

Coatema Coating Machinery GmbH

Pilot coaters as part of the 'lab2fab' vision

Coating and printing technologies in new emerging markets like batteries, fuel cells, electrolysers, solar and printed electronics are advancing rapidly, and Coatema is at the forefront of providing specialised and standardised solutions for pilot equipment that meet both research and production requirements. As a leading German supplier, Coatema offers a comprehensive range of pilot systems designed specifically for the coating and printing industries.

This article will provide an in-depth technical analysis of their pilot equipment, focusing on the versatility and advanced features that support both manufacturing and research applications.

Understanding pilot equipment in coating and printing

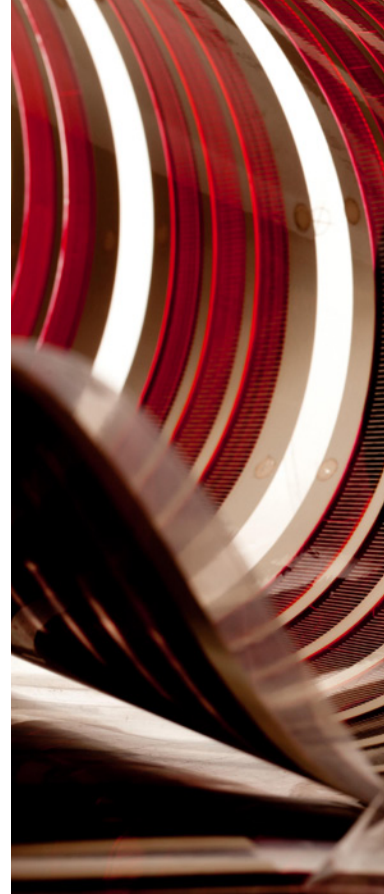
Pilot equipment serves as a crucial link between laboratory research and full-scale production. In coating and printing applications, pilot systems allow manufacturers to test and refine processes before scaling up, ensuring consistent quality and efficiency while reducing risks. Coatema's pilot solutions are engineered to provide scalability with high precision, flexibility and modularity the company demonstrates with systems like the Click&Coat pilot platform.



Coatema's Smartcoater

Scaling up technology from a low Technology Readiness Level (TRL) to a high TRL is a complex process requiring careful planning, reliable pilot equipment, and thorough testing. In the context of coating equipment, successful scaling involves transitioning from small-scale lab experiments to pilot-scale trials and ultimately to full production. This progression requires addressing several critical factors:

- 1. Process validation at low TRL levels:** At early TRL stages (TRL 1-3), the focus is on developing a fundamental understanding of the coating process, including material properties, coating techniques, and initial feasibility. During these stages, Coatema's tabletop and lab equipment, like the Easycoater and Smartcoater enables researchers to experiment with different coating heads, substrates, and drying mechanisms to validate core concepts.
- 2. Parameter optimisation and repeatability:** At mid-range TRL levels (TRL 4-6), it becomes essential to optimise process parameters to ensure consistent coating quality. Coatema's pilot systems like the Basecoater and Click&Coat offer precise control over variables such as coating thickness, drying temperature, and substrate tension, which allows for repeatable results. This stage involves iterative testing to fine-tune the process and meet quality and performance requirements. Here, inline quality control systems like thickness measurement, optical inspection, XRF and more are integrated.
- 3. Scaling equipment flexibility:** For higher TRL levels (TRL 7-9), the challenge is adapting the optimised process for a production environment. Coatema's modular pilot equipment is designed to facilitate this transition by providing scalability and flexibility. The ability to integrate multiple coating technologies on a single platform ensures that processes developed at the pilot scale can be adjusted for larger production lines without significant reconfiguration. Here, a number of Coatema platforms like the Click&Coat are used for pre and production in tech markets like fuel cells and electrolysers for the green hydrogen economy.
- 4. Risk mitigation and troubleshooting:** Pilot equipment is essential for identifying and mitigating risks before transitioning to full-scale production. Coatema's systems enable real-time monitoring, allowing operators to detect and address issues early in the process. By simulating production conditions at the pilot scale, manufacturers can reduce the likelihood of encountering problems during large-scale manufacturing.



Flexible organic photovoltaic cells



The Easycoater is an entry-level pilot coater that is ideal for research and small-scale production. It is designed for versatility and ease of use, allowing operators to quickly change coating techniques and substrates. The Easycoater supports multiple coating methods, including knife-over-roll, slot die, and gravure coating. This system is particularly well-suited for universities and research institutions that require a flexible yet straightforward coating solution for experimental purposes.

