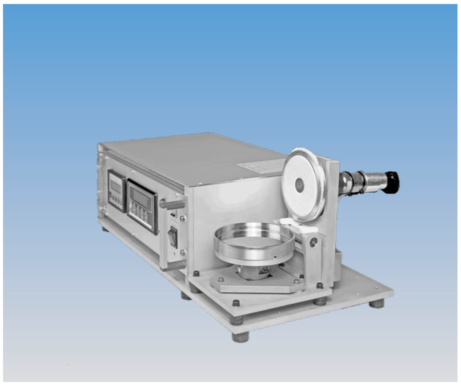


Fig. 32 Rotation wiping simulator MK II according to Labuda-Schöttle, 1994.

this I received a patent with the priority date 15 May 1995. The doctoral students from the Fraunhofer Institute IPA were the first to measure with the Part-Lift. Dr Klumpp even told me yesterday that he often used the Part-Lift in his dissertation experiments at the time. The collector was then manufactured and marketed in a modified form by Clean-Controlling GmbH under licence for several years.

Labuda/Schöttle Linear Wiping Simulator MK I (Fig. 30)
One of the first devices from my portfolio was the linear wiping simulator MK I. We wanted to simulate the degree of carry-over of contaminants from different wiping agents during wiping cleaning procedures. Four individual glass substrates, for example microscopic object carriers, are arranged one behind the other on the slide. A textile test specimen is attached under a weighting weight of 1 kg which you can see there. On the second glass surface there is a contamination. The weight with the wiping agent attached underneath is now placed on the first glass substrate and moved to the fourth substrate to remain there. The question is how much of the contamination was carried from the second to the third and from the third to the fourth slide. This can be determined gravimetrically. This gave us an idea of how much contamination the various wiping agents absorb or carry over from different contaminants during the cleaning process.

Labuda-Textile Abrasion Test
I always wanted to find out what exactly happens between the surface and the wiping agent during the wiping process. When wiping, there is always an object surface that we touch with the wiper, and particles and chemical substances come off the wiper. Where are they? Until then we had not been able to determine this by measurement. Then I asked Klaus Schöttle to build a simulator with a rotor and a tray with given bottom roughness. In our collaboration, with the exception of the fulling simulator, we used to follow these steps: First I sketched my concept to Klaus Schöttle, he then transferred it on the computer into a 3D design, and a Swabian mechanics company built a machine on the basis of this design. This was no different with the MK II simulator (Fig. 32). But we had something additional built in, which was new for that time. We mounted the friction tray so that it could rotate on an ultra-sensitive torque transmitter. So now we could measure for which wiping agent structures, solvents and/or tray topographies the inhibition of the rotation movement is more or less strong. For the simulator we designed five different trays with different bottom roughness. We stretched a wiper on the rotor and let it rotate on the different rough bottoms. Then we filled the tray with DI water and counted the particle attrition with the liquid particle counter. This was how we learned that a relatively large number of particles can be released during the wiping cleaning process, but that they are picked up again by

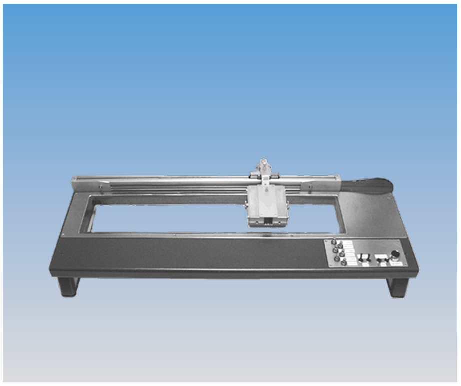


Fig. 33 Linear wiping simulator MK II according to Labuda for determining the dynamic liquid absorption of textile wipers.

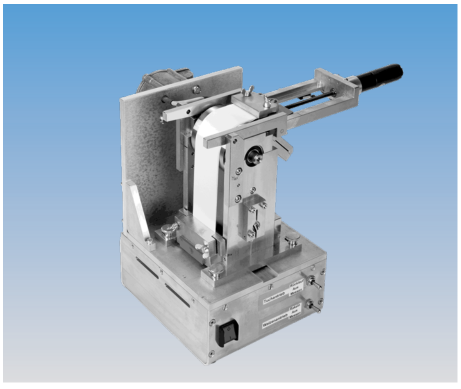


Fig. 34 Rotation wiping simulator MK III according to Labuda/Schöttle for determining the cleaning effectiveness of textile wipers.

