Sales presentation, as of 06.2025

Bosch Manufacturing Solutions | BMG

BOSCH

BMG | **who we are**

Bosch Manufacturing Solutions | BMG –

Global industrialization partner & turnkey special machinery provider for production equipment & automation

- > 30 years of experience as special machinery supplier
- > 4.000 assembly & testing systems
  > 10.000 small & services projects
- Automation level adjustable, semi- to fully automated solutions
- Digital planning & process to digital engineering & i4.0 applications

>17
Locations

Full-liner
portfolio

Several industries & product areas

1.900
Employees

~680
TNS m€

BMG | **our purpose statement**
The difference in manufacturing

For us, **‘Invented for life’** means to build a **more sustainable future** through production equipment by Bosch Manufacturing Solutions.

We create a difference in our customers’ products by offering **“the difference in manufacturing”**

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BMG | **our portfolio**
Customized assembly & testing systems

Global industrialization partner & turnkey special machinery provider for production equipment & automation, offering

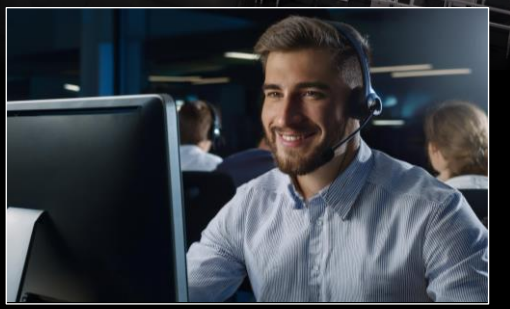
Customized assembly & testing systems

empowered by ...

Engineering Consulting & Digital Engineering

Advanced Manufacturing Processes & Technologies

Digital & Intelligent Solutions



Services along the entire product lifecycle

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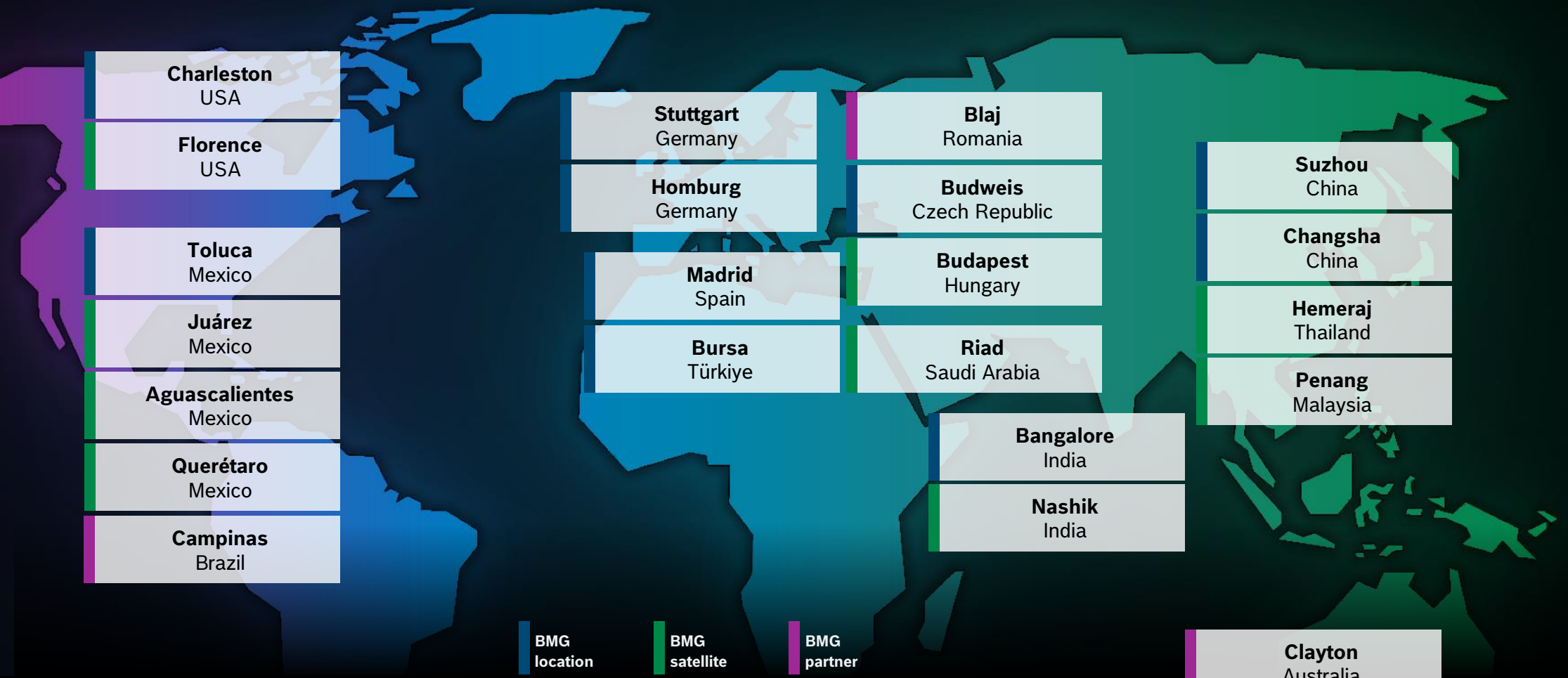
BMG | **global strength in network & partners**



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BMG | **focus industries & product areas**

Focus industries


eMobility


Automotive (ICE)


Energy

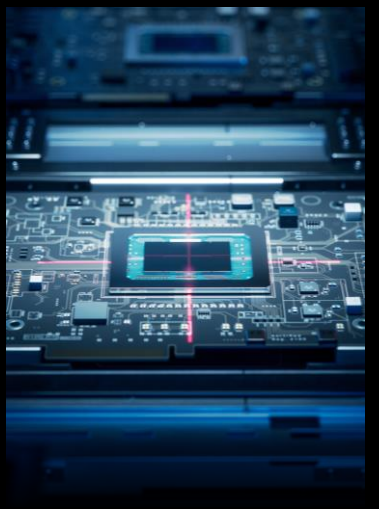

Consumer Goods

Focus product areas

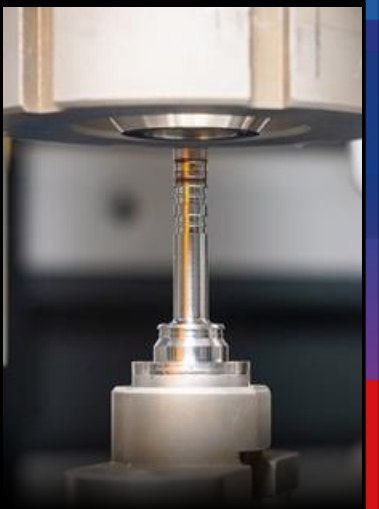

Battery


H2 Solutions / Fuel Cell


eDrive


Sensors & Electronics


Chassis & Steering


Combustion Engine

BOSCH

BMG | **focus industries & product areas**

Battery

Stay charged

with battery production equipment from Bosch Manufacturing Solutions | BMG. Our expertise reaches from cell production technologies up to fully automated and intelligent Cell to X assembly and testing systems.

Cell Manufacturing

- Dry Electrode Manufacturing
- Smart Battery Formation

Cell to X Manufacturing

- Cell Supply
- Cell Cleaning
- Electrical Testing (BOL/EOL)
- Dispensing
- Resistance Welding
- Laser Welding
- Machine Vision
- Leakage Testing

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Driving mobility

with innovative eDrive production equipment from Bosch Manufacturing Solutions | BMG. Our expertise ranges from various winding technologies such as Hair-Pin, I-Pin, X-Pin, for all vehicle classes, to individual line concepts from semi to fully automated, including AI based solutions for increased efficiency.

