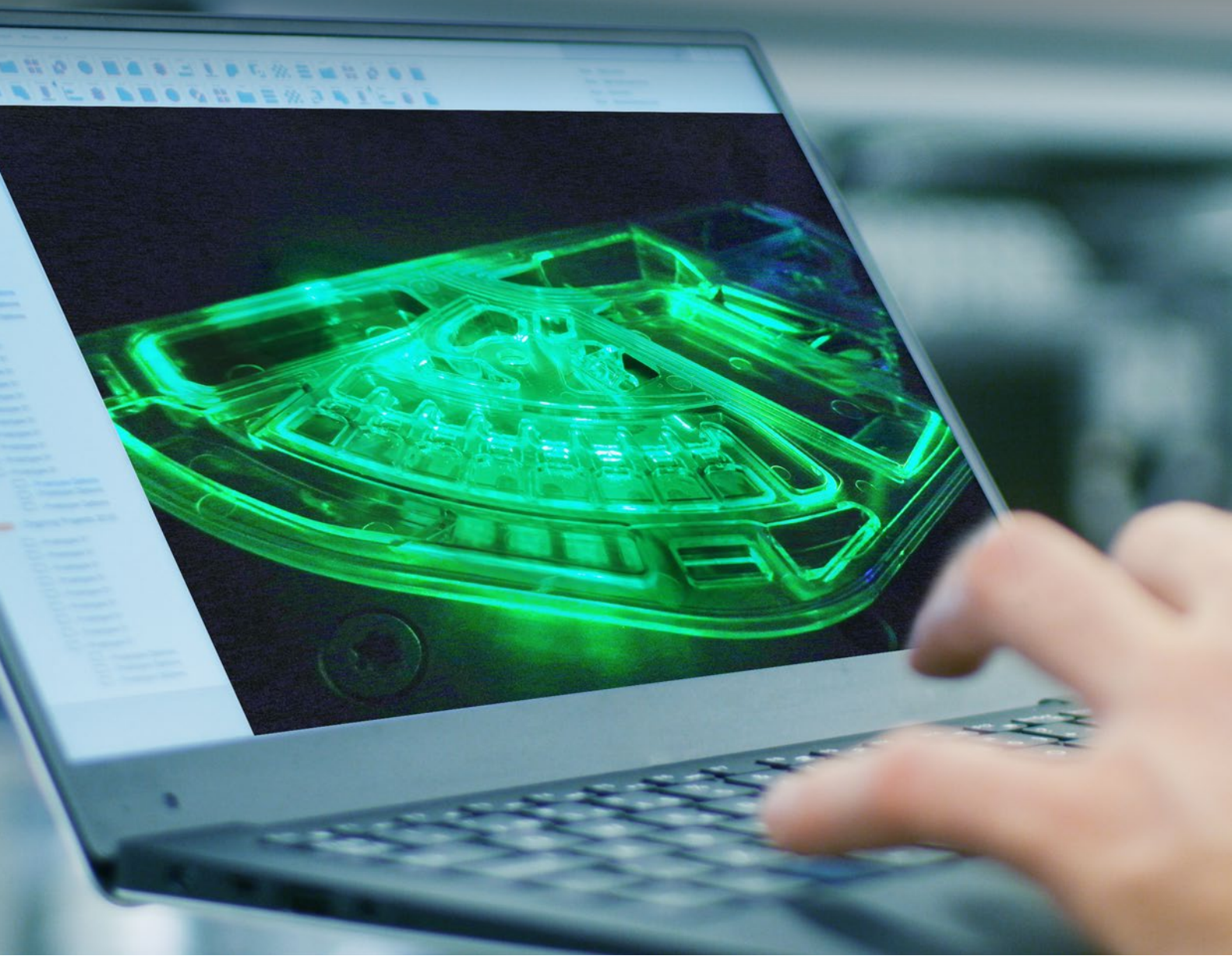
Polytec

Interview

White-light interferometry
for lab-on-a-chip manufacturing



Areal evaluation of small structures and step-height

White light interferometers are in their element when it comes to inspecting the surfaces of fine structures – whether in electronics production or research laboratories. The non-contact, optical measurement method works on almost any material. Optical 3D metrology provides a functional and structural evaluation as basis for quality control and production process optimization. It also creates an intuitive vizualization of a surface that is easy to interpret by the human eye. In lab-on-a-chip systems, used for PCR or tuberculosis tests, white-light interferometers are demonstrating their value in adapting the required tools for sealing or optimizing the injection molding tools for manufacturing.

The term lab-on-a-chip refers to a microfluidic system, packaging all the functionality of a lab into a small glass or plastic carrier called cartridge, typically the size of a credit card. This enables a full and automatic analysis of small quantities of a liquid on a single chip. The samples are being transported between the different reaction and analysis chambers by capillary and centrifugal forces. Such systems have found a familiar application in point-of-need PCR testing, for example in doctors' offices or pharmacies.

From development to series production

Hahn-Schickard in Freiburg, Germany specializes in lab-on-a-chip systems. The institute is part of the Hahn-Schickard-Gesellschaft for applied research in Villingen-Schwenningen, a research and development service provider developing custom solutions, and supporting customer projects until they are ready to