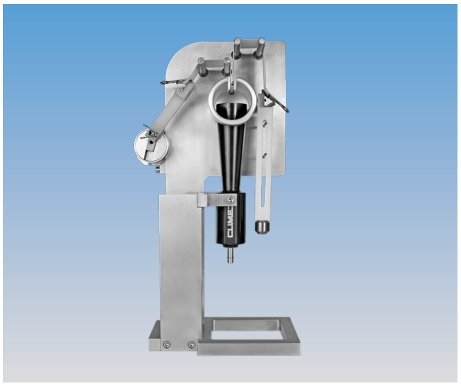


Fig. 35 Fulling simulator MK I according to Schöttle/Labuda for determination of particle release.

the same wiper during the wiping movement. This was new for us, and we want to investigate this again soon.

Labuda-Dynamic Liquid Absorption

In a semiconductor production and also in some pharmaceutical companies, liquid splashes and puddles often occur which have to be eliminated quickly. In order to better understand the process, we wanted to visualise the dynamic liquid absorption of wiping agents. We developed the linear wiping simulator MK II (Fig. 33). We then installed a camera under the wiping head, which moved linearly on a glass plate, applied a puddle of ink to the glass plate and filmed through the glass plate how the ink splotch spreads in the cloth, sometimes not at all, sometimes very quickly and sometimes very slowly. This was also an interesting lesson for us.

Labuda-Cleaning Effectiveness

Any cleaning cloth can be used to easily remove a 1 mm thick layer of grease from a baking tray. But reducing a 50 nm thick silicone film layer to 10 nm with a cleaning wiper can be a task that can hardly be solved. The question we were looking for an answer to in 2007/2008 was: How can we measure the cleaning Effectiveness of a wiper for the thinnest layers of contamination? In this case we proceeded as follows: We took a highly polished metal cylinder and rotated it on a chassis. We applied fluorescent oil to the cylinder and distributed it evenly over the entire cylinder width using a squeegee. Then we fixed the cloth at one end. At its other end we fastened a weighting weight (Fig. 34). We let the weighted wiper hang over the rotating cylinder so that 1/4 of the cylinder surface was covered by the test specimen, and we determined the thickness of the contamination layer on the opposite side of the cylinder using laser fluorescence analysis. This works very well and therefore we know much more about the effectiveness of differently structured cleaning wipers today.

Schöttle/Labuda Fulling Simulator (Fig. 35)

In the end, the not-so-perfect „Labudator" gave me no peace and I sought to find a more effective design to obtain a result more reliable than either the Labudator or the well-known Gelboflex simulator made possible. Also my second construction did not work well at first. Schöttle said about that: „That will never work!" I said: „It's possible!" It did not work, and that's why the resulting simulator is called Fulling Simulator according to Schöttle/Labuda.

This current design works perfectly. A textile strip can be inserted into the simulator. It is guided around a fulling mandrel. The material strip is then automatically drawn alternately in both directions around the thin mandrel. Particles are released during the flexing process. The particles are released into the isokinetic probe of the particle counter, which

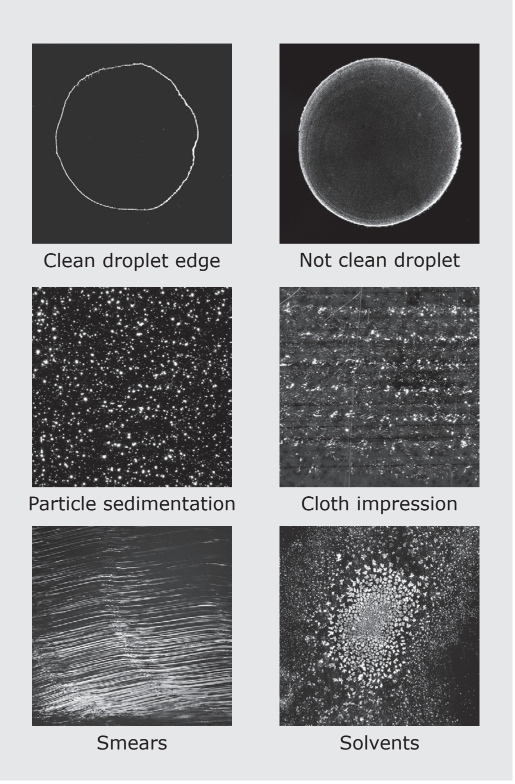


Fig. 36 Different visualisations by means of indicator plate (patent Labuda).

