

PEROVSKITE SOLUTIONS



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Merging Excellence

In April 2016 CreaPhys GmbH became a member of The MBRAUN Group. The excellent worldwide sales and service network of The MBRAUN Group combined with CreaPhys' deep technological knowledge and strong working relationship with today's research community allows to offer our global customer base cutting edge system designs as well as sublimed materials of the highest purity level available on the market.



Combining of expertise

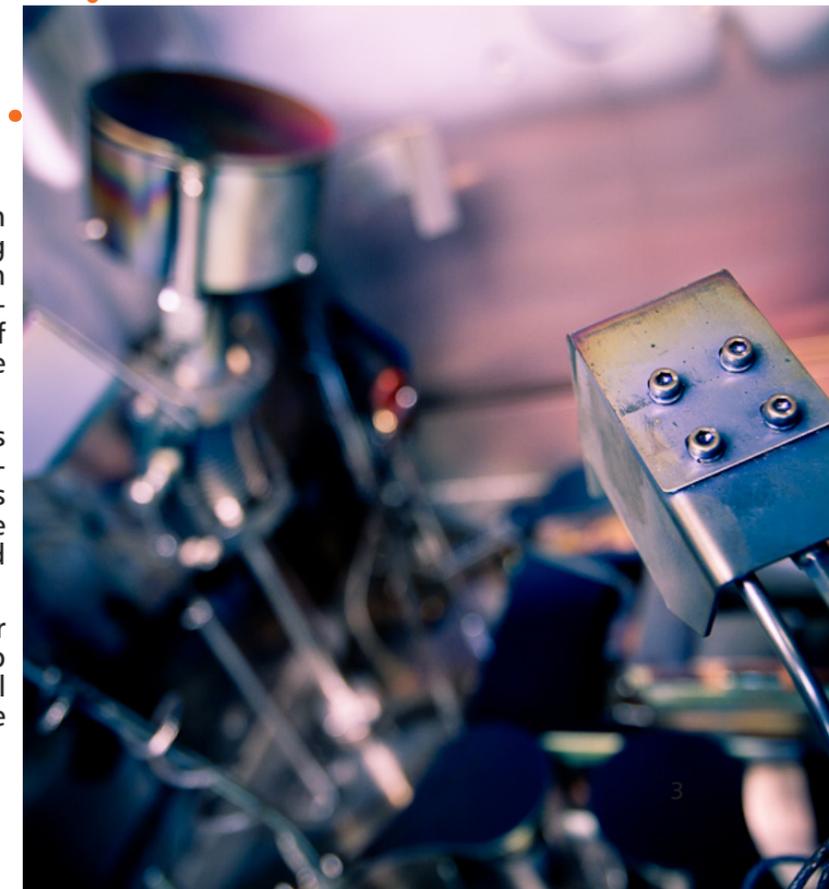
MBRAUN has been a specialist in the design of glove boxes in inert atmosphere since 1973. Together with leading research institutes and well-known high-tech companies MBRAUN continuously developed and improved its product portfolio. Bespoke system designs with innovative concepts such as inert clean rooms which allow to achieve ISO 1 clean room conditions inside gloveboxes, allowed MBRAUN to become one of the leading inertgas companies in the world.

CreaPhys

is a technology leader in sublimation technology as well as vacuum coating equipment for advanced high-tech compounds which are required in nowadays research and manufacturing of opto-electronic devices and perovskite solar cells.

The vacuum coating equipment ranges from standardized stand-alone platforms, over glovebox integrated systems up to entirely customized designs. The systems find their main use in advanced R&D and pilot scale manufacturing.

Sublimation systems are available cover the entire range from lab-scale units up to mass manufacturing in which several kilograms of sublimed material can be processed per day.



