Cleaning Process Simulation by Glass Test Boards

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ABSTRACT

This article explains the utilization of Glass Test boards for different tasks for the cleaning process building, optimization, and monitoring. We have 12 years of experience building and using Glass Test Boards as a precise tool for comparing material properties, machine settings, and process optimization. Some years ago, we decided to do a joint project with the company, Magnalytix, and build another kind of test board capable of being optical inspected and tested on the surface resistance.

We want to share our experiences and show the advantages of utilizing such glass models for enhancing the quality of the cleaning process and lowering the cost of building the process.

KEY WORDS: Glass test boards, Surface insulation resistance, Cleaning PCBA, Cleaning process optimization, Cleaning process qualification

INTRODUCTION

Cleaning electronic assemblies has changed dramatically during the past 20 years. The reason is the introduction of new packages, increasing density on the boards, and much stronger requirements on final cleanliness (quality of surface resistance and signal integrity) for a long lifetime. The BTC (Bottom – terminated packages) has brought particular challenges because of its lower gap under the component and much larger gap area than other packages. Besides that, an optical inspection of rest residues is almost impossible.

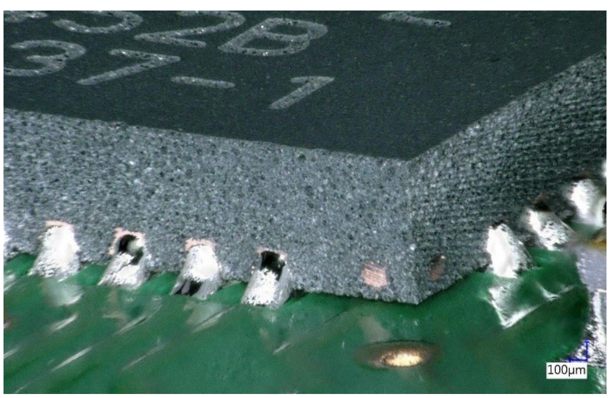


Figure 1: QFN soldered – after cleaning – checking residues between poles optically is almost impossible.

Finding the optimal parameters for thorough cleaning is not a straightforward process. It requires an optical check of the result and the next test with changed parameters. The fastest way to do it is to tear components from the board. Such operation is mostly connected with damage to the PCB.

Figure 2: Special pliers for tearing components. Each can be used only for a specific type of component.

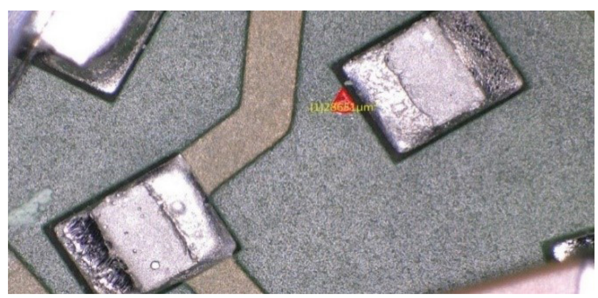


Figure 3: A trained person can tear the component of the board without board damage

Our experience says that the "hot" method (hot air desoldering) can never show the actual situation under the component. We met situations where a flux from voids "exploded" during desoldering and contaminated the surrounding area. Recognizing that such small flux splashes are not an uncleaned residues is almost impossible.

Pliers cannot tear bottom terminated connections. Heavier techniques must be utilized.

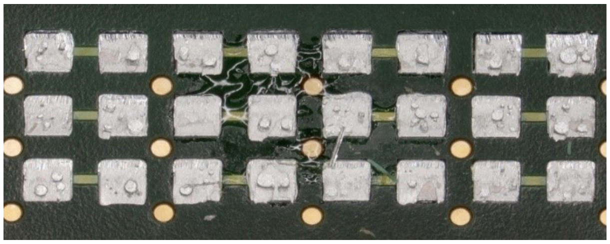


Figure 4: Dismounted joints of daughter board as an LGA connection. Residues and voids are visible.