is located directly below the mandrel. Professor Fissan may now be thinking, „What kind of particles are these? Are these really the particles that would be released during the handling of a wiper?" And as he thinks, he may be right; we have never examined these particles in detail. The conceivable advantage of our simulator over the Gelboflex system lies in the relatively small distance of 14.5 mm between the location of the particle release (fulling mandrel) and the upper edge of the probe. This results in comparatively low coefficients of variation of the measured values.

Residue Visualisation

The idea of the indicator plate (Figs. 36 to 38) for residue visualisation of liquids with a high evaporation rate has its origin in the dissertation of Dr Bernhard Klumpp. Years ago, he introduced an electronic device for determining the number and size of particles and fibre fragments on surfaces based on Mie scattering. In the course of studying his work, we discovered an interesting phenomenon. We applied the drop of a non-pure solvent to a previously cleaned black glass plate and found out, according to the „coffee grounds phenomenon" known from physics, that the non-volatile impurities of the solvent, depending on the mass, form a circular structure with different edge widths. Based on the width of the edges - which you see as very small in the picture - we can determine how contaminated the solvent is. And in high-purity solvents this is reflected as an extremely narrow ring. If, on the other hand, the solvent is very contaminated, then this ring, of which in the present picture only the periphery can be seen, becomes a white surface in its entirety, while the surroundings are black.

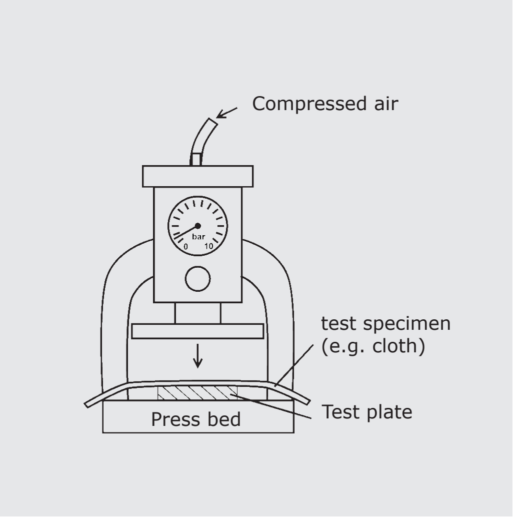


Fig. 37 Scheme of residue visualisation by means of indicator plate and pneumatic press. (Proposal by M. F. Sovinski, NASA).

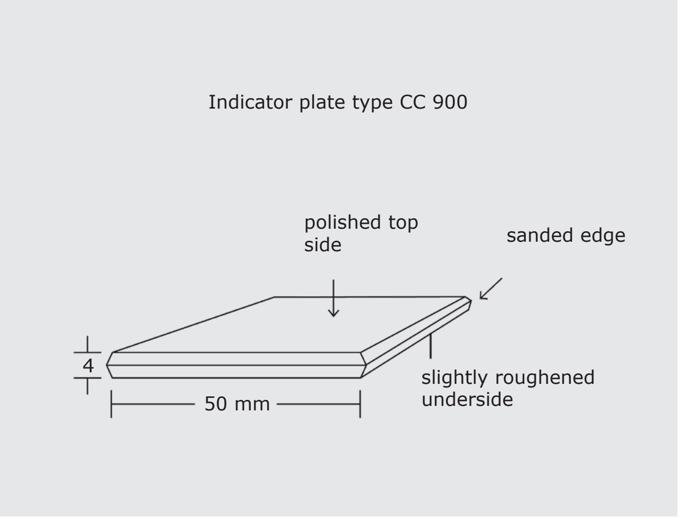


Fig. 38 Clear & Clean indicator plate for the visualisation of particles and nano-layers, Labuda patent

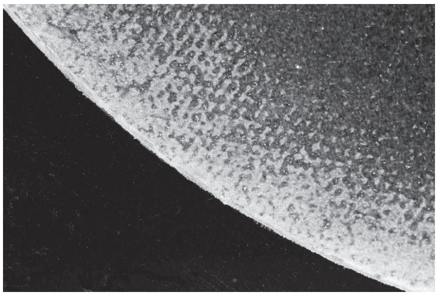


Fig. 39 Chemical residue after textile surface extraction on indicator plate in small-angle reflexion.