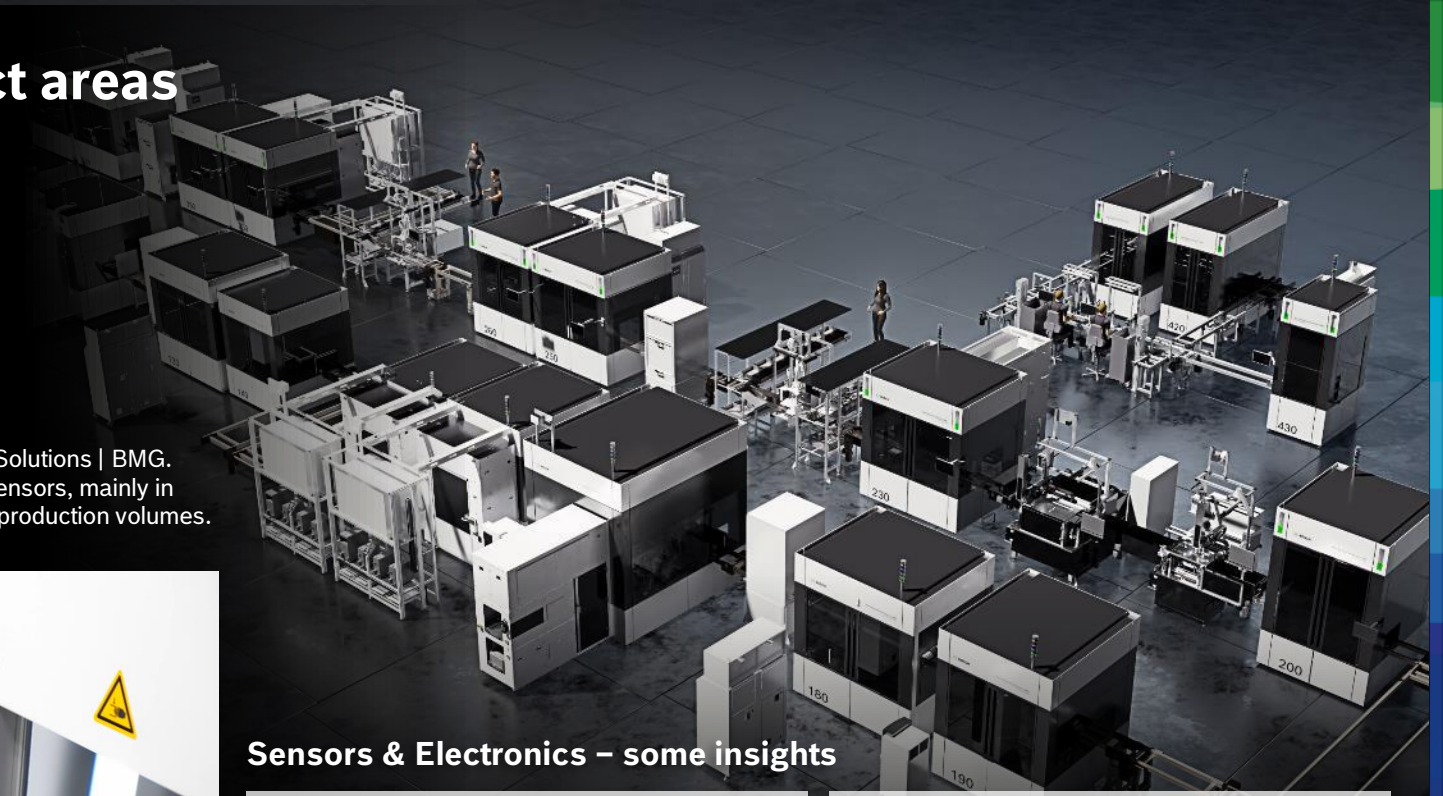
eDrive Lab

eDrive – some process highlights

Pin Manufacturing	**Trickling**
Handling & Robotics	**Clamping**
Twisting	**Optical Inspection: Post Vision**
Laser Welding	**Electrical Testing**
Separating & Cutting	**Further …**

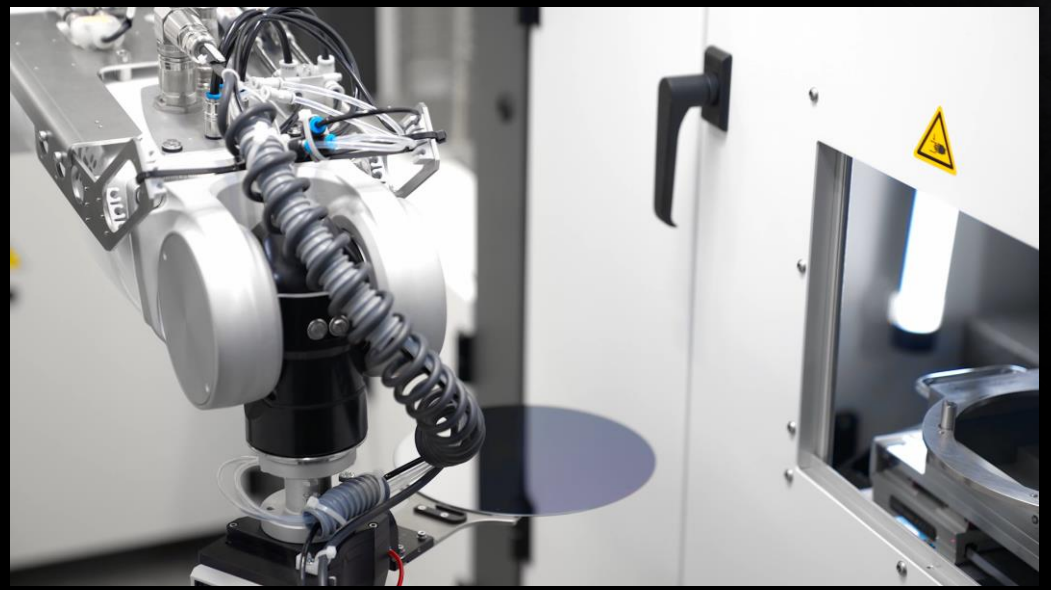
BOSCH

BMG | **focus industries & product areas**
Sensors & Electronics



Unleash power

with sensors & electronics production equipment from Bosch Manufacturing Solutions | BMG. We provide flexible assembly technology for ECUs, power electronics, and sensors, mainly in eMobility. Our scalable solutions optimize investments and adapt to variable production volumes.



Sensors & Electronics – some insights

Flexfoil Handling	Screwing
Laser Welding of Electrical Connections	Pressfit & Single Pin Insertion
Laser Micro Structuring	Optical Inspection
Laser Cleaning	Magnetic Conveyor System
Dispensing	

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» **Reference Project NorthH2 & Fraunhofer IWES**

From Water to Energy –

empower your sustainable future with H_2 solutions by Bosch Manufacturing Solutions | BMG, in the area of water purification & electrolysis, fuel cell assembly & testing as well as power generation.

