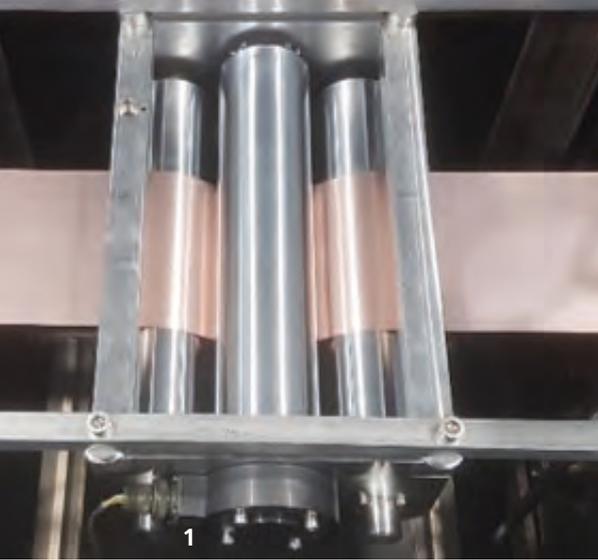


PROCESSING THIN METAL FILMS IN THE VACUUM COATING LINE MAXI





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Introduction

The processing of thin metal strips in a vacuum often poses a great challenge with regard to the prevention of plastic deformation such as wrinkling and bulging. Weak points are often the exceeding of critical tensile loads, the compliance with the upper limit for the

strip temperature as well as the strip guidance. Fraunhofer FEP operates special equipment for wet-chemical pre-cleaning, pre-treatment, cooling, coating and post-treatment of thin metal strips in a vacuum. Thanks to the technical equipment, the continuous

gain of experience and the extensive technological know-how, even the most demanding development tasks can be solved at Fraunhofer FEP.

6 Application examples for functional coatings

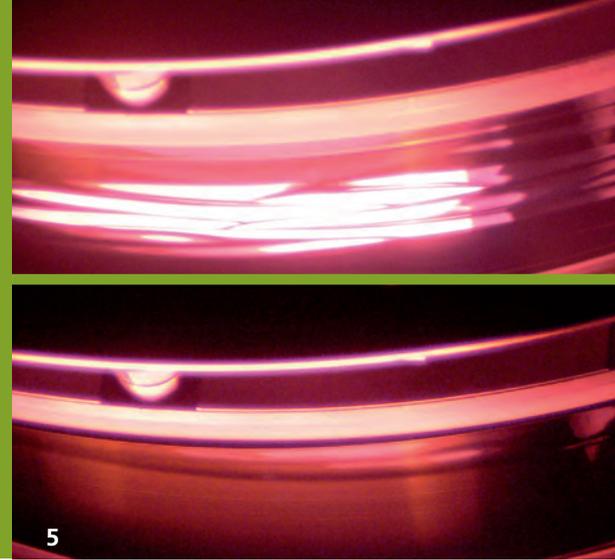
Thermal barrier coatings (TBC) <ul style="list-style-type: none"> ■ Ceramics 	Battery technology <ul style="list-style-type: none"> ■ Thin film battery ■ Thin film anodes ■ Separator materials ■ Solid electrolyte 	Decorative design <ul style="list-style-type: none"> ■ Metallic finishing of surfaces ■ Adjustable colored interference layers ■ Transparent oxide layers
Corrosion protection <ul style="list-style-type: none"> ■ Dense layer structures ■ Alloy formation by post-treatment ■ Coatings of e.g. Al, Ti, CrNi, ZnMg, AlMg, TiN, ... 	Strip materials <ul style="list-style-type: none"> ■ Copper / Aluminum ■ Steel / Alloys ■ Titanium, nickel alloys ■ Width: ≤ 280 mm ■ Thickness: ≥ 10 μm 	Semiconductor technology <ul style="list-style-type: none"> ■ PV absorber layers ■ Barrier layers ■ Functional layers for devices
Scratch protection <ul style="list-style-type: none"> ■ Transparent hard coatings ■ Coatings of e.g. TiN, TiAlN, CrN, SiO_x, Al_2O_3, ... 	Electrical engineering <ul style="list-style-type: none"> ■ Insulation layers ■ Contact layers ■ Thin HF conductors (Ag, Cu, Au) 	Power engineering <ul style="list-style-type: none"> ■ Fuel cells ■ Solar selective coatings ■ Electrolyte layers

Technical possibilities

- Precise strip guidance with low strip tension below the tensile strength limit
- Wrinkle-free winding at high process speed
- High deposition rates (> 100 nm/s)
- Large-area coating with high coating thickness homogeneity (coating width up to 280 mm)
- Control of strip temperature by low heat load (< 1 W/cm²) and efficient cooling (> 1000 W/m²K)
- Excellent coating adhesion due to in-situ plasma pre-treatment

Strip parameters

- Strip widths: 100 – 280 mm
 - Strip thicknesses: 10 μm – 1.5 mm
 - Strip materials: copper, aluminum, steel, alloys
 - Winding core diameter: 150 – 450 mm
 - Strip speed: 1 mm/s - 1 m/s *
 - Strip tensile force: 10 – 10 000 N
- * depending on the strip thickness