market. During the scale-up phase, suitable manufacturing processes are evaluated and implemented through technological process development, enabling the reliable manufacture of medical technology products while keeping in mind costs and time-to-market. The production line in the company's own facility covers the entire value chain for series production of test carriers for in-vitro diagnostics in medium batch sizes of up to approximately 100,000 units per year. The flexible production concept is capable of coping with different product requirements and technologies: from microthermoforming of the plastic cartridge over modification of plastic surfaces, to pre-storage of liquid reagents, introduction of detection reagents, and finally to the fluidic-tight sealing of the cartridges and their final packaging.

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Hahn-Schickard -
Microsystems technology of the future

Hahn-Schickard develops intelligent products with microsystem technology: from the initial idea to production, spanning all industries. The RnD service provider is represented with its institutes at four locations in southern Germany: in Stuttgart, Villingen-Schwenningen, Freiburg and Ulm. In close cooperation with the industry, Hahn-Schickard creates innovative products and technologies in the fields of sensor technology, intelligent embedded systems for the Internet of Things, artificial intelligence, lab-on-a-chip and analytics as well as packaging technology and electrochemical energy systems. Hahn-Schickard's portfolio also includes the production of small and medium-sized series as well as the transition to large-scale production.

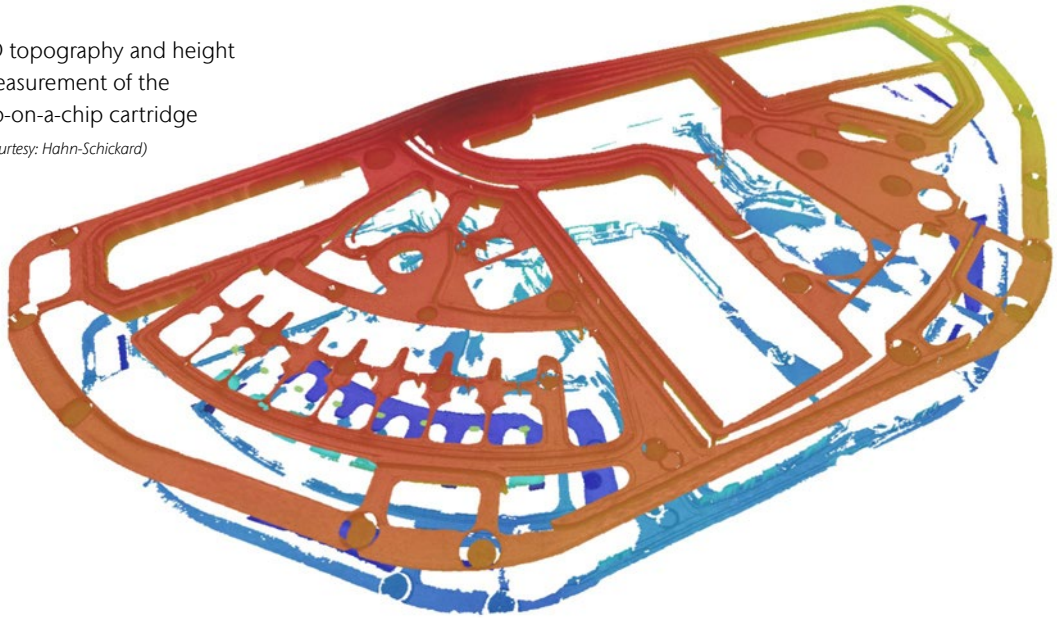
Lab-on-a-chip system for tuberculosis tests