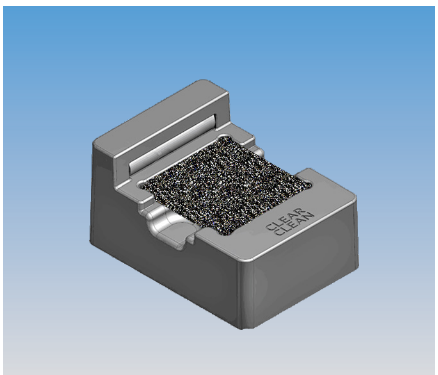


Fig. 40 MICROLITE - Viewing device for the visualisation of particles, organic layers and liquid residues, the 95 x 70 x 35 mm battery-powered device generates intense oblique light.

Material Impression Method

On an experimental basis, we pressed porous or elastic test specimens onto an indicator plate using a pneumatic press at high contact pressure. We hoped that this would provide us with information as to whether there are any impurities in the textile surface structures that can be seen on the plate due to the contact pressure of 2 bar. Our aim is to analyse these imprints of the ingredients using the analysis methods FTIR-IRRAS or Raman-FTRS, so that it is possible to determine which substances are contained in the material imprints, i.e. also in the materials.

Here (Fig. 39) we see something interesting: If, for example, we place a circular cloth cutout with a sealed edge on an indicator plate and apply a few drops of analytically pure solvent to the cloth, an extract of the chemical impurities contained in the cloth section forms on the surface of the plate. After drying we remove the cloth from the plate and if it was very dirty then it looks like this. This means that here an extracting substance transfer from the textile structure to the plate surface has occurred. With this wonderful microscope Axiozoom V16, which Volker Hagen from the company M-Image in Hamburg delivered to me - today he is also among our guests - we can now visualise how impure in reality any porous structure is. We then further examined the above and thought, if we illuminate the plate in oblique light (Fig. 40) then even the thinnest streaks, imprints or evaporation residues are displayed. Within seconds we see, what we cannot measure yet, or perhaps also do not want to measure. After all, we can make it visible.

Fig. 41 Clear & Clean Research Laboratory.

Fig. 42 Clear & Clean Research Laboratory.

Fig. 43 Clear & Clean Research Laboratory, ISO class 3 cleanroom.

Clear & Clean Research Laboratory

Our research laboratory (Figs. 41 to 43) serves the purpose of expanding the general state of knowledge about the various aspects of surface purity as far as they concern the techniques of clean working, but in particular about the cleanroom consumables used in these techniques. As of July 2018, there are about 40 analysis systems in use in our laboratory - from electron microscopy to atomic force microscopy to fluorescence microscopy, from drop shape analysis to UV/VIS spectrometry, from laser fluorescence analysis to headspace gas chromatography - all this is possible in our laboratory - but in fact much more. In the limited time I unfortunately can only briefly introduce you to no more than 11 of our 40 Lab Eyquipment:

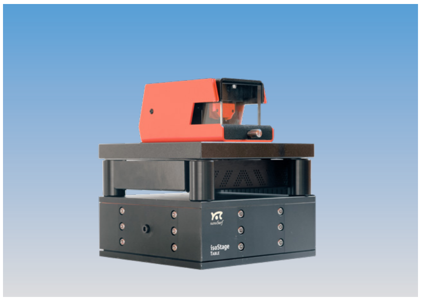


Fig. 44 Atomic force microscope.

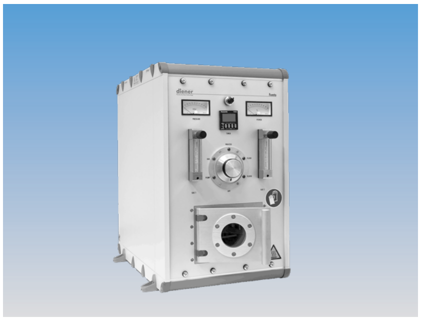


Fig. 45 O_2 plasma generator with high vacuum chamber.