STATE OF

Perovskite research

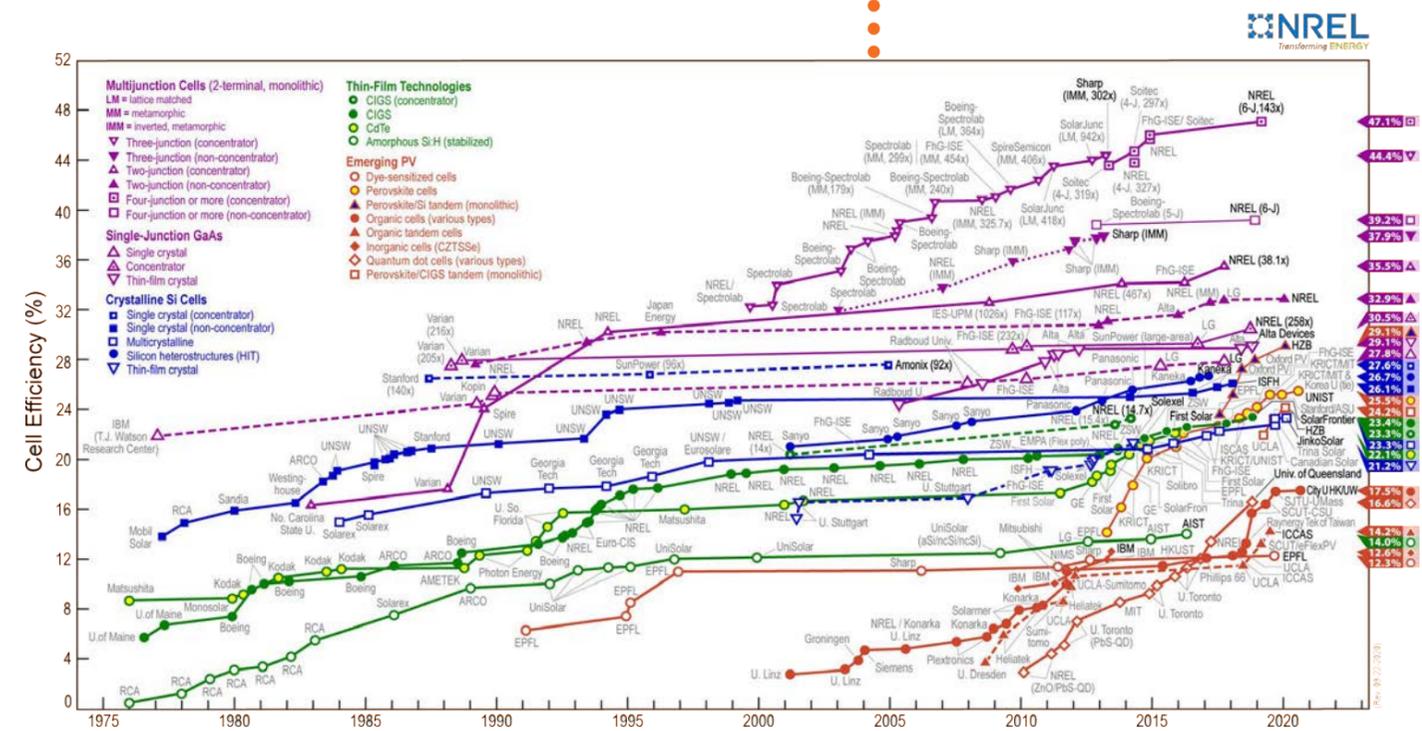
Perovskites are materials with a certain crystal structure in which many different cations can be embedded, allowing the development of diverse engineered materials.

In the past 10 years this material class has been widely used in the development of PSCs which is a type of solar cell incorporating a perovskite-structured compound, most commonly a hybrid organic-inorganic lead or tin halide-based material, as the light-harvesting active layer. The past years have seen the unprecedentedly rapid emergence of this new class of solar cell.



Perovskite materials, such as methyl-ammonium lead halides and all-inorganic caesium lead halide, are cheap to produce and simple to manufacture.

BEST RESEARCH-CELL EFFICIENCIES



While the first efficient solid-state perovskite cells were reported in mid-2012, there has been extremely rapid progress in recent years. Solar cell efficiencies of devices using these materials have increased from 3.8% in 2009 to 25.5% in 2020 in single-junction architectures and, in silicon-based tandem cells, to 29.15%, exceeding the maximum efficiency achieved in single-junction silicon solar cells. Perovskite solar cells are therefore the fastest-advancing solar technology as of 2016.

Furthermore, a wide range of different manufacturing approaches and device concepts are represented among the highest-performing devices - this diversity suggests that performance is far from fully optimized.