(Courtesy: Hahn-Schickard)

Precise adaptation of the sealing tool

"Applying the sealing film to the cartridges of our lab-on-a-chip is challenging," reports Raimund Rother, process engineer at Hahn-Schickard: „First, there is the demand of achieving a high seal strength without closing the fine channels of the cartridge during bonding. Secondly, production tolerances regarding the injection molding thicknesses cannot be eliminated completely, which has to be compensated when sealing." The height increments of the sealing tools must therefore be precisely matched to the cartridge. If the height is too low, the sealing force is too low and the cartridges are not tight. If the height is too high, pressure splashes occur and melt can block the fine channels. "In order to adjust the sealing tool precisely, we measure the height levels of the cartridge using a scanning white-light interferometer. The obtained 3D measurement data then forms the basis for designing the sealing tool."

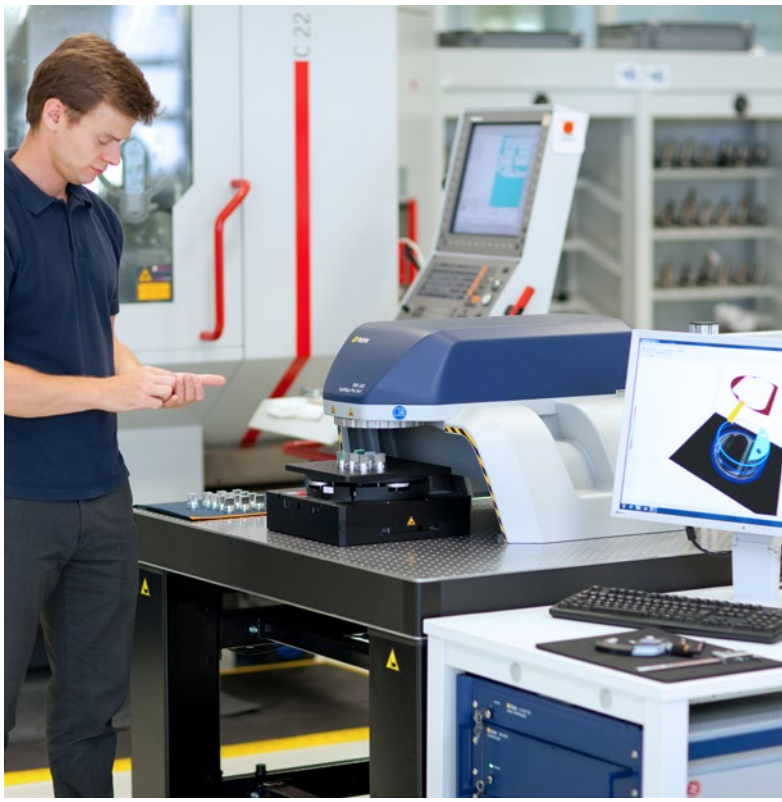
3D topography and height measurement of the lab-on-a-chip cartridge
(Courtesy: Hahn-Schickard)



"In order to adjust the sealing tool precisely, we measure the height levels of the cartridge using a scanning white-light interferometer. The obtained 3D measurement data then forms the basis for designing the sealing tool."