» **H2 circle –**
BMG as system industrialization partner

Water Purification
- » **BMG Pure Water System**

Electrolysis – from water to hydrogen
- » **PEM Ely Stack Testing**
- » **PEM Electrolyzer System**
- » **AEM Ely Stack Testing**
- » **SOEC Stack Testing**

Fuel Cell – from hydrogen to energy
- » **PEMFC Testing**
- » **PEMFC – FCPM Assembly & Testing**
- » **PEMFC – FCPM Power Generator**
- » **PEMFC – FCPM – Bipolar Plates Processes**
- » **PEMFC – Coatings**

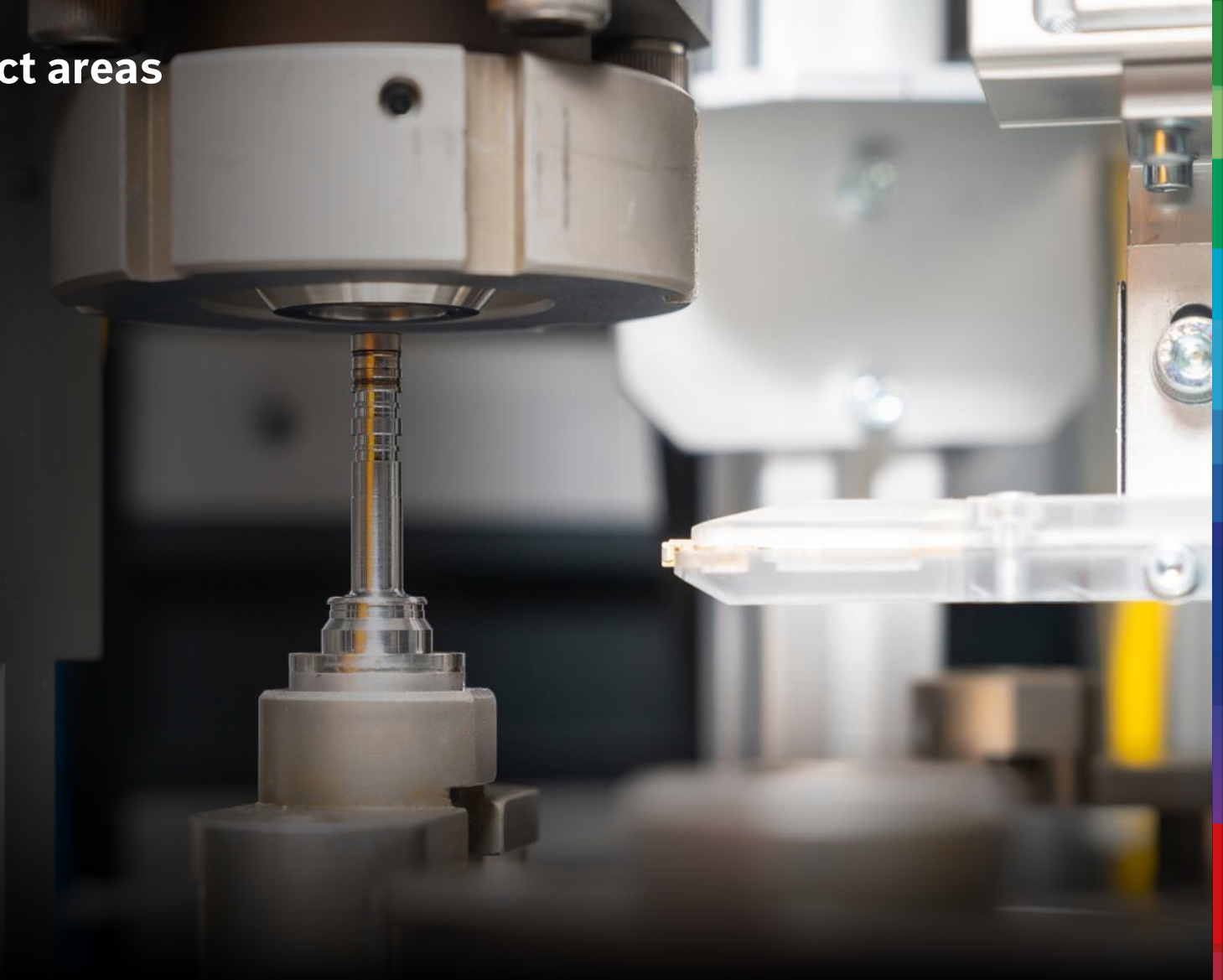
» **Hydrogen Gas Injection**

BMG | **focus industries & product areas**
Chassis & Steering

As a technology and process expert for the automotive industry, we offer you the optimum manufacturing equipment for various components in the field of chassis and steering.

From hydraulic to electric steering and driving systems: New Braking Systems like the Integrated Power Brake (IPB) and the electronic stability program (ESP) are just some examples of components manufactured with equipment from Bosch Manufacturing Solutions | BMG.

BMG | **focus industries & product areas**
Combustion Engine



Our high-precision production and testing equipment for diesel and gasoline injection systems, e.g. including high-pressure injectors, diesel pumps, and exhaust gas systems, are backed by the expertise of Bosch Manufacturing Solutions | BMG.

As the ICE sector matures, our services are crucial in maximizing performance and extending the lifetime of your systems. From cycle time improvements and modernizations to relocation projects, we ensure peak efficiency throughout your equipment's lifecycle.

BMG | **focus industries & product areas**

Battery

Stay charged

with battery production equipment from Bosch Manufacturing Solutions | BMG. Our expertise reaches from cell production technologies up to fully automated and intelligent Cell to X assembly and testing systems.

Cell Manufacturing

- Dry Electrode Manufacturing
- Smart Battery Formation

Cell to X Manufacturing

- Cell Supply
- Cell Cleaning
- Electrical Testing (BOL/EOL)
- Dispensing
- Resistance Welding
- Laser Welding
- Machine Vision
- Leakage Testing

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BMG | Battery
Benefits at a glance

- Over 15 years of experience in battery manufacturing
- Level of automation adjustable,
  Semi- or completely automated solutions
- Digital production engineering
  Model based digital toolchain
- USPs in process technology
  e.g. joining, machine vision, testing
- Simultaneous engineering support,
  line dimensioning, process application

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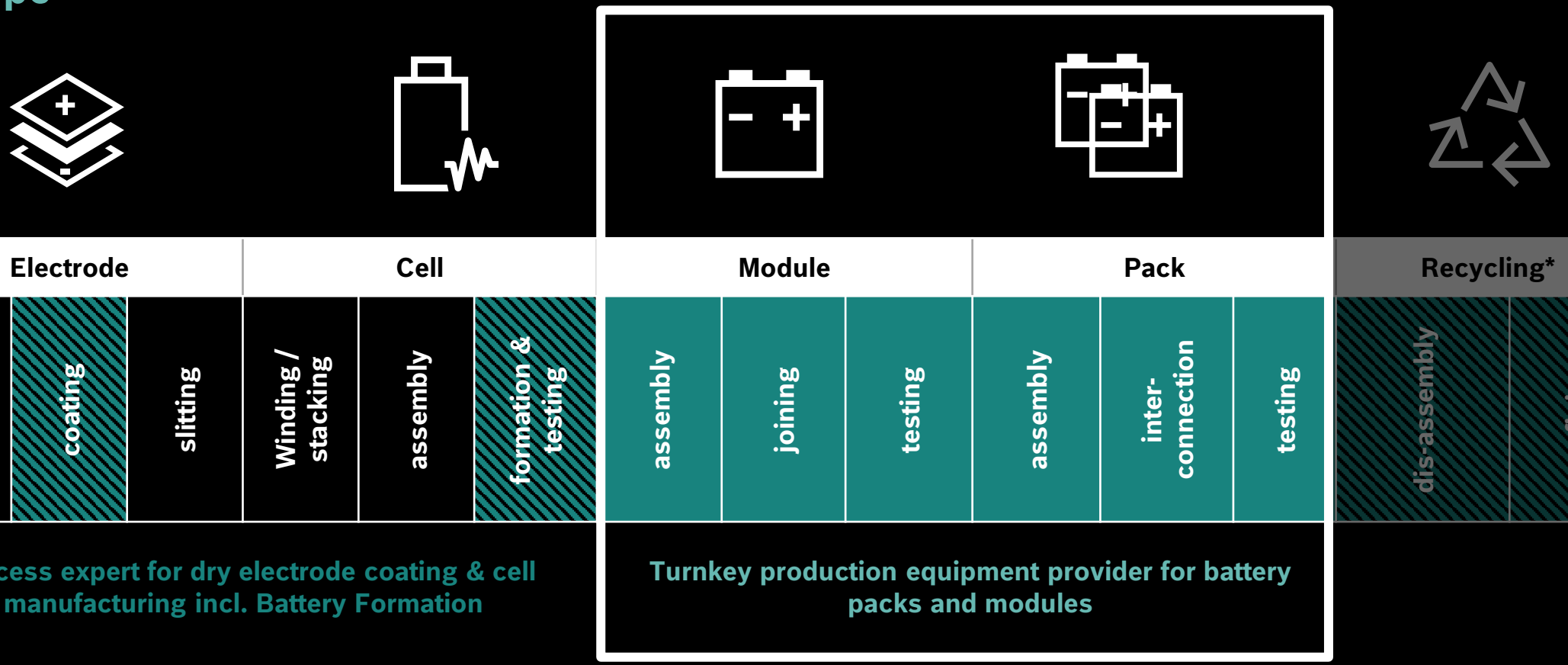
BMG | Battery
Scope