PEROvap Concept

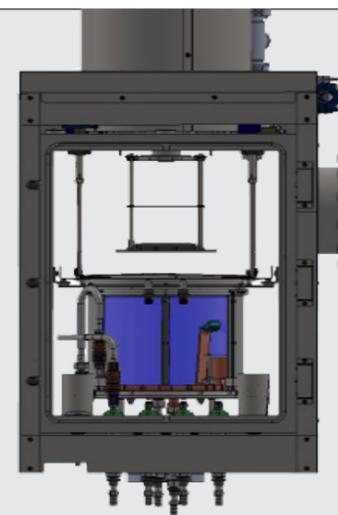
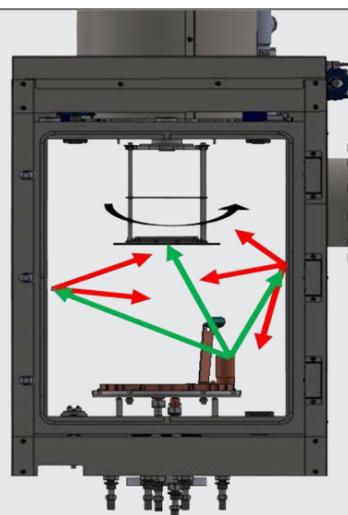
Problems with conventional vapor deposition systems?

This patented vacuum deposition platform has specifically been designed to deposit perovskite materials with a low boiling point. A commonly used material with this characteristic is for example Methyl-ammonium iodide. Low boiling point results in re-evaporation of already deposited material even at room temperature preventing a repeatable and stable process. A unique design allows to prevent this. The core idea of the PEROVAP series is to thermally control the entire system to prevent re-evaporation of already deposited layers. Using proprietary ULT sources which can be cooled down to sub-zero temperatures, a temperature controlled inner shell as well as a temperature-controlled substrate stage, combined with a highly accurate control system provide the operator with a setup that generates highly-repeatable, stable and exceptionally uniform coating results.

..... This is our Solution!

Small molecular weight organic precursor*

- Low evaporation temperature
 - Deposition on and re-evaporation from all chamber surfaces
 - Process under "partial pressure" of halides
- Bad process control



Temperature control by PEROvap concept*

- Main chamber can be temperature controlled
 - Inner chamber can be cooled down to -40°C in order to achieve excellent process control and repeatability over deposition rates and layer quality
 - Special ULTE ("Ultra Low Temperature Evaporator") source has been developed and widely proven for the use of highly volatile substances such as MAI
- Perfect process control & repeatability

Operator protection*

- Use of toxic materials (Pb, I, Br, Cl)
- Untested compounds without toxicity rating
- Corrosive atmosphere in the chamber



Safety through to Glovebox Integration*

- Operation under inert gas condition
- Safety features

Material Compatibility*

- Halogens (I, Br, Cl): oxidizing agents
- Pump system protection
- High partial pressure of organic halide



High-end Design*

- Special organic halide deposition source
- All component materials chosen for high corrosion resistance
- Very special design of all part and components to enable easy cleaning and maintenance especially with respect to the corrosive and poisonous Perovskite materials
- Protection of the pump system by cold trap

*Standard vacuum chamber offered by most manufacturers

*PEROvap design by Creaphys & MBRAUN



MINI PEROVap

The Mini PeroVap is our most cost-efficient platform, designed to take the first steps in perovskite research including the unique system characteristics of the larger systems. Main limitation is substrate size and available optional upgrades. Easy to integrate into existing glovebox as it comes as a stand-alone unit. The ideal tool for a scientist who does not want to compromise on performance and repeatability but can accept smaller devices to be coated.



Applications:

Perovskite compounds
Organic deposition

- Compact design
- Integrable in existing MBRAUN systems
- Economic Solution
- Short delivery times
- Easy retrofit in existing gloveboxes
- Substrate size up to 50x50 mm
- Up to 4 deposition sources



MINI PEROvap

The MINI PEROvap consists of a dry turbo-molecular pump system with up to 70 l/sec (Pfeiffer, HiPace80), as an option it can be equipped with a larger pump system with a LN2 cold trap.

The used highly volatile organic precursors require a defined evaporation at very low temperatures. Moreover, they can easily be re-evaporated from all chamber surfaces. The MINI PEROvap is equipped with a vacuum chamber and an cooled inner enclosure, which allows a higher repeatability, independence on environmental conditions and gives an additional lever to fine-tune the perovskite deposition.

The Mini PEROvap can be additionally equipped with several process components (sources, shutters, mask/substrate shutter). Furthermore a temperature control of substrate heating/cooling can be added.



PEROvap

The PEROvap deposition system is glovebox integrated to operate under inert conditions to protect the materials from oxygen and water influence. The used highly volatile organic precursors require a defined evaporation at very low temperatures. Moreover, they can easily be re-evaporated from all chamber surfaces.