Raimund Rother, development engineer at Hahn-Schickard

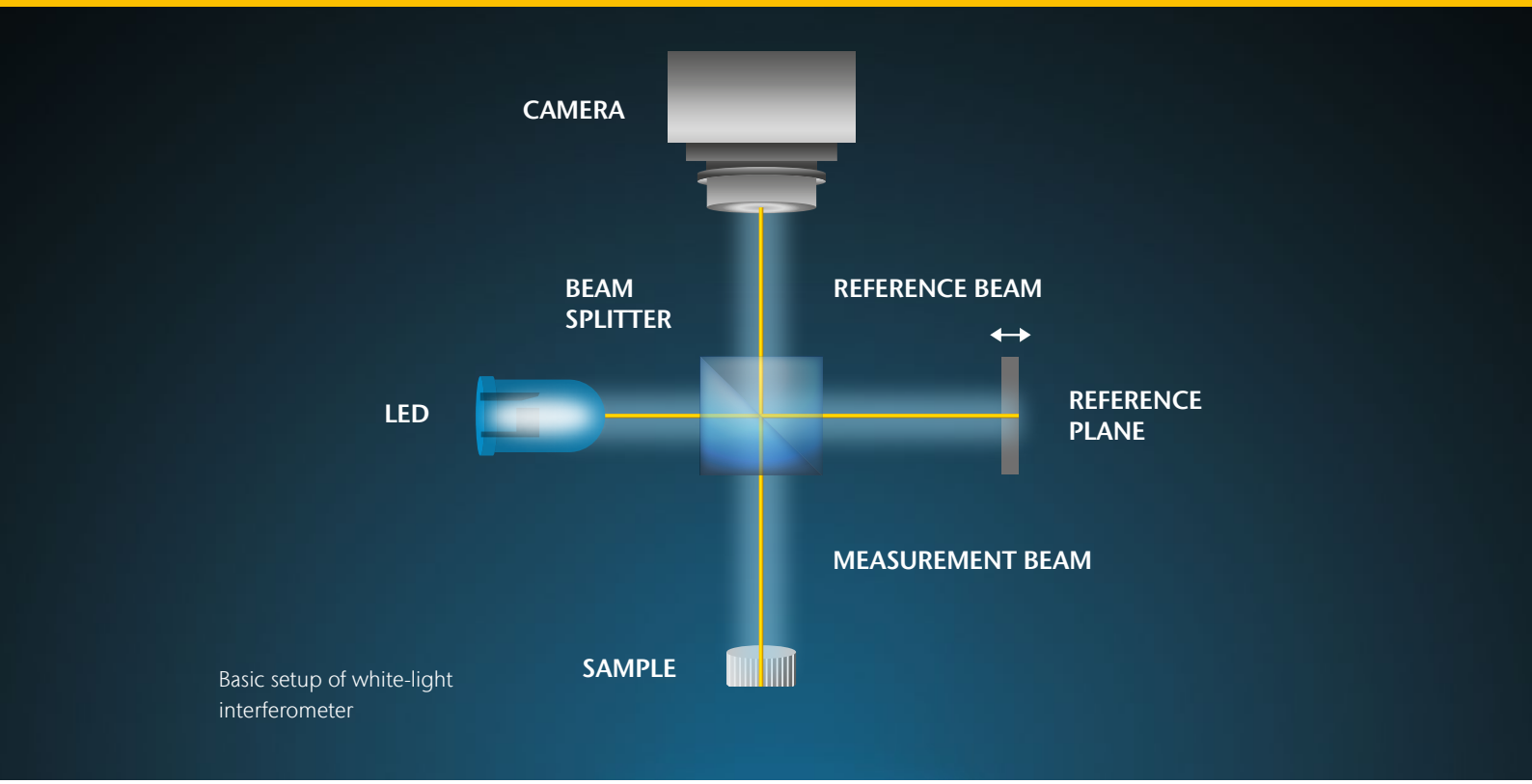
The cartridge is measured using a Polytec white-light interferometer. Their TopMap surface metrology systems featuring a high vertical and lateral resolution are ideal for inspecting fine components and structures. "A vertical resolution in the nanometer range and a high measuring speed are ideal for our requirements", says Raimund Rother. "Our wall thickness in the injection molding typically deviates from the design data by +/- 10 µm, so the optical profiler system has to be much more precise and showing a higher resolution for valid results when adapting the sealing tool." With its high resolution, telecentric optics and high measurement speed, the white-light interferometer captures all details. Within a few seconds, it collects two million measurement points on an area 44 x 33 mm² without need for stitching. The large field of view allows for measuring the entire chip at once. With the cartridge being transparent, we also obtain measurements from top and bottom simultaneously, indicating the exact thickness of the cartridge, as well," continues Raimund Rother.



