

2. High-throughput organic coating platform

Together with HTE, Flamac has developed a unique combinatorial coating workflow that can provide a competitive advantage to your company by accelerating drastically the rate of innovation for a wide range of applications in the field of specialty chemicals.

2.1. Platform Design

A schematic of the fully automated coating platform is shown in Figure 2.1. The handling of formulations, substrates and coating tools is performed by appropriate robotics, thus ensuring a robust and reliable coating application. Following the application, the coated substrates can be processed in an arbitrary sequence in the IR drying unit and/or the UV curing unit. Barcodes are then applied on the back of the coated substrates for identification in the downstream processes.

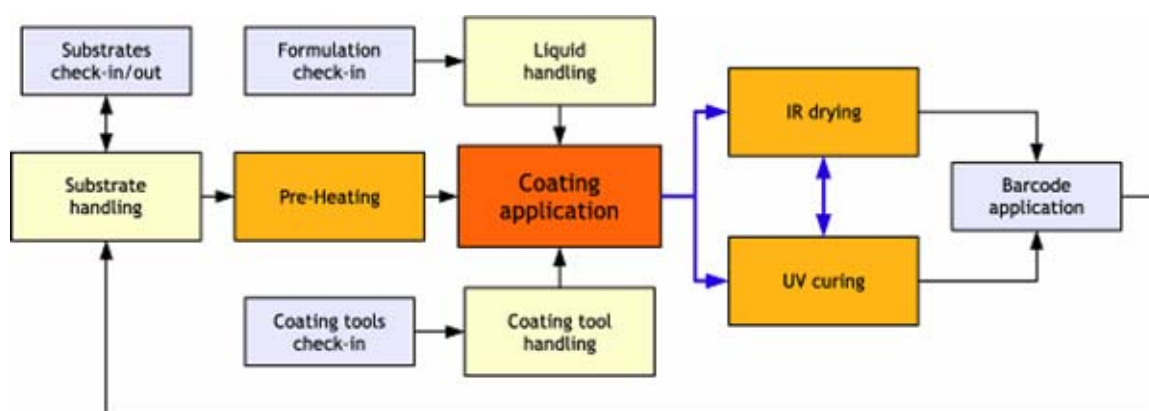


Figure 2.1: Chart illustrating the functional modules of the high-throughput coating platform.

2.2. Substrate Handling

The platform is equipped with two substrate holders that can be moved independently over a linear transfer system. Each of the holders has an optimal design so that different types of substrates, rigid (metal, glass, silicon, plastic, wood...) or flexible (plastic foils, paper, textile...) can be processed on the platform. Thanks to this fast and robust transfer system curing and/or drying of the freshly coated substrates can be done shortly after the coating application (around 0.5s).

For substrate handling, a powerful articulated-robotic arm is used, as shown on Figure 2.2. The robot picks up substrates of different types and thicknesses from stacks and delivers them to the substrate holders. After processing, each substrate is labelled with a barcode and placed into the substrate hotel, from where it can be transferred to characterization and performance testing. The handling of the formulations is carried out by a customized 8 needles liquid handling robot. Up to 120 formulations can be stored, heated and stirred on the deck of the liquid handling module. The formulations are transferred to the substrate by using disposable tips.



Figure 2.2: Substrate handling and formulation handling module.

2.3. Coating Application and Curing

The coatings are applied using an innovative coating process using proprietary application tools allowing very thin and homogeneous films. Depending on the tool geometry, different coating patterns (number of stripes, full-width coatings etc.) and properties such as film thickness (from $1\mu\text{m}$ to $200\mu\text{m}$) can be generated (see Figure 2.3). Furthermore, the coating speed is freely adjustable up to 1 m/s, which is generated by moving the substrate instead of the tool. As two substrate holders are available, an automated switch from rigid to flexible substrates is possible. Additionally, multilayer coatings can be performed. The tool is cleaned and/or exchanged automatically after the coating application.

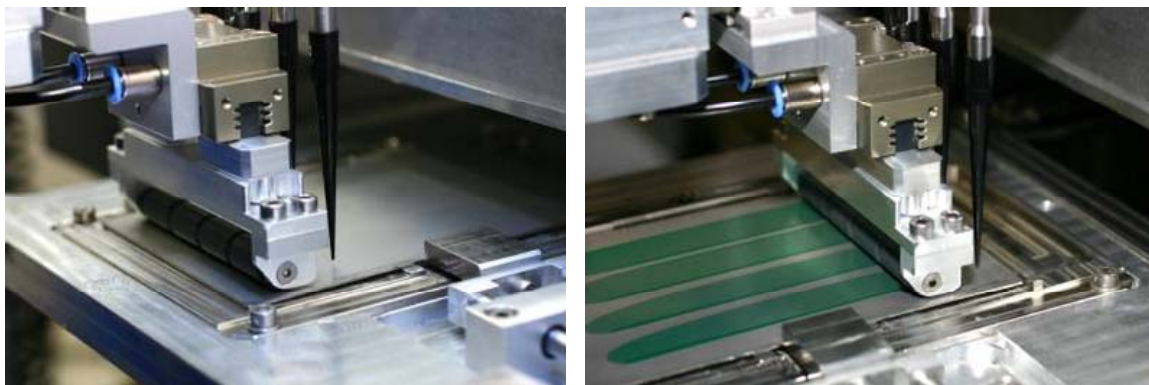


Figure 2.3: Pictures of the coating process before (left) and after (right) coating application.