BMG | focus industries & product areas | Battery
Portfolio & References

Battery module assembly line for cylindrical cells

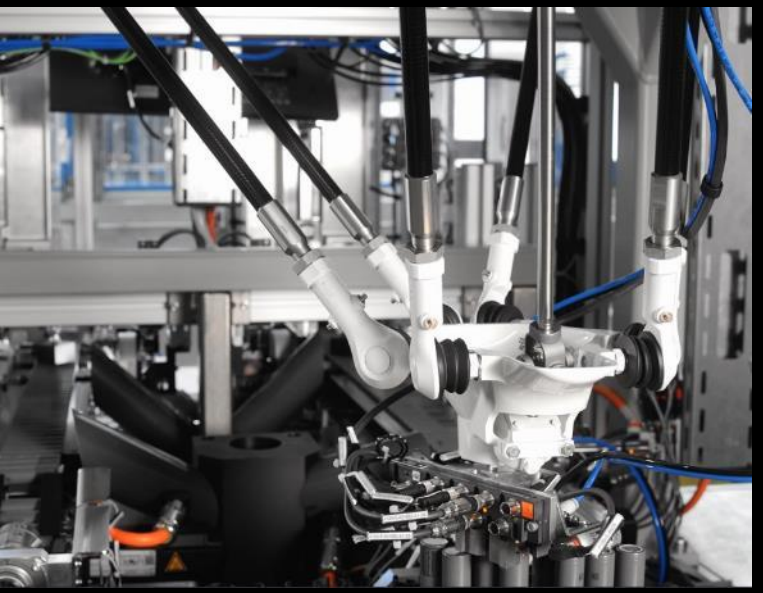
- Cycle time handling < 0,4 s/cell
- Up to 10 cells per pack
- Standardized solutions for 18650 and 21700 cells

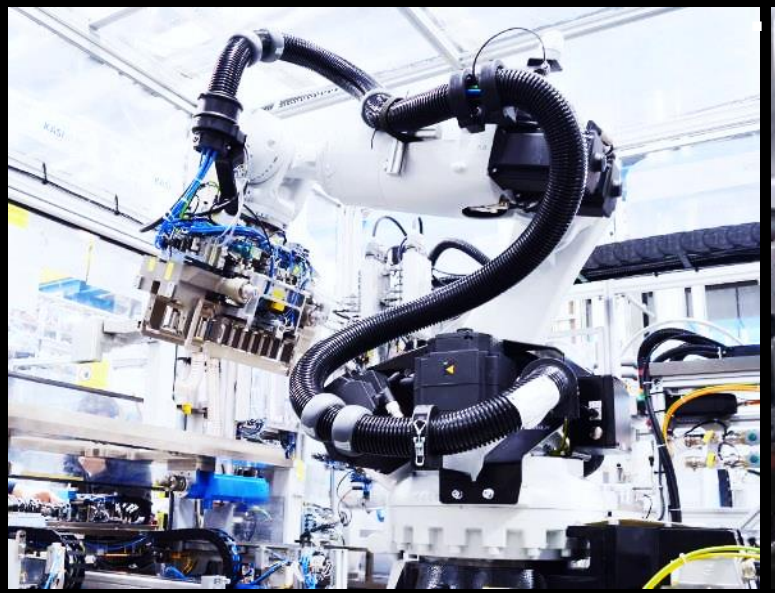
Battery module assembly line for prismatic cells

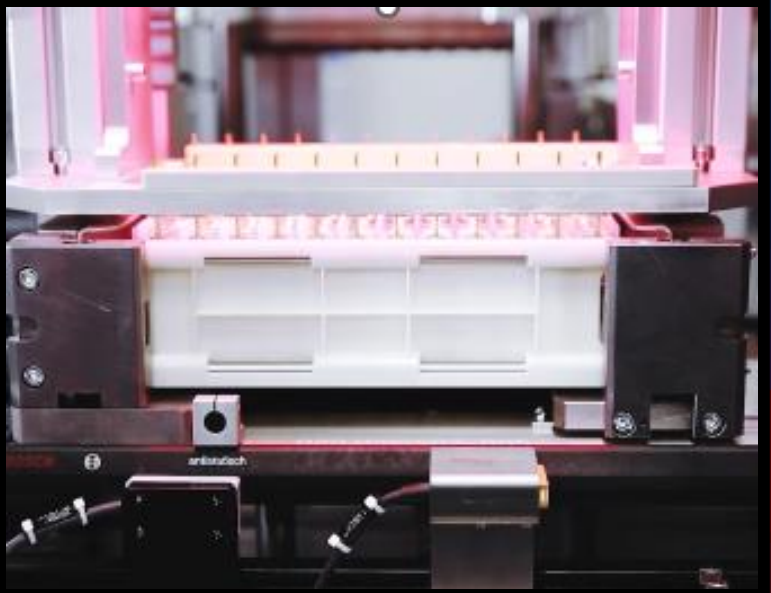
- Module Assembly line for 100.000 modules/a
- Cycle time: approx. 120s/module with 8 prismatic cells per module
- Output: 270 MWh/a