The Helmholtz Zentrum Berlin achieved an efficiency of 29.15% (Jan.2020) in an MBRAUN PEROvap system.



©Helmholtz Zentrum Berlin

This platform has been specifically designed for high-end research and is positioned directly ahead of pilot-scale manufacturing. The system features corrosive resistant chamber(s) and vacuum pumps addressing the properties of many perovskite materials, a cooled inner chamber, cold traps mounted upstream of the vacuum pumps, ULT sources and a dedicated control system enabling the operator to define and store hundreds of recipes, track and record the process data and repeat the process in a highly automated manner repeatedly.

This platform is completed with a comprehensive set of optional upgrades including automatic mask changers, tailored source arrangements, connection to gloveboxes or even to vacuum cluster systems for demanding research applications.

- Ideal tool for advanced R&D
- Ready for band gap-tuning with various composites
- Proprietary new system design, patent pending
- Special Ultra-Low Temperature sources
 - High stability at low temperature
- Stable and defined process control
- High repeatability
- Material compatibility
- Up to 8 sources (with co-deposition possible)



Inner vacuum chamber can be cooled down to -40°C in order to achieve excellent process control and repeatability over deposition rates and layer quality



Main vacuum chamber

Slot-Die Coating

Slot-Die Coaters offer a fraction of the cost and excel in material yield (up to 95%) when compared against vacuum deposition equipment. Slot die coating is frequently used in emerging high-tech applications in which liquid materials need to be deposited in thin films on either solid or flexible substrates.. Moreover, slot-die technology continually gains recognition as a viable method for upscaling to larger sizes and higher volume in thin film solar manufacturing. MBRAUN and its partners play an important role in transferring proven R&D processes into pilot-scale and even high-volume manufacturing operations for many different layers and types of solar cell technologies and thin film solar cell coatings which are based on solution processed materials.

A variety of slot-die coating platforms along with a comprehensive set of options allow to tailor the system configuration to the coating requirements.