One of the main design goals of the platform was the ability to perform a very fast drying and curing of the substrates after the coating application, as it is required in many applications. By using the unique and very dynamic transfer system concept, the substrates can be transferred in a very short time to the curing units. For example, at a maximum speed of 4 m/s, the drying or curing unit can be reached after not more than 0.5 s. As such, industrial coating conditions, e.g. in coil coating or in the application of reactive coatings, can be mimicked.

For drying, two IR units can be operated independently. The full substrate surface can be heated homogeneously to the target temperature (up to 300°C) by adjusting the transfer speed and the

IR power. Furthermore, there is an option to heat the substrates from the back-side to mimic induction heating.

UV curing is done using two UV units, which can be operated individually at different power, with different bulbs. Furthermore, the curing can also be performed under inert conditions by using a nitrogen flush.

As the transfer system is bi-directional, arbitrary curing sequences can be defined. For instance, the substrate could be pre-heated in an IR unit, and then coated with a thin film, which is dried in two steps in the IR units and then finally cured in the UV.

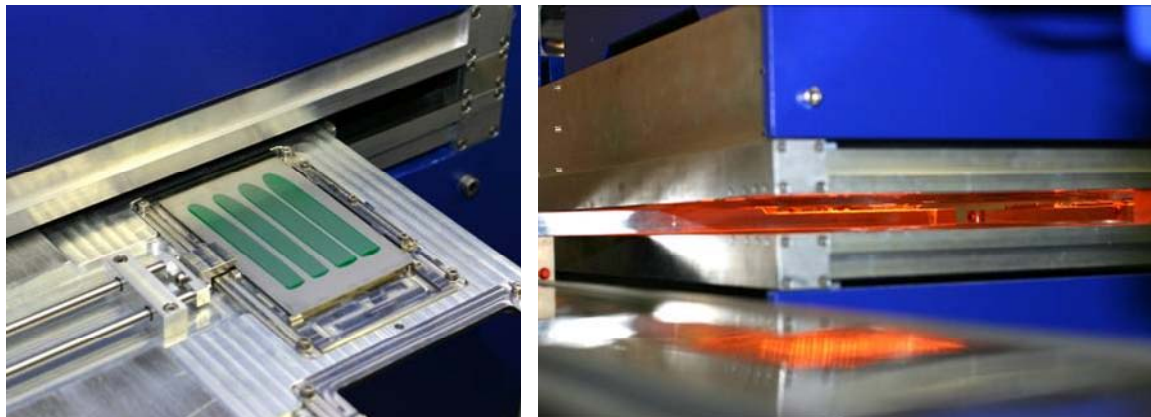


Figure 2.4: High speed curing of the coated substrates.

2.4. Software

Id	Substrate	Search Substrate	Preheat Parameters	Per layer parameters layer 1	Tool parameters layer 1	Layer 1		Stripe 1	Stripe 2	Stripe 3	Stripe 4
						1_TOC_Workflow_IRHeat Duration	1_TOC_Workflow_IRHeat Power	Formulation	Formulation	Formulation	Formulation
<input type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	30	wb-UV 10	water	silane	Acetone
<input type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	30	wb-UV 10	wb-UV 10	wb-UV 10	wb-UV 10
<input checked="" type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	30	silane	silane	silane	silane
<input type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	50	wb-UV 10	water	silane	Acetone
<input type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	50	wb-UV 10	wb-UV 10	wb-UV 10	wb-UV 10
<input type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	50	silane	silane	silane	silane
<input type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	70	wb-UV 10	water	silane	Acetone
<input type="checkbox"/>	Example material 1	Search sample	none	IR-Cool	5-8-12-17	1	70	wb-UV 10	wb-UV 10	wb-UV 10	wb-UV 10

Figure 2.5: Screenshots of the wizard to create coating recipes within myhte®.

The operation of the coating workflow is fully supported by advanced software tools, allowing to efficiently explore the multidimensional parameter space associated with coating development.

Myhte[®] is used for experimental design, data management, data analysis and workflow integration, and hteControl[™] for process control, scheduling and monitoring.

2.5. Conclusions

The platform is built upon robust technical components and stands out for its flexibility and extensibility. By using its high-speed substrate transfer system, hundreds of coating experiments can be performed under conditions as close as possible to the industrial application allowing a fast selection of few candidates for pilot and production scale.