Testing equipment of battery cells, modules and packs

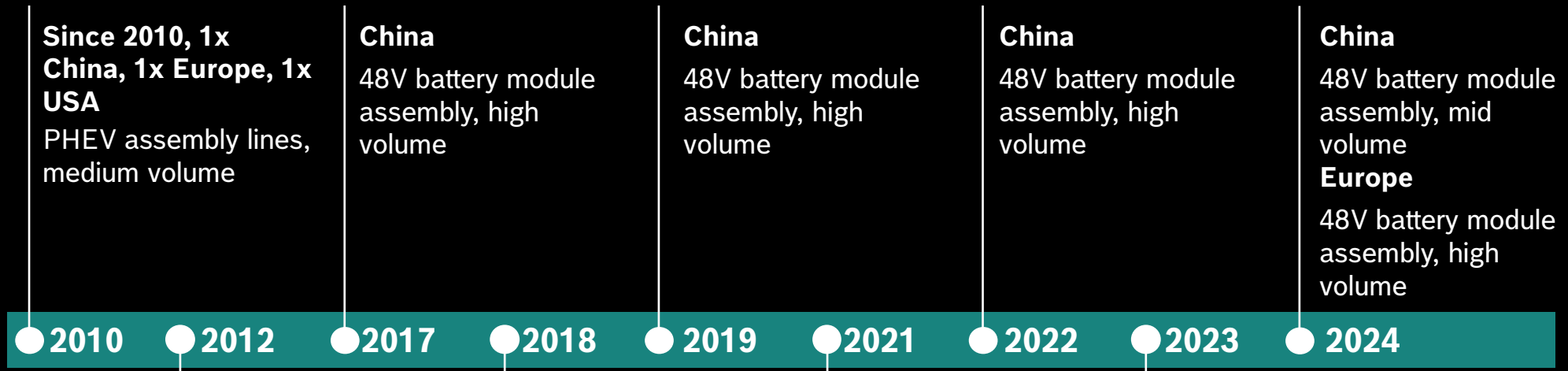
- Measurement of current, voltage, temperature & SOC
- Identification of battery cell parameters: OCV, ACIR, DCIR, SOC
- Fully automated integration in production line or stand-alone solutions possible







BMG | Battery
References



2010
Since 2010, 1x China, 1x Europe, 1x USA
PHEV assembly lines, medium volume

2012
Europe
module assembly, medium volume & sample shop
cell assembly line sample shop

2017
China
48V battery module assembly, high volume

2018
Europe
pack assembly for automotive company realized with AGVs, small series volume

2019
China
48V battery module assembly, high volume

2021
Europe
48V battery module assembly, high volume
Automotive module assembly, mid volume
e-bike battery assembly, high volume

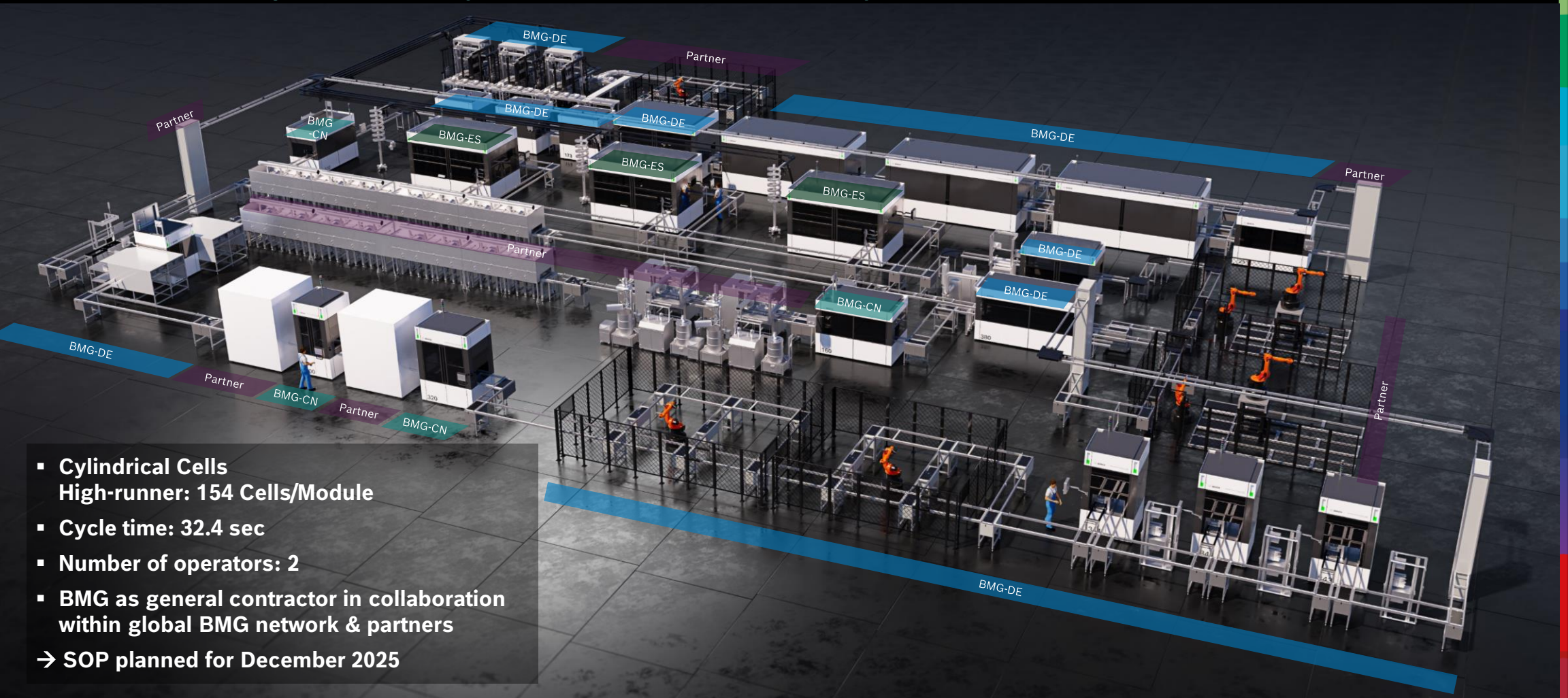
2022
China
48V battery module assembly, high volume

2023
Europe
48V battery module assembly, high volume

2024
China
48V battery module assembly, mid volume
Europe
48V battery module assembly, high volume

BMG | Battery

Reference project: Battery Cell to Module Line Cylindric Cells



- **Cylindrical Cells**
  High-runner: 154 Cells/Module
- **Cycle time: 32.4 sec**
- **Number of operators: 2**
- **BMG as general contractor in collaboration within global BMG network & partners**