Some of our Lab-Equipment

Atomic Force Microscope (Fig. 44) We use this device, for example, to investigate the properties of ultrapure polymer, wafer or glass surfaces, especially polymer fibre surfaces, after we have cleaned them in CO_2 plasma. There are already very nice pictures available. In principle, we have the plan to examine the various filament surfaces of the PES/PA yarns in our cloths with the AFM microscope.

High-Vacuum Plasma Generator (Fig. 45) On the left we see our plasma generator with vacuum process chamber. The C&C indicator plates, for example, are fed into this chamber and then cleaned with O_2 plasma. After 90 minutes in the plasma, only a few molecules of the original contamination should remain on the plate surface, according to the manufacturer. Again, Professor Fissan would probably say that you will be surprised if you analyse this properly; then you will find much more. He‘s probably right. We‘ve only examined it with the electron microscope. The results are documented in Clear & Clean Laboratory Report No. 050717-MG-01.

Electron Microscope The first instrument we purchased in 1990 was an ISI electron microscope (Fig. 46). It was a giant machine at the time. You needed a whole room for it. The woman in the picture is no longer with us; at the time she was

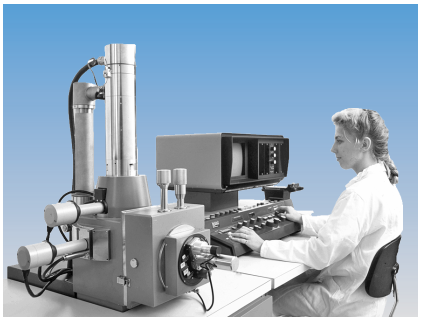


Fig. 46 Our first electron microscope ISI 60 in 1990.

Fig. 47 Our new electron microscope, 2017.

married to one of our employees. A modern electron microscope now looks like Fig. 47. It is the size of a PC.

Mapping Ellipsometer, (Fig. 48) a device that Dr Riss from Riss Ellipsometerbau in Ratzeburg built for us at the time. This device is so important for us because it enables us to analyse the thickness of sub-monolayers on test surfaces. This was the only way we could find out that with our most effective cleaning wipers on wafer surfaces with low-viscosity paraffin oil as contaminant we were able to measure residual layers of less than 0.5 nm thickness. Dr Riss is a really clever fox. Not only can he calculate like Maxwell. He is also one of the holders of the Clear & Clean Research Award (2015) for the discovery of the wide field affinity between antigens and antibodies in the interaction kinetics of human antibodies and recombinant antigens. He published the mathematical proof for his thesis in the June 2011 issue of the *European Biophysics Journal*.

In the slide I have shown just one example of what you can do with the Riss Mapping Ellipsometer. In Fig. 49 we see a diagram from a lecture given recently by Mr Szabang from Clear & Clean during the Lounges 2018 in Karlsruhe. If we deliberately contaminate a surface and the contamination would then have a thickness of 150 nm, then we achieve a thickness of 10 nm by wiping with our most effective cleaning wiper. (Interjected question: How many times did you clean, Mr Szabang? Answer „Once." And if you had cleaned a second time? „Then probably everything would be gone." Then everything would be gone? – Then everything would be gone, he says. (friendly laughter from the specialist audience). So here we see the 3D mapping with this ellipsometer. I think this is a very interesting visualisation of the surface purity in the 10 nanometer range. I think you have rarely seen the effect of a wiping precision cleaning in the nanometer range as clearly as is shown here.

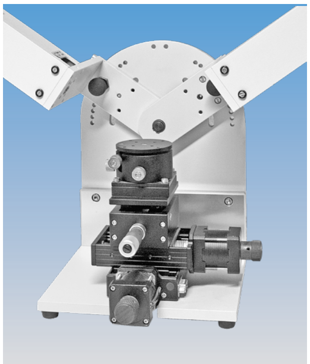


Fig. 48 Mapping ellipsometer according to Dr Riss (sub-nano range).