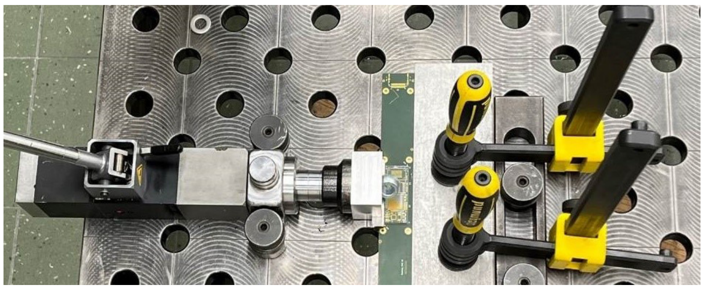


Figure 5: A dedicated hydraulic jig for tearing assembly from Fig. 4

Tearing components is effective from the point of fast process building, however, not from the cost view. Current assemblies might be expensive, as well as some BTC components. Moreover, scraping such material in the time of current delivery problems became less and less popular.

GLASS TEST BOARDS WITH MATRIX OF PASSIVES

Already in 2008, we developed the prototypes of Glass Test Boards. (GTB) The original purpose was to compare the cleaning efficiency of our products - cleaning machines. Soon, we learned that such a precise tool, reusable, with a long lifetime, can also be used for other tasks in the cleaning process building.

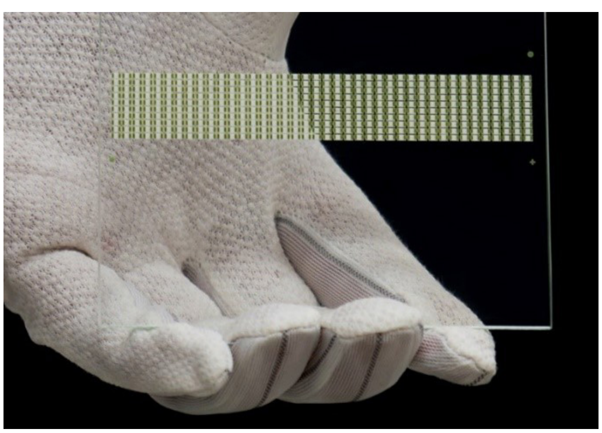


Figure 6: Glass Test board with 400 chips (0805)

Today, we manufacture them for our test purposes, but also customers. They have two passives sizes (0805, 0511) and three gap thicknesses. (35,60 and 70um) An essential difference between them is the different typical times to complete cleaning.

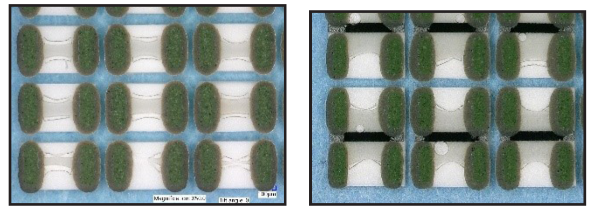


Figure 7: Details of Glass test boards with passives 0805 and 0511 (right side). Half cleaned.

Test preparation is easy. You must deposit three parallel lines of flux from solder paste on the top of the passives matrix. Then reflow it at the same temperature profile as the PCBA. After cooling to room temperature, the Glass Test Board is ready for the test. The test is targeted to cleaning under components. By experiments, it was confirmed that the time to clean the surface and gaps between components is less than 10% of the time needed to clean under chips. Therefore, the method is not sensitive on the surplus of flux which remains on the surface. Always, it is necessary to check optically the completeness of wicking the flux under components (no voids).

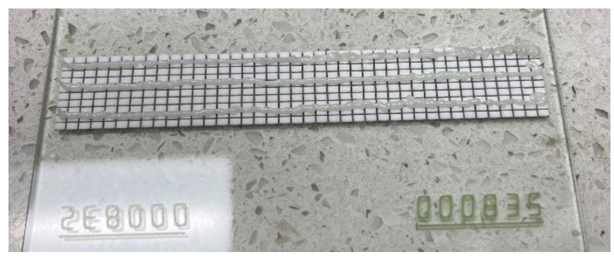


Figure 8: Deposit of solder paste flux before reflow

Test board evaluation of rest residues by the naked eye is not precise enough and always subjective. To increase precision, we have developed a dedicated tool.

AUTOMATIC OPTICAL TEST SYSTEM FOR GLASS TEST BOARDS

Figure 9: Automatic optical test system VERINAS for evaluation of Glass Test Boards

The test system automatically makes a test protocol. It evaluates all 400 chips in the matrix and gives necessary statistical calculations.