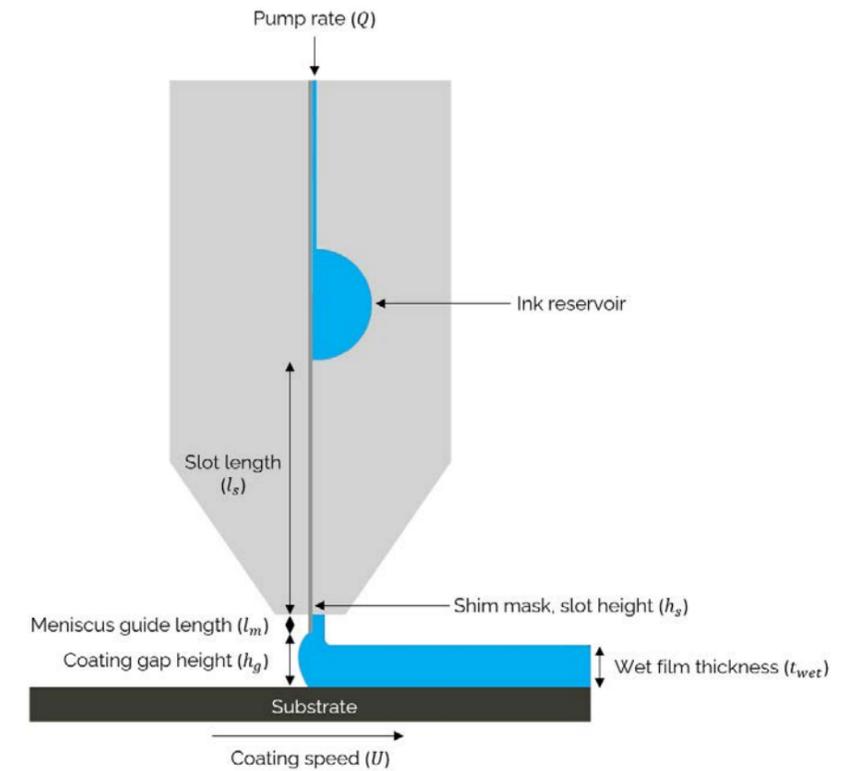


- Customized coater with 2 heads, based on the FOM alphaSC

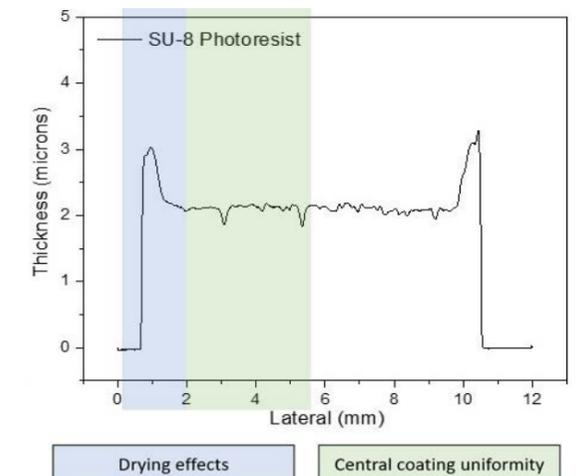
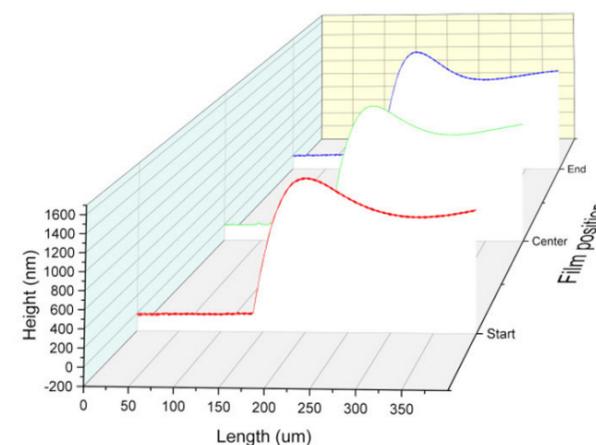
In slot-die coating applications special attention has to be taken towards airborne particles. The nm thick films (dry film thickness) deposited during slot-coating can be entirely damaged when particles get stuck in them. To avoid this problem MBRAUN developed local clean-rooms which can be run under inert conditions and reach clean-room class levels down to ISO 1.

Made by
FOM
TECHNOLOGIES

How does it work?