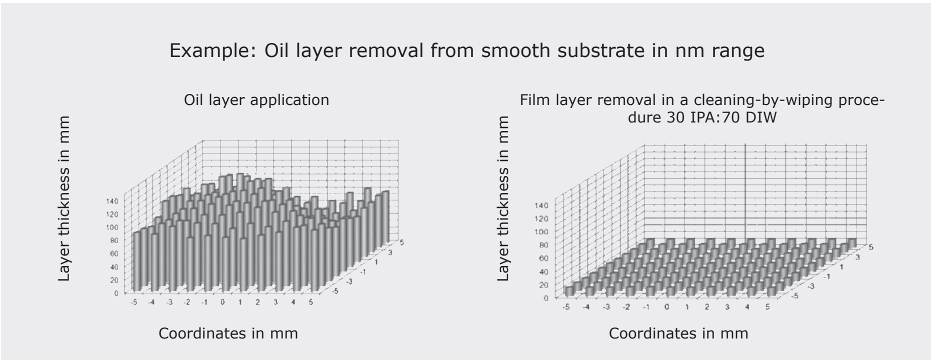


Fig. 49 3-D mapping diagram with Dr Riss ellipsometer. The diagram height corresponds to 150 nm, the diagram area corresponds to 10 x 10 mm.

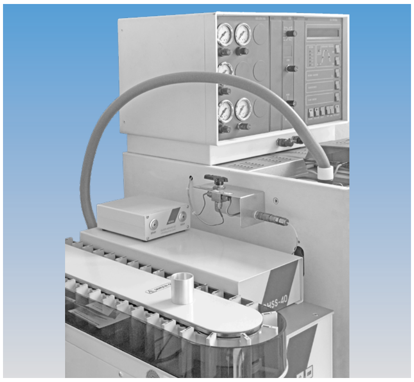


Fig. 50 Headspace-GC gas chromatograph for outgassing measurement of clean-technology consumables.

Fig. 51 Capillary electrophoresis apparatus for the determination of cations and anions in liquid extracts.

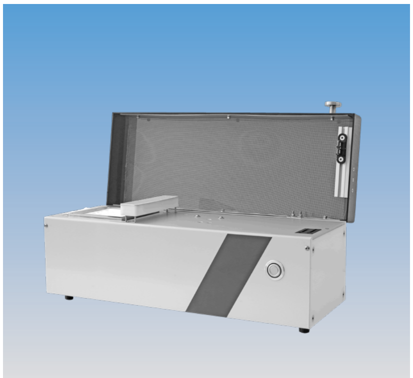


Fig. 52 Electric charge measuring device.

Headspace-GC (Fig. 47) For some time now, we have had a gas chromatograph with headspace sampler for vapour space analysis. This means that we can chemically analyse possible outgassings from pure consumables - such as our ultrapure wiping agents - and determine their contents.

Capillary Electrophoresis Apparatus (Fig. 48) This year, after solvent extraction, we determined the anion and cation inventory for all high-tech cleaning wipers available to us, both from our own production and from the production of various competitors, with great effort. For the extraction we used our programmable microwave analyser.

Electric High-Voltage Generator (Fig. 49) In our laboratory we have developed a method that allows us to determine the degree of purity (e.g. spin oil residues) of flat textile surface structures under certain conditions within a measuring time of < 2 minutes. Previously, this was only possible gravimetrically using NIR or NMR.

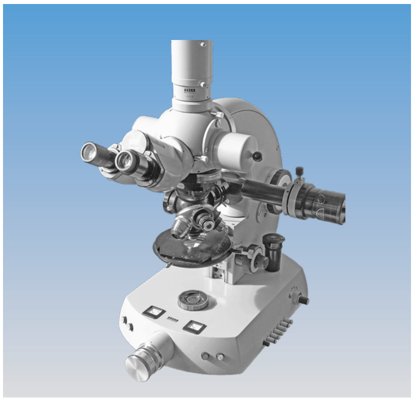


Fig. 53 DIC microscope, differential interference contrast for the visualisation of transparent drop formations.

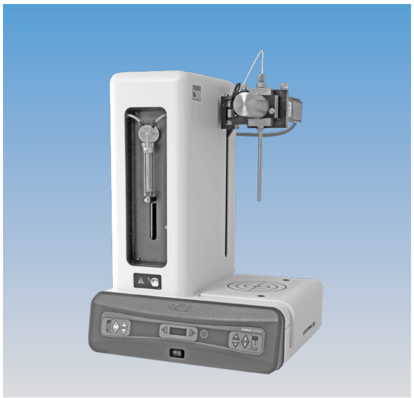


Fig. 54 Liquid particle counter, particle size range = 0.5 - 600 μm.