For the lab-on-chip cartridge design, measurement speed and high vertical and lateral resolution are key.

About Polytec

As a pioneer in laser technology, Polytec has been providing optical measurement solutions for research and industry since 1967. After its first years as a pure distributor, the high-tech company, based in Waldbronn near Karlsruhe – Germany started developing its own laser-based measurement devices in the 1970s, until having become the world market leader in optical vibration measurement using laser Doppler vibrometers. Related otpical sensor systems for industrial length and speed measurement, surface metrology and process analysis are have expanded the portfolio. Polytec now continues its distribution business for optical systems.



Basic setup of white-light interferometer

With vast export options, the 3D measurement data gathered with the white-light interferometer can then be processed using any suitable evaluation software. The native evaluation within the proprietary TMS software already covers most needs, like Hahn-Schickard uses it. It offers numerous options for quick evaluation of results in accordance with ISO standards. "So-called measurement recipes", for example, make routine measurements easier and faster. All settings for data acquisition (e.g. measuring position, lighting settings, camera parameters) as well as evaluation parameters (e.g. post-processing steps, visualization or export options) for special measuring tasks can be defined and prepared in advance. This saves time and avoids operater errors, especially in production environment. "One special feature of the Polytec software is the transparency of how post-processing works, setting it apart from competition," explains Raimund Rother. "Post-processing of measurement data can become tricky, as you want to process your measurement data but not affect it accidentally." For measurement tasks in lab-on-chip production, 3D optical measurement technology is indispensable. With the non-contact method, the quality control spares mechanical wear or impact on measuring system or cartridge specimen, while speeding up the measurement procedure far beyond of what tactile technology could provide.

On this particular cartridge examination, tactile methods would not be a good choice, as the height information would only be obtained in 2D along a profile. In addition, it is not possible to inspect the thickness by simultaneously measuring both sides of the cartridge using other methods. In the meantime, the white-light interferometer has proven its worth for adapting the sealing tools. "We now also use the measurement data for continuous optimization of the injection moulding tools" like Raimund Rother states.

White light interferometry

Modern white-light interferometers use the interference effects that occur when the light reflected by the measurement object is superimposed with a reference signal. The measurement method is based on the principle of the Michelson interferometer, whereby the optical setup contains a light source with a coherence length in the µm range. At a beam splitter, the collimated (i.e. straightened or parallelized) light beam is split into measurement and reference beams. The measurement beam hits the measurement object, the reference beam hits a mirror. The light reflected by the mirror and the measurement object is superimposed on the beam splitter and imaged on a camera. If the optical path for an object point in the measuring arm matches the path in the reference arm, constructive interference occurs for all wavelengths in the spectrum of the light source. The camera pixel of the object point in question then has the maximum intensity. For object points that do not fulfill this condition, the associated camera pixel has a lower intensity. Devices with a telecentric design capture the topography of large areas in a single measurement process within a short measurement time and even reach recesses that are difficult to access, such as drill holes. If, on the other hand, a high lateral resolution is required, microscope-based systems are ideal, since the optical setup and reference arm are integrated into the lens.