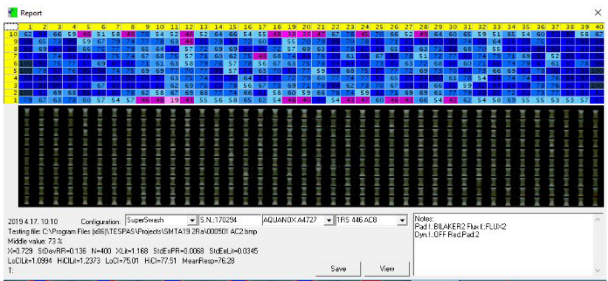


Figure 10: Test report from the Automatic optical system VERINAS

The optical tester measures the ratio of not cleaned area to the area of a complete gap under component. The repeatability of such reading is better than +-5%. Other differences can be caused by changing of reflow parameters. For precise measurement, the reflow conditions and time between reflow and cleaning should be constant.

These Glass Test Boards have multiple use. During the first phase of building a cleaning process (see also IPC CH65B), at least two studies for Cleaning process feasibility can be effectively performed using such a tool.

MATCHING CLEANING AGENT TO FLUX RESIDUES.

We use a technique of step-by-step (sequential) washing and measuring results after each step. With that approach, we get a record of residue percents under chips during cleaning. We call it a washing curve.

Because our Glass Test Boards are very precise and always the same, we can compare the dynamic solubility of proposed combinations of flux residues and cleaners by keeping all cleaning parameters at the same level.

For one type of cleaner, we can get such data for a virtually unlimited number of solder pastes (in practice, up to 32 in our machines)

Such a study, when performing it on the cleaning machine, can take one shift for one cleaner.

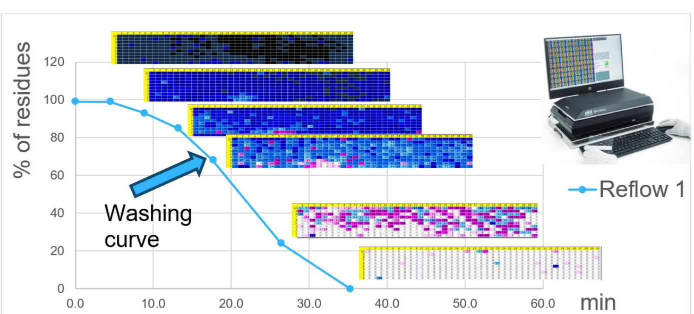


Figure 11: Sequential washing and cleaning curve

To compare the solubility, we introduce a figure, "Cleaning Resistance Value" (CRV) which is proportional to the area under the cleaning curve-

More soluble combinations have the cleaning curve steeper and the area under the cleaning curve smaller. The CRV value is indirectly proportional to the ability of the cleaner to dissolve flux residues.

PROCESS CHANGES VALIDATION

Another application of Glass Test Boards is a validation of cleaning process changes. The difference in the cleaning result on the Glass test Board before and after the process change can quickly determine whether the washing (the first step) is better than before the change.

Such a test result can be used as written evidence supported by the figures that the process change did not negatively change the performance.

WASH PROCESS MONITORING

Periodical cleaning of the Glass test Board can bring actual information of the washing bath condition.

For such measurement, we must choose the flux and type of the Glass Test Board so that the result of rest residues under chips on the Glass Test Board is about 50%after standard wash time. Any deviation from these values is a signal of some change in the activity of the cleaner. Each cleaning cycle gets a certain amount of flux residues, depending on the amount of printed solder paste to the boards. Refreshing by the topped-up cleaner brings a new, active cleaner to the system. The top-up dosing amount is proportional to the drag-over.

When different products run through the machine, the condition of the cleaner can vary in both -side directions.

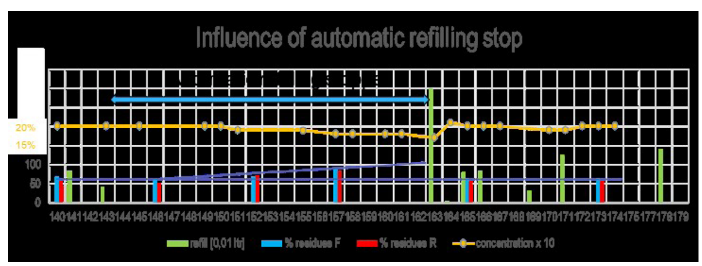


Figure 12: Record from a process monitoring.