Fig. 55 FTIR spectrometer.

Fig. 56 Automated light microscope Axio Zoom.V16 with fluorescence, polarisation, differential interference and phase contrast for transmitted and oblique illumination.

Differential Interference Contrast Microscope Fig. 53 shows my „old“ microscope with differential interference contrast imaging. This allows the smallest drop-shaped impurities to be displayed in many colours and quasi three-dimensionally.

Liquid Particle Counter (Fig. 54) We use liquid particle counters to determine the particulate decontamination state of our wiping agents and other products. They facilitate and shorten the workload and increase the measuring accuracy.

FTIR Spectrometers (Fig. 55) are physical analysis devices for the chemical analysis of organic substances. We use them to determine the chemical composition of extracts from textile materials, gloves or auxiliary materials within seconds.

These were only a few of the 40 devices we have at our disposal. However, in the short time available I can‘t go into any more detail about the others.

The Technical Essays

It has always been my desire to pass on the acquired knowledge through publication. For this I have written 40 technical papers and have revealed many procedures that other manufacturers often keep to themselves. I work in the spirit of the American physicist Alvin Lieberman. His name in the United States designates a high, unusual honour of the IEST - Institute of Environmental Sciences and Technology for special achievements in the field of technology. The award statement is as follows:

“This award is presented for significant contributions to the success of others through mentoring, and willingness to share expertise. This award is meant to recognize an individual’s unselfishness, and willingness to help others in any technical field.”

Together with my co-authors I have published a large number of articles (Tab. 2) between 1988 and 2018, most of them with Wiley-VCH, formerly GIT-Verlag. Dr Katja Habermüller, director of Corporate Sales, and Dr Roy Fox, editor-in-chief of the journal ReinRaumTechnik, are among our guests today. They even brought me a handwritten greeting from Sir James Fraser Stoddart as a birthday present, so to speak. Thank you very much for this special honour. I have experienced 20 years of good cooperation with Wiley Publishing. We have produced many - and many exclusive - publications together, such as a 42-page special supplement on cleanroom consumables recently. Many thanks to both of you but also to the unforgettable Dr Heiko Baumgartner at home in Weinheim, to my editor Dr Heinz-Josef Kiggen and to all the invisible helpers for this longstanding and fantastic cooperation.

Thanks

Fig. 57

And last but not least: on such a day, too, my thanks go to all of you, and I would like to address this to you all:

Thanks to all of you who have so cordially come to celebrate my 80th birthday with us in such large numbers. Each one of you has been close, meaningful or even indispensable to me at some point in my life. Today the day has come to say thank you. I would also like to travel back in time and ask forgiveness from those whose expectations I could not live up to. I had a great, fulfilling life in which I enjoyed an abundance of friendly support for all my plans, unearned material prosperity and relative health into old age. My Lord God has guided me well.
Farewell is when you wait – putting your work on your outstretched hand – to see if you could give it wings. If this succeeded, then farewell is not painful. That's the hope.