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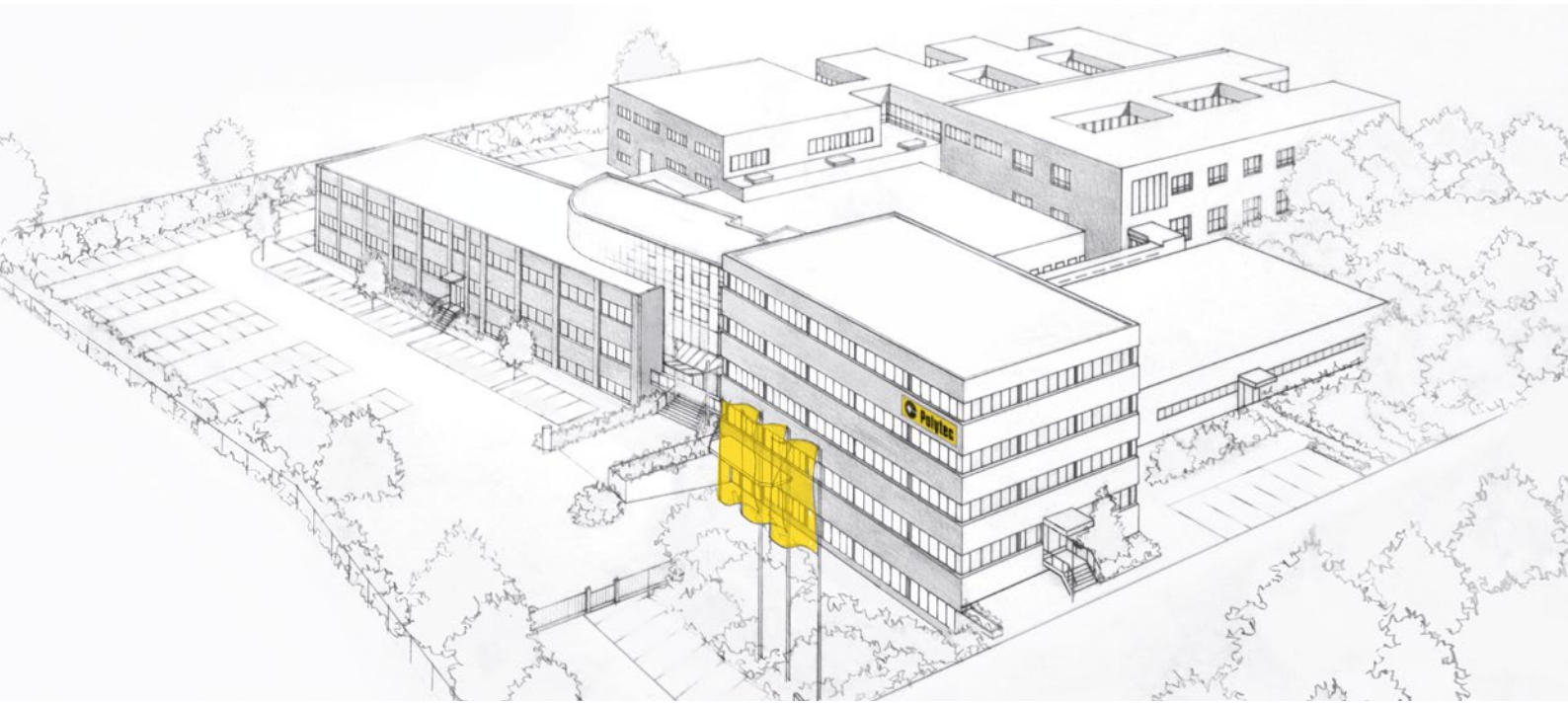

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