→ **SOP planned for December 2025**

BOSCH

BMG | Battery
Inhouse competencies

Cell Manufacturing

- Dry Electrode Manufacturing
- Smart Battery Formation

Cell to X Manufacturing

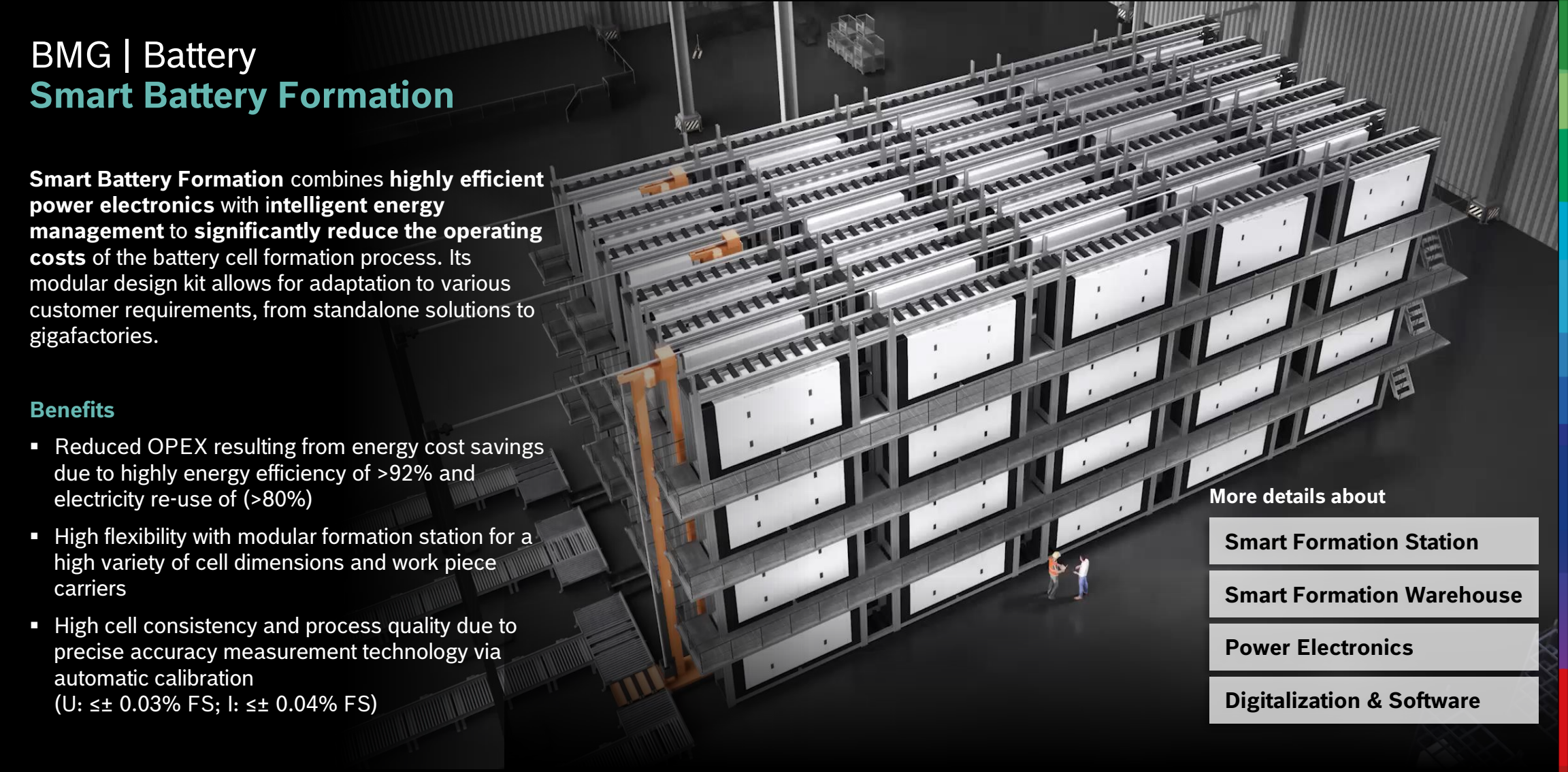
- Cell Supply
- Cell Cleaning
- Begin & End of Line Testing
- Dispensing
- Resistance Welding
- Laser Welding
- Machine Vision
- Leakage Testing

BMG | Battery
Smart Battery Formation

Smart Battery Formation combines **highly efficient power electronics** with i**ntelligent energy management** to **significantly reduce the operating costs** of the battery cell formation process. Its modular design kit allows for adaptation to various customer requirements, from standalone solutions to gigafactories.

Benefits

- Reduced OPEX resulting from energy cost savings due to highly energy efficiency of >92% and electricity re-use of (>80%)
- High flexibility with modular formation station for a high variety of cell dimensions and work piece carriers
- High cell consistency and process quality due to precise accuracy measurement technology via automatic calibration
  (U: ≤± 0.03% FS; I: ≤± 0.04% FS)



More details about

- **Smart Formation Station**
- **Smart Formation Warehouse**
- **Power Electronics**
- **Digitalization & Software**

BMG | Battery
Smart Battery Formation Chamber

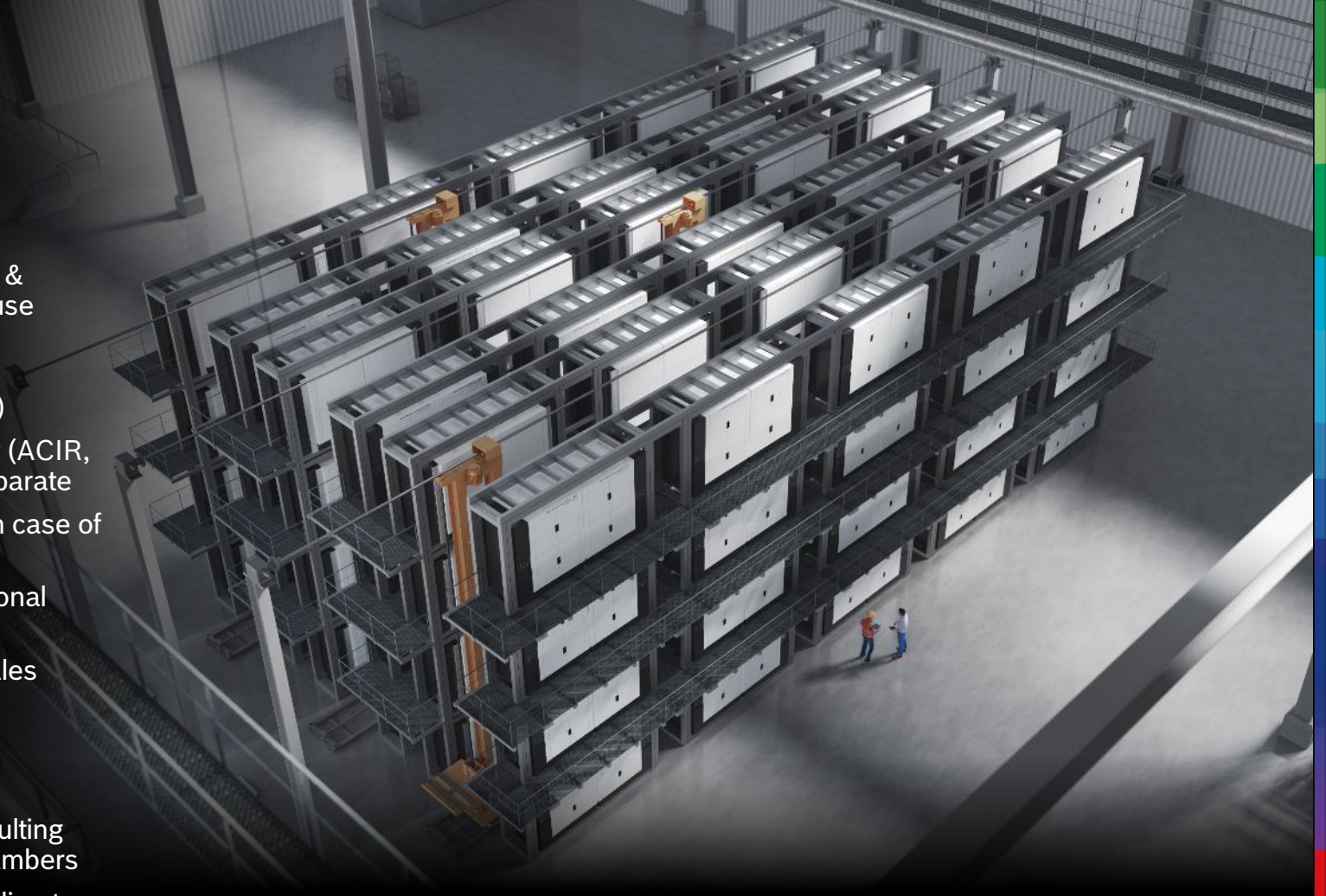
Smart Formation Station

- Smart Formation Station for battery cell formation of prismatic & cylindrical cells
- Modular formation chamber for a high variety of cell dimensions and workpiece carriers
- Up to 1,024 channels for cylindrical cells or 128 channels for prismatic cells