During 20 cycles, the concentration dropped by nearly 2% (Yellow line). However, the residues on the Glass Test Board increased by nearly 30%. The blue and red columns are the results of cleaning two GTB. (As a demonstration, we stopped the refilling.) After refilling the cleaner to the initial concentration, the cleaning result got back to the previous values.

MACHINE CAPABILITY STUDIES

Almost every customer wants to have the machine capability study after installation. Hence customers like to measure all controlled parameters. According to the method for such measurements, at least 50 or 100 values are needed to make results. Measuring bath temperature stability would mean running 50x or 100x from room temperature to the set point. But cooling 100 ltr liquid in the machine takes about 24 hours. And bath temperature is only one of several parameters which still do not define the result completely. And there is no standard information about the necessary tolerances for each controlled parameter. We have, several times, proposed to measure the machine's capability by cleaning a sequence of Glass Test Boards. At least for the washing section, such an attempt can bring acceptable accuracy in a reasonable time.

Before such measurement, we must determine the cleaning space homogeneity. Many machines have spots in the chamber where the cleaning intensity drops down. Cleaning several Glass Test Boards can quickly give data on such irregularities.

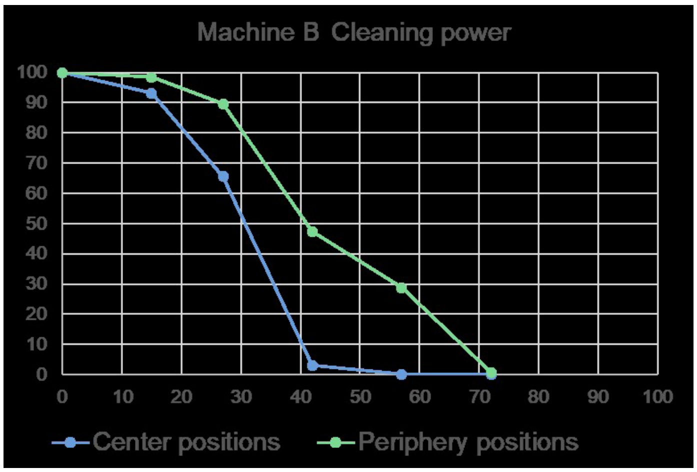


Figure 13: Machine with rotation arms record from washing homogeneity measurement by several Glass Test Boards

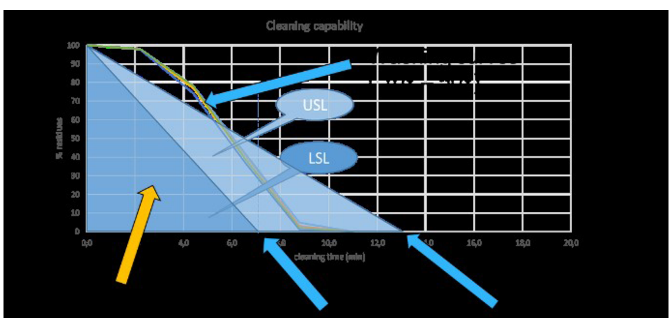


Figure 14: Determination of Cmk from Measuring the Cleaning Resistance Value during several runs of Glass Test Board

For calculating the Cmk, an Upper and Lower acceptable value (of the washing time) must be defined. The upper time is limited by the chemical compatibility of components, inscriptions, labels, or plating on the boards. Usually, the lower value can be determined during process optimization.

GLASS TEST BOARDS FOR PROCESS OPTIMIZATION AND PRE-QUALIFICATION

The GTB with chip matrix is suitable for any comparison studies. Its advantage is the possibility of automatic evaluation of cleaning results.

However, some components have specific challenges in cleaning—especially Bottom Terminated Components.

Difficulties in optical evaluation make setting parameters for proper cleaning difficult and expensive.

Therefore, we decided to develop Glass Test Boards, which enable easy checking of residues under packages and, simultaneously, measuring of Surface Resistance.