Publications by Win Labuda and Colleagues from 1988 to 2018

1	1988	Ionic and Particle Contamination through Cleanroom Consumables	VDI Report 693, 1988, Munich
2	1989	Quality Assurance for Cleanroom Consumables	VDI Report 783, 1989, Stuttgart
3	1990	Measurement of Particle Release from Cleanroom Wipers	ICCS World Congress, Zurich, 1990
4	1991	The Labuda Colander Method, Method to Measure Particle Abrasion in Cleanroom Consumables	VDI Report 919, 1991, Bielefeld,
5	1994	Quality Characteristics of Cleanroom Papers	VDI Report 1095, 1994, Stuttgart
6	1994	Load Diagram for Cleanroom Wipers	VDI Report 1095, 1994, Stuttgart
7	1995	Laser Carving, Modification of Textile Surfaces to Increase Wiping Effectiveness	Techtextile Symposium Frankfurt, 1995
8	1996	Pressure-Dependent Particle Collector	ICCS World Congress, Den Haag, 1996
9	1997	Triboelectric Effects in the Use of Cleanroom Wipers and Paper Products	VDI Report 1342, 1997
10	1997	Cleanroom Consumable Products Part 1 Cleanroom Wipers and Paper	Clear & Clean Publication, 1997
11	1998	A Personal Retrospective of 20 Years of Research, 1978 - 1998	Clear & Clean Publication, 1998
12	2000	High-Tech Wipers – Precision Tools of a Modern Production Culture	ReinRaumTechnik 1/2000
13	2000	Protective Gloves in Clean Technology – Elastic Barrier between Person and Product	ReinRaumTechnik 2/2000
14	2000	Cleanroom Paper – Mobile Data Carrier in Cleanroom Operations	ReinRaumTechnik 3/2000
15	2001	The Costs of Wiper-Based Cleaning in Cleanroom Operations	ReinRaumTechnik 1,2/2001 updated 2014
16	2001	Quality Optimisation of Cleanroom Consumables	ReinRaumTechnik 3/2001
17	2002	Passion for Cleanroom Technology Heiko Baumgartner interviewed Win Labuda	ReinRaumTechnik 2/2002
18	2002	Cleanliness as System Parameter	ReinRaumTechnik 3/2002
19	2003	The Evaluation of Cleanroom Consumables	ReinRaumTechnik 2/2003
20	2003	Surface Cleanliness after a Wet-Cleaning Procedure with Precision Cleaning Wipers	ReinRaumTechnik 3/2003
21	2004	The Negative Effect on Surface Cleanliness by the Ingredients of Solvent-saturated Cleanroom Wipers	ReinRaumTechnik 1/2004
22	2004	Factors Determining Cleaning Procedure Costs	ReinRaumTechnik 3/2004
23	2005	Triboelectric Charges in the Semiconductor Production Environment (three-part essay)	ReinRaumTechnik 1,2,3/2005
24	2006	The Effect of Laser-Induced Micro-Roughness of Textile Fibres T. Bahners, K. Opwis, T.Textor, W. Labuda, E.Schollmeyer	Kash L. Mittal “Particles on Surfaces: Detection, Adhesion and Removal”, Band 9
25	2006	Cleaning Wipers: Handling Variants and Active Surface	ReinRaumTechnik 1/2006
26	2007	Clear & Clean Test Methods for Cleaning Wipers and Papers Used in Clean Environments	Clear & Clean Publication, 2007 and 2013
27	2008	Win Labuda - Researcher, Entrepreneur, Artist – A Biography (2008)	ReinRaumTechnik 3/2008
28	2009	Time Requirements and Surface Cleanliness in Wiper-Based Cleaning Procedures	Clear & Clean Publication, 2009
29	2009	Classification of Cleanroom Wipers According to Cleaning Effectiveness	ReinRaumTechnik 3/2009
30	2013	Particle Release by Cleanroom Wipers – The New Schöttle-Labuda Fulling Simulator Mk I	ReinRaumTechnik 4/2013
31	2014	Microcontamination of Surfaces by Wiping Procedures	ReinRaumTechnik 3/2014
32	2014	The Removal of Nanoparticles by Wiping Procedures (Lecture)	Lounges 2014, Stuttgart, 4. Juni 2014
33	2015	The Reduction of Surface Quality after Wiper-Based Cleaning Procedures (Lecture)	Lounges 2015, Stuttgart, 20. Mai 2015
34	2015	Cleanroom Consumables – Source of Contamination in the Clean Production Process?	ReinRaumTechnik 4/2015
35	2016	Reality and Simulation – in Testing Particle Scattering during Use (Lecture)	Lounges 2016, Stuttgart 5. April 2016
36	2017	Cleanroom Consumables - Aspects, Test Methods, Discussion	ReinRaumTechnik 1/2017
37	2017	Commentary to Labuda’s Article “Cleanroom Consumables - Aspects, Test Methods, Discussion” by Thomas von Kahlden	ReinRaumTechnik 2/2017
38	2017	Visualisation of Microcontaminants– Indicator Plate for Liquid Residues, Material Impressions and Particles	ReinRaumTechnik 2/2017
39	2018	On the History of Clean Working	ReinRaumTechnik 3/2018
40	2018	Contribution to the Cleanliness of Technical Systems	Clear & Clean- Publication, 2018

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