Benefits

- Outstanding technical availability due to easy maintenance and repairs of <5min due to replaceable contacting modules
- High chamber temperature uniformity for consistent cell quality (± 2°C)
- Flexible output from ±5 A for cylindrical and up to ±320 A for prismatic cells, accuracy: U: ≤± 0.03% FS; I: ≤± 0.04% FS
- High safety feature - adaptable to requirements
- Flexible software integration into automation architecture
- Optional: Integrated ACIR, DCIR & OCV testing in the chamber

BMG | Battery
Smart Formation Warehouse



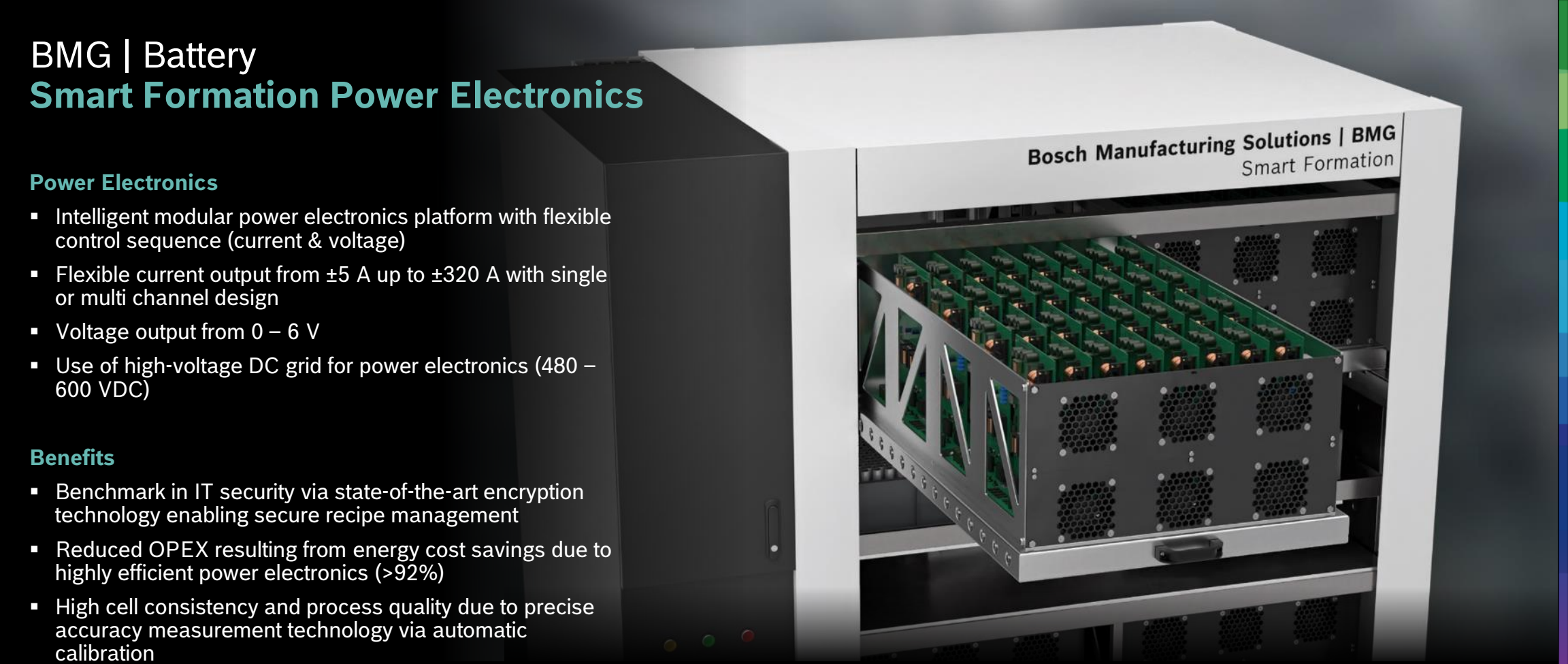
Smart Formation Warehouse

- Turn-key battery cell formation area for prismatic & cylindrical cells incl. formation chamber, warehouse system & software architecture
- Customization based on requirements (building construction, logistics concept, workpiece carrier)
- Optional extendable by further testing equipment (ACIR, DCIR, OCV) within smart formation station or separate
- Safety concept with integrated quarantine area in case of disaster or emergency possible
- Software system for efficient operations and optional interface to enterprise IT (e.g. MES)
- Ramp up support, process optimization & aftersales services

Benefits

- Reduced OPEX resulting from energy re-use resulting from intelligent energy flow concept between chambers
- Optimized floor loading & space efficiency according to your requirements with modular concept

BMG | Battery
Smart Formation Power Electronics



Power Electronics

- Intelligent modular power electronics platform with flexible control sequence (current & voltage)
- Flexible current output from ±5 A up to ±320 A with single or multi channel design
- Voltage output from 0 – 6 V
- Use of high-voltage DC grid for power electronics (480 – 600 VDC)

Benefits

- Benchmark in IT security via state-of-the-art encryption technology enabling secure recipe management
- Reduced OPEX resulting from energy cost savings due to highly efficient power electronics (>92%)
- High cell consistency and process quality due to precise accuracy measurement technology via automatic calibration
  (U: ≤± 0.03% FS; I: ≤± 0.04% FS)
- Outstanding technical availability due to easy maintenance and repairs of <5min due to replaceable power electronics