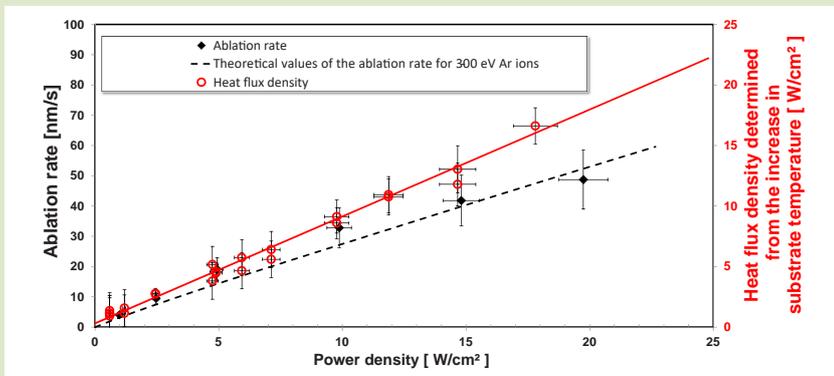


Our services

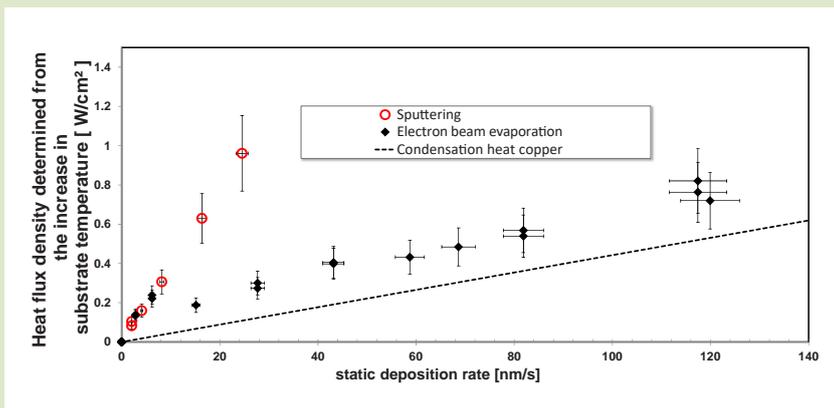
We offer:

- Conducting feasibility studies
- Technology development
- Development of optimal process parameters
- Pilot trials
- Accompanying process and product analysis
- Support up to plant realization

7 Measured ablation rate and heat flux density during pre-treatment by inverse sputter etching



8 Measured heat flux densities during deposition of Cu by sputtering and at high rate by electron beam evaporation (EB-PVD)



COVER PICTURE

Guide roller on unwinder

- 1 Measuring device for strip tension
- 2 Copper coating by EB-PVD
- 3 Winding station with Cu strip of the in-line vacuum system for coating metallic plates and strips (MAXI)
- 4 Gas cooling roll in a coating chamber of the MAXI
- 5 Thin metal strip during high-rate coating: insufficient strip cooling results in pronounced wrinkles (top); effective strip cooling prevents damage to the strip during high heat load (bottom)

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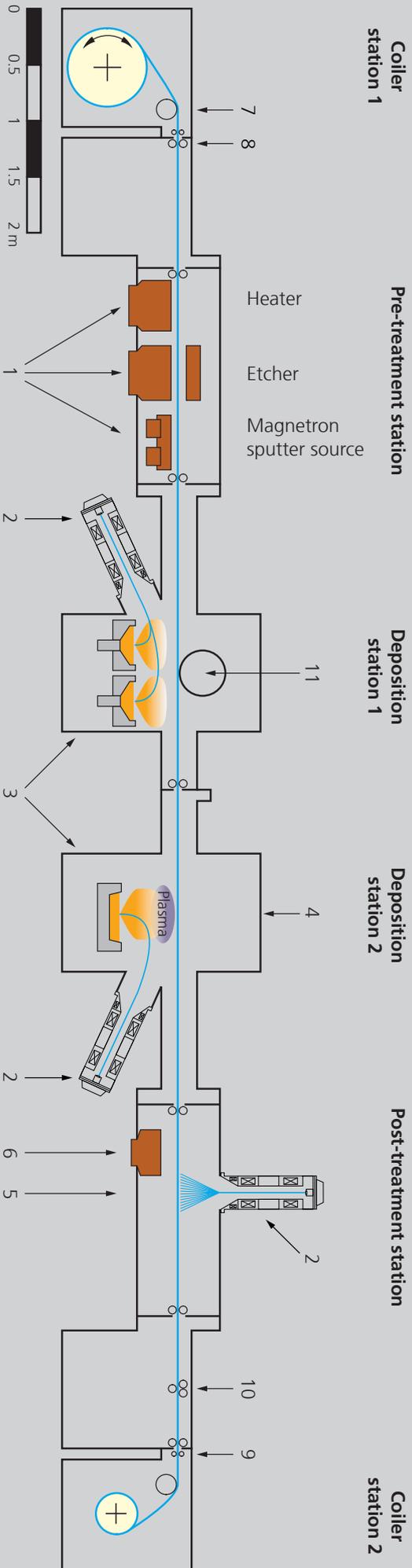
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Schematic layout of the MAXI plant in the operating mode for coating of strips



Flexible technological equipment – example

- 1 ... various pre-treatment processes, e.g. heating, etching, deposition of interfacial layers
- 2 ... high power electron beam gun
- 3 ... various crucibles to evaporate different materials (metals, alloys or compounds)
- 4 ... plasma-activated deposition process
- 5 ... thermal after-treatment, e.g. electron beam heating

- 6 ... XRF thickness distribution measurement system, optical film thickness measurement system by using acromatic light
- 7 ... strip edge control system
- 8 ... sealing roll pairs, to decouple pressure
- 9 ... squeeze valve, during coil change
- 10 ... strip tension measurement
- 11 ... gas cooling roll