Some examples of such boards are on the following figures:

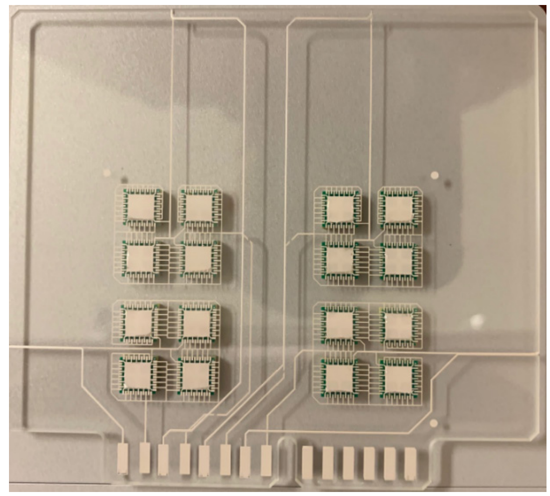


Figure 15: Glass test Board for flux degassing studies with 4x4 QFN44

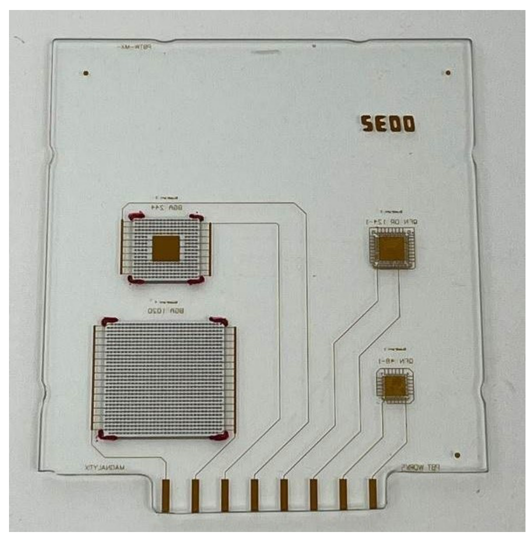


Figure 16: Glass Test Board for cleaning parameters optimization with QFN48, QFN DR124m, BGA244, and BGA 1020.

Such boards can also quickly help to compare the robustness of the No-clean flux system during moisture test. The advantage is a non-destructive analysis of ion migration.

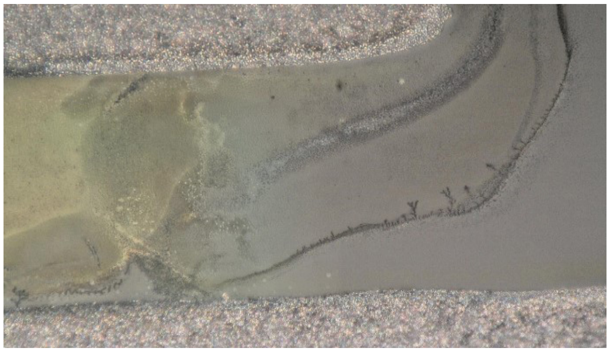
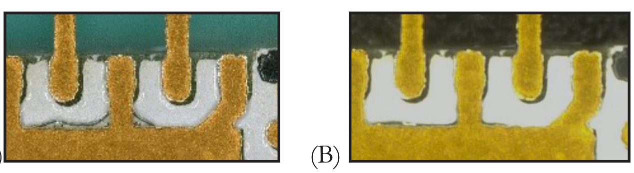


Figure 17: Migration of ions caused by leakage current.

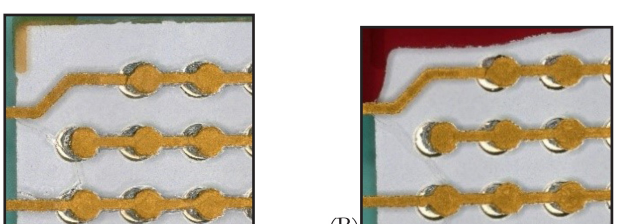
Figure 18: Details of the Dendritic structure of Siver, grown in flux residues during the moisture test 90%rH, 40°C, 169 hrs.

GTB enables observing even tiny changes in the flux residues amount during and after cleaning.



(A) (B)

Figure 19: Flux residues (A) before and (B) after the SIR test (169 hrs, 40°C, 90% RH). Mention a reduction of flux residue volume, probably by a continuing degassing process during the test. (in figure B)



(A) (B)

Figure 20: Comparing BGA structure (A) before and (B) after cleaning. The gap size is 220um