The Smartcoater is a highly adaptable pilot coater that offers advanced control features and the ability to handle a broad range of coating techniques. It is designed for R&D as well as pilot production, providing enhanced precision and repeatability. The Smartcoater can be equipped with various coating heads, drying units, and laminating modules, making it an excellent choice for scaling up processes from the laboratory to pilot scale. Its modular design ensures that users can configure the system to meet specific requirements, whether they are working with functional coatings, printed electronics, or advanced materials.

The Basecoater is a pilot coater that is specifically designed for a high flexibility in design and dimensions. It is ideal for applications that require a stable and consistent coating process, such as battery electrodes and thick-film coatings. The Basecoater provides precise control over coating parameters and is equipped with powerful drying units to ensure optimal performance. This system is favoured by industries like energy storage and photovoltaics, where a small scale version of big scale production equipment can make a difference in product developments.

The Click&Coat system represents Coatema's most versatile and modular pilot coating solution. It is designed with a unique modular platform that allows users to „click“ different coating and printing modules together, creating a fully customised pilot line. The Click&Coat system can integrate multiple coating techniques, printing units, and drying systems, making it ideal for multi-step processes and complex material development. This flexibility makes Click&Coat an excellent choice for industries working on advanced materials, printed electronics, and multi-layer functional coatings. The system's modularity also ensures that it can easily be adapted to new projects, providing a future-proof solution for evolving R&D needs.

5. Data collection and process transfer: Effective scale-up also requires the transfer of process knowledge. Coatema's digital interface solutions facilitate data collection throughout the pilot stage, ensuring that critical process information is documented and available to guide the transition to full production. This data-driven approach helps maintain consistency and quality as the process scales up. Here, the use of IoT gateways, IPC systems and more to get the collected data from the machine into the cloud, the use of AI to directly analyse and control production parameters and in the final layout to provide coating as a service in the long run are part of a number of German and European funded projects that Coatema is part of.

By addressing these key aspects, Coatema's pilot equipment serves as an essential tool in bridging the gap between laboratory research and industrial-scale production, providing the flexibility and precision needed to move technologies from concept to commercialisation.

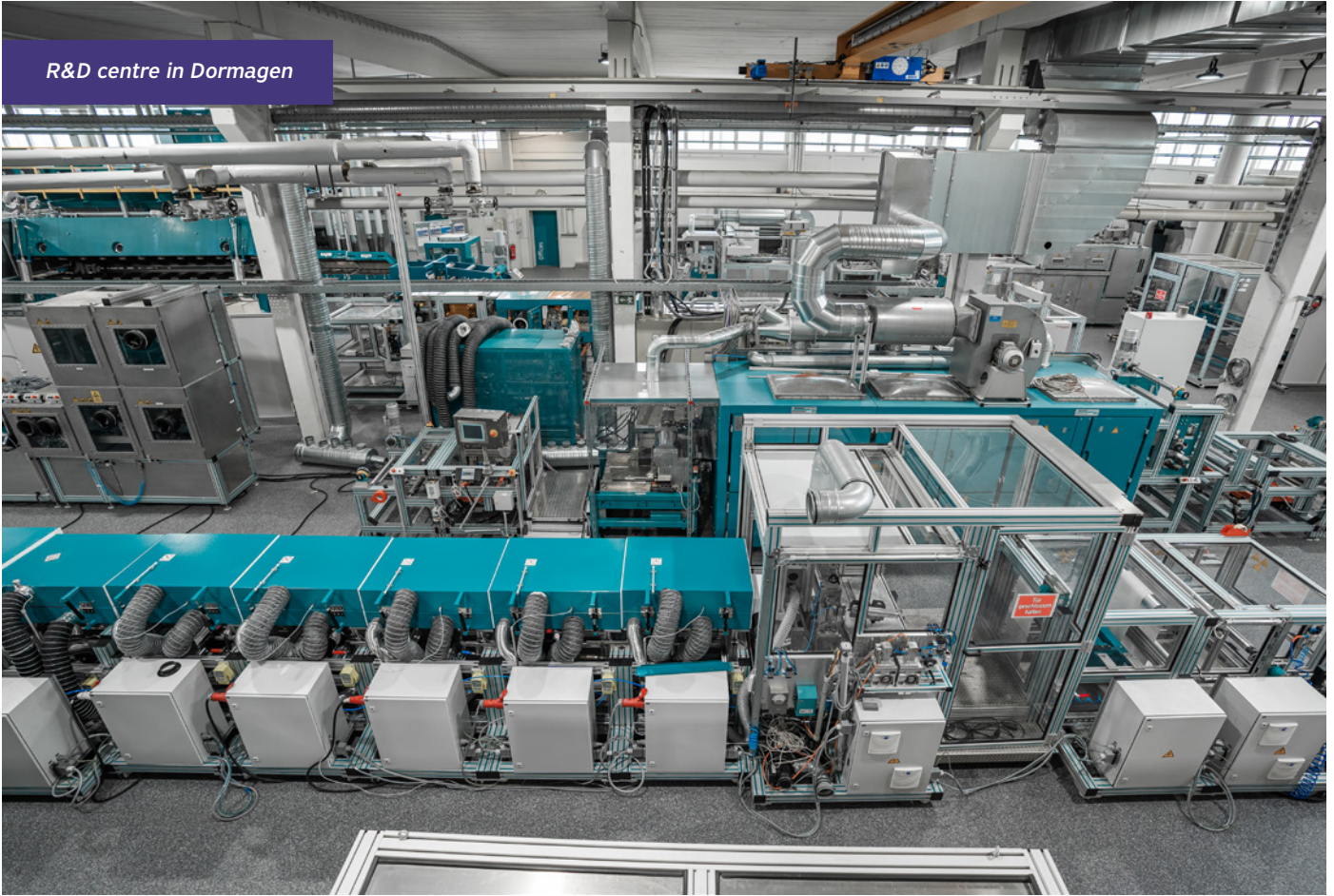
Coatema's range of pilot coating systems