Extract of the coating capabilities



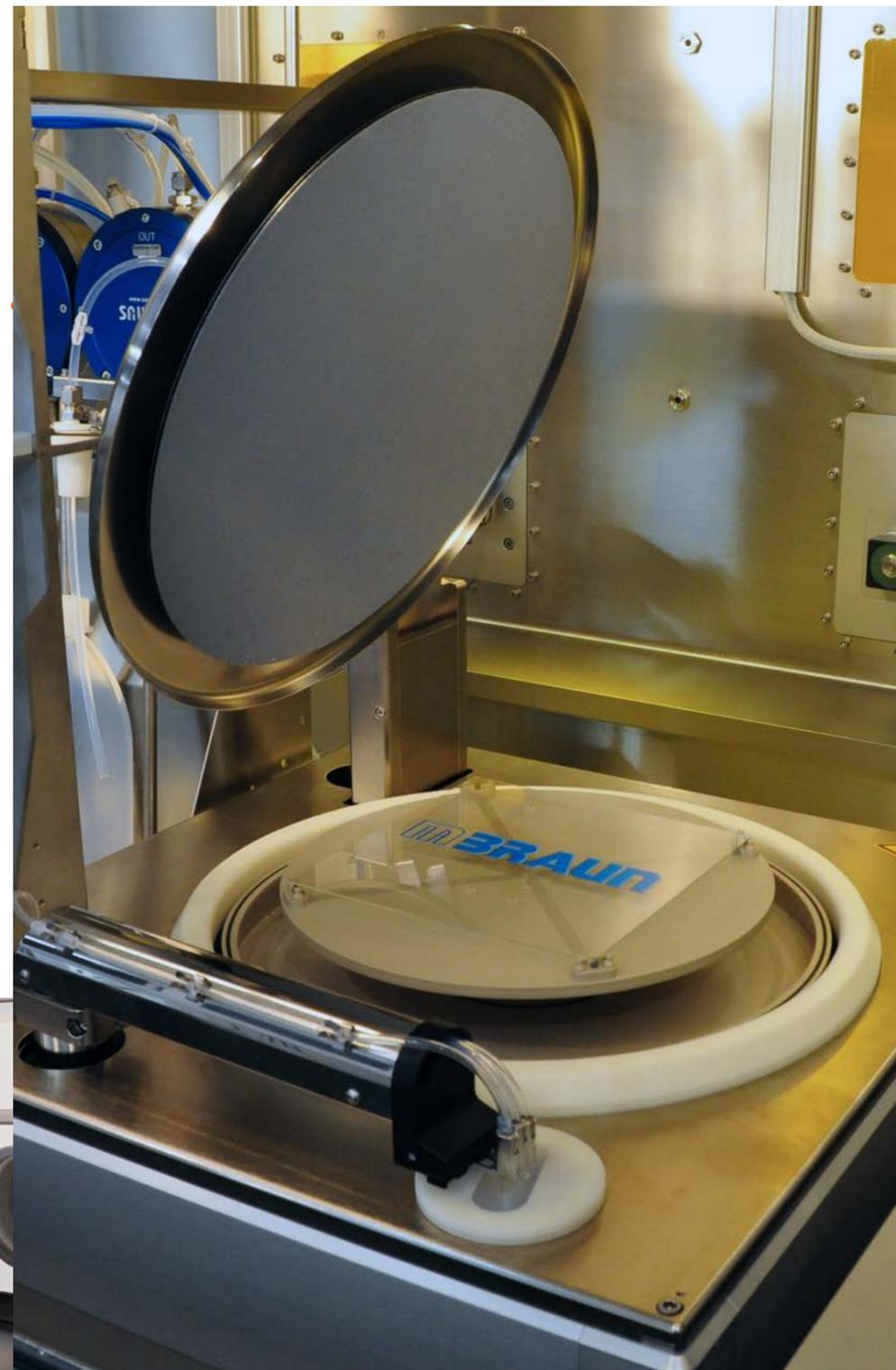
Spin Coating

- Cost efficient compared to other coating equipment
- High uniformity
- Easy programming of individual recipes
- Flexibility to conduct advanced research

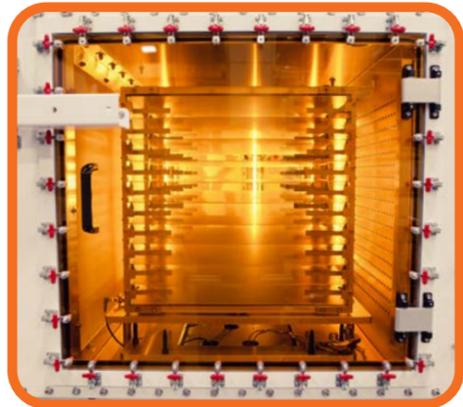
The spin coating technique is commonly used in research and development as well as in industrial applications to coat thin layers onto rigid substrates.

Easy programming of individual recipes include speed, acceleration and time. This gives users the flexibility to conduct advanced research, especially when air sensitive materials are being utilized.

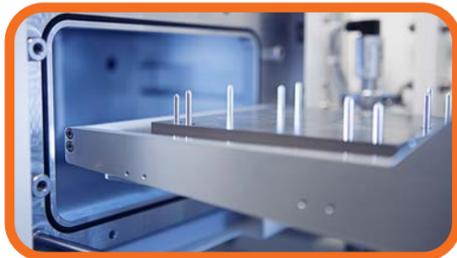
A variety of optional accessories are available like a semi-automatic cartridge dispensing system, foot switch, additional protection bowl (for easy cleaning). A full array of customized and standardized vacuum chucks, equipped with a quick change mechanism completes the comprehensive spin coating package.



Curing & Hot Plates



Wet coating devices require good curing to achieve homogeneous coatings and to build efficient devices. The MBRAUN MB-HPL-400 Vacuum Hotplate has been designed to cure sensitive organic layers under defined process conditions. Application ranges from basic research up to sophisticated manufacturing processes.



The hot plates designed by MBRAUN is one of the latest designs in the MBRAUN process tool series. The basic function is to cure organic layers under controlled conditions after being deposited onto a rigid substrate. Focused on very good temperature uniformity, temperature accuracy, process repeatability and stability whilst offering a high level of flexibility.



AUTOMATION

When elimination of human error, increase of throughput or improvement of process stability and repeatability are getting into the focus of the client, automation solutions are unavoidable. Over the years MBRAUN designed and shipped several fully-integrated systems ranging from semi-automation to full automation incorporating vacuum-systems, process tools run under inert conditions or simply operated in regular clean-rooms.

Automated systems are always tailored solutions addressing exactly the needs of the client.



Automated systems offer the following key benefits:

- Increased quality in the manufacturing process
- Reduced operation and handling time
- Improved repeatability, precision, and reproducibility of processes and products
- Dust prevention
- Higher accuracy
- No risk of wrong movement, resulting in broken samples
- Handling of small and big substrates or other types of products





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