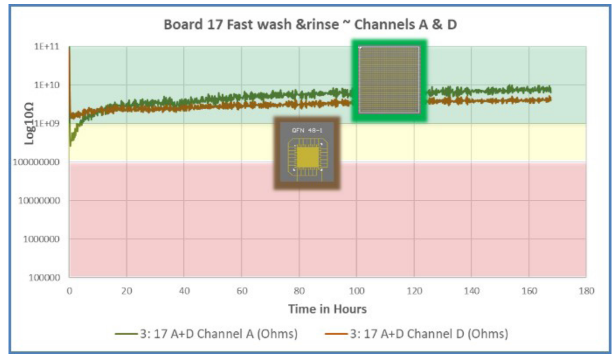
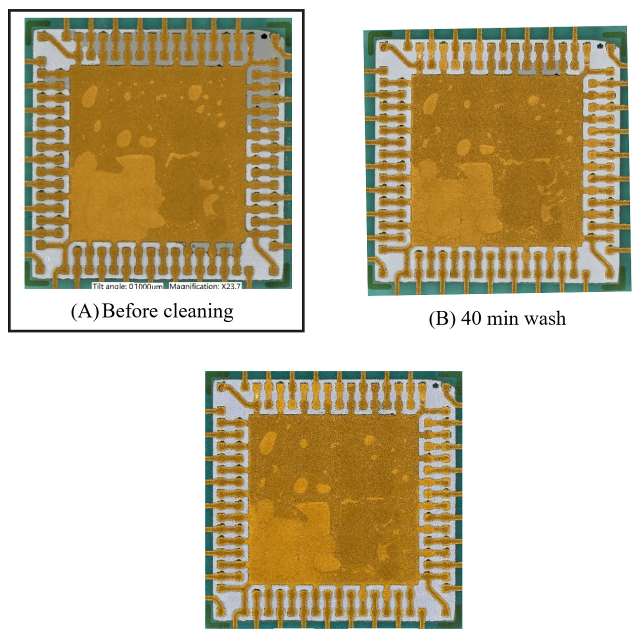


Figure 21: SIR values of QFN and BGA (from Figures 19 and 20)

Sequential cleaning can help to analyse also other factors which can strongly influence cleanability. This is component tilting during soldering. The following pictures show a massive difference in cleaning time in different corners of QFN 124 DR. The cause is a very different gap thickness in those corners. We assume that such tilting can occur by degassing during the soldering process. Too short time for degassing did not allow all gasses to escape before solidification.



(A) Before cleaning

(B) 40 min wash

(C) 50min wash

Figure 22: Sequential cleaning shows a slower process in the upper right corner.

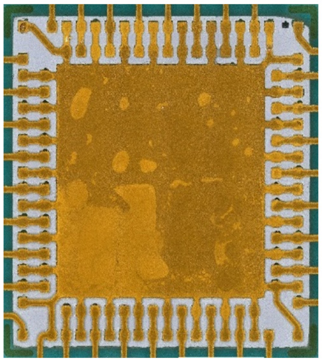


Figure 23: Gap thickness measured by 3D microscope through glass – shows tilting of package during soldering. Flux accumulate un the lowest corner, fully clogged spaces between terminals. Cleaning such components is more challenging.

CONCLUSION

Using Glass Test Boards can help optimize processes, both no-clean and cleaning.

Glass Test boards with the chip matrix help to speed- up necessary works for new cleaning process building and saves cost for components and PCBs which would have to be scrapped during such tests.

Glass Test Boards with different dummy components can make cleaning process parameter optimization easy and fast. Such optimization can need only one piece of Glass Test Board. Such a board can be cleaned using a sequential cleaning approach. Short washing cycles and repeatedly observing the result determine the necessary time for a wash. Also, the SIR test with the same type of Test board can check the resulting quality.

Glass Test Board can also be used for checking the flux robustness during the surface insulation test. It can discover critical points where the bias potential is highest and induces leakage currents or initiates dendrite growth.

We plan to offer fast service in building Glass Test boards, with some standard configurations of challenging components or customized for unique configurations and types of components.

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BIOGRAPHY

Vladimir Sitko is a founder and mentor of PBT Works s.r.o, a recognized manufacturer of electronic assemblies cleaning systems. After finishing his studies at Technical University, he started his career (nearly 50 years ago) as a designer of measuring devices for silicon analysis and machines for chip processing, assembly, and encapsulation.

In the 90s, he gained expertise in soldering, paste printing, and PCBA cleaning. At the same time, he built the first cleaning machines for PCBA cleaning in his company. Cleaning assemblies and tools for microelectronic assembly have become his primary focus until now. More than 30 years of experience gave him much information on increasing the reliability of electronics by cleaning. He participates in several research tasks for cleaning technology. He owns several patents for details of cleaning machines and test tools.