Coatema's pilot equipment lineup includes an extensive selection of coating and printing systems that can accommodate a wide array of substrates and processes. Their pilot coaters are known for modularity, enabling researchers and engineers to combine different coating techniques on a single platform. Whether working with slot die coating, knife-over-roll, or spray coating, Coatema systems offer the adaptability to handle a variety of materials, from foils and textiles to paper and specialty films.



Click & Coat

R&D centre in Dormagen



Advanced digital printing solutions

In addition to the coating technologies, Coatema also provides sophisticated pilot-scale printing systems. Their pilot printing units support several printing methods, including gravure, flexographic, screen printing, inkjet, and Laser-Induced Forward Transfer (LIFT). With these digital methods, lot size one, which refers to the production of individualised products in small quantities, often as low as a single unit is possible. This helps to reduce the carbon footprint by minimising material waste and energy consumption. Since the process is highly precise and tailored, it avoids overproduction and reduces the need for large inventories.

Inkjet printing is particularly suitable for applications requiring high precision and the ability to deposit small volumes of functional materials. It is widely used in printed electronics and biomedical devices where exact placement and material conservation are critical. The digital nature of inkjet printing also supports rapid iteration, making it ideal for R&D environments.

Laser-Induced Forward Transfer (LIFT) is an advanced technology that enables precise material transfer using a laser to apply the coating material onto the substrate. This technique is highly effective for depositing sensitive or viscous materials without direct contact, making it valuable for prototyping in advanced electronics and other high-tech applications.

Innovation and industry applications

Coatema's pilot systems are known for their role in advancing research and development in industries such as photovoltaics, energy storage, and printed electronics. The combination of coating and printing capabilities enables rapid prototyping of cutting-edge technologies—all on a single system. This versatility not only speeds up the development cycle but also allows for a seamless transition from lab to production. One of the standout innovations in Coatema's portfolio is the inclusion of digital interface solutions that allow easy data collection and remote operation, facilitating a more streamlined R&D workflow. Researchers can control parameters, collect process data, and analyse results to optimise their coatings and prints—all while minimising waste and production costs.

Coatema is also at the forefront of the integration of laser drying technology, which provides a more energy-efficient and precise drying solution for sensitive coatings. This innovation reduces drying time significantly and helps maintain the quality of delicate materials. In collaboration with its sister company Drytec, Coatema is developing new flotation dryers for pilot equipment. These dryers are designed to offer superior drying efficiency and uniformity, especially for sensitive substrates, enhancing the quality and consistency of coated and printed products. Integration of other technologies like spatial ALD, UV nano imprint, thermal nano imprint and the inline integration of spectroscopy and other technologies are part of the work of the R&D projects team and are demonstrated in the Coatema R&D centre or at cooperation partners in technology clusters all over the globe.



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