BMG | Battery
Smart Formation – Digitalization & Software Architecture

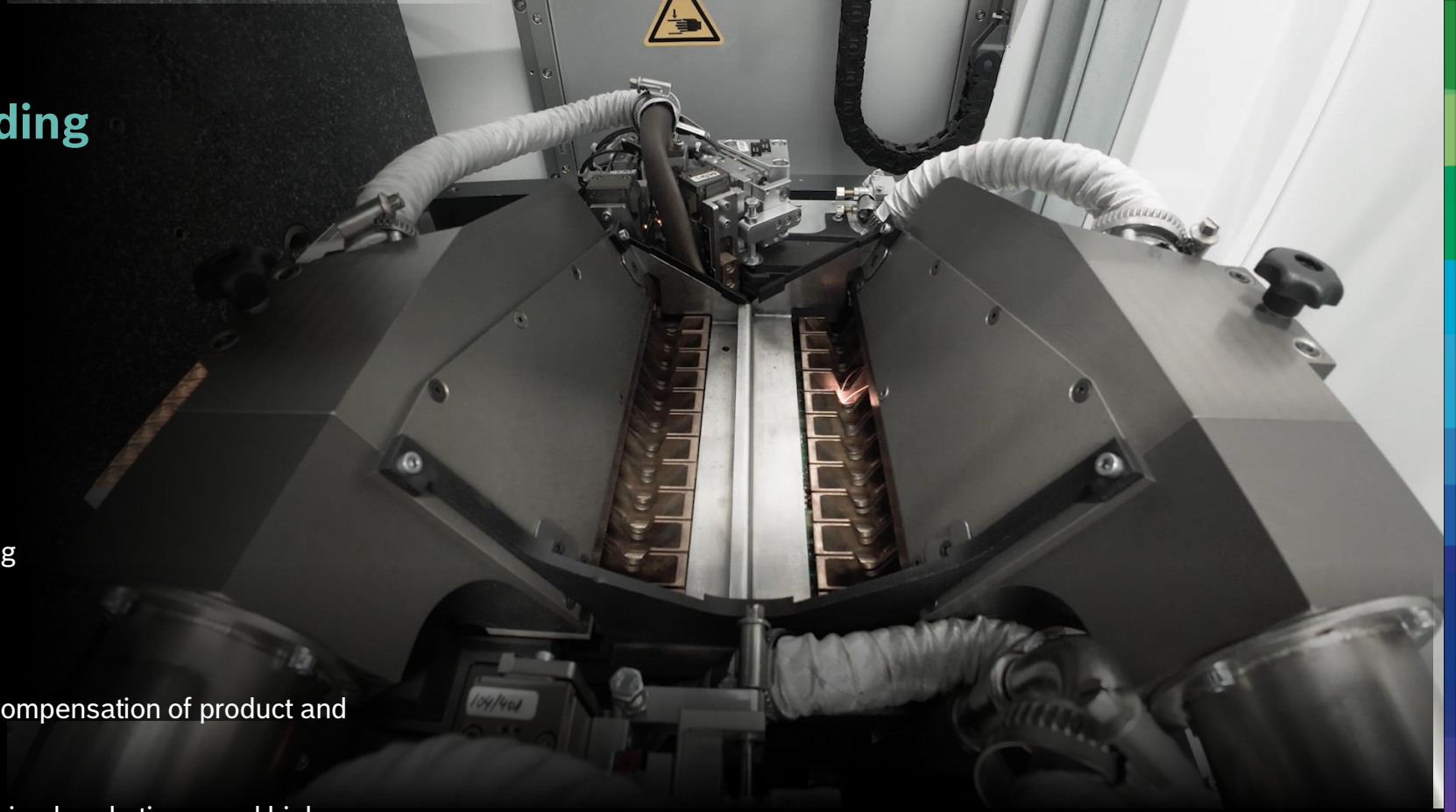
Digitalization & Software Architecture

- Formation Control System with various functions to optimize the formation process like predictive maintenance, cell traceability, data analysis, KPI output statistic
- Operatable as Cloud and/or OnPremise Edge solution
- Flexible integration into enterprise IT (e.g. MES)

Benefits

- Increased productivity & transparency through data driven operations
- Modular software design enables customization based on your requirements and optimized IT operation costs
- High user experience through one common web interface

BMG | Battery
InFly Battery Laser Welding



Unique. Safe. Efficient.

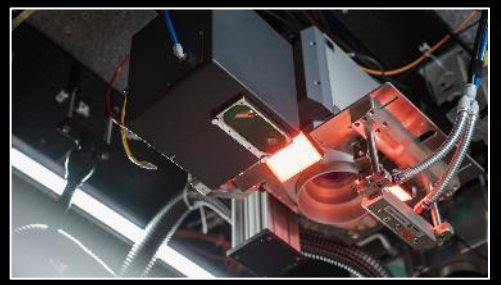
“InFly” stands for intelligent, optically guided, on-the-fly laser welding of battery cell connectors. This provides automated optical measurement, real-time data processing and optically guided laser welding at unprecedented speeds, ensuring safe, efficient and high-quality production.

- Enhanced process stability through compensation of product and manufacturing tolerances
- Increase in productivity through optimized cycle times and higher manufacturing speed
- Reduction of scrap and cost savings through dynamic welding shape correction

BMG | Battery
InFly Battery Laser Welding

Automated Optical Measurement

- Automated optical measurement accurately captures actual position of weld spot before welding
- Measurement data used as basis for subsequent weld correction
- Scanner optics adjust weld in real time to ensure maximum accuracy and optimal alignment
- Improves manufacturing quality and efficiency



Optically guided laser welding on-the-fly

- Allows continuous welding at speeds up to 1000 mm/sec
- Achieves up to 10 welds per second with real-time corrections
- Continuous motion ensures that the battery is not damaged in the event of a scan system failure

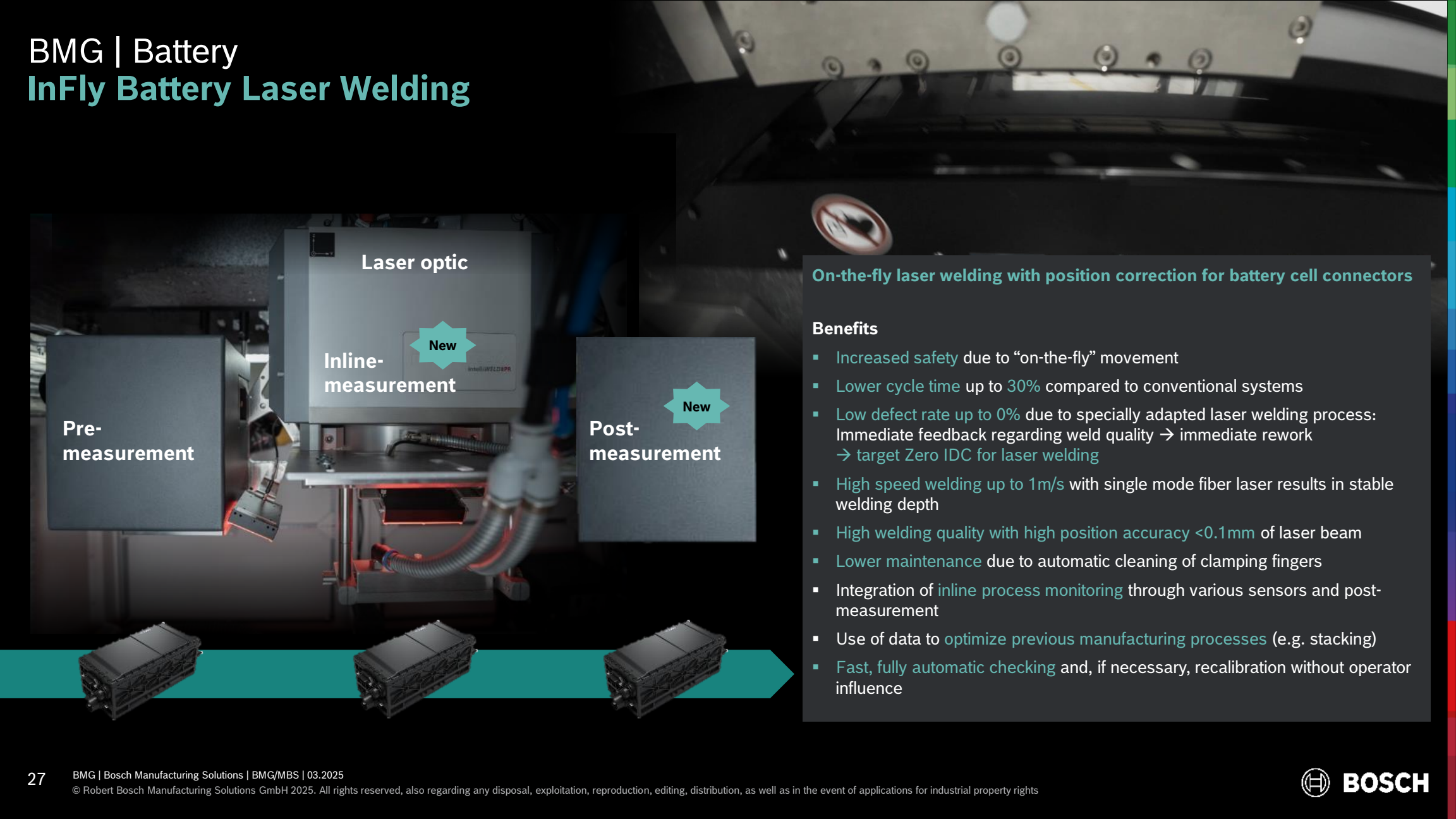
Intelligent Dynamic Weld Seam Correction

- Provides precise, real-time adjustments for optimal weld placement
- Automatically detects battery poles and contact systems
- Calculates optimal weld position
- Dynamically adjusts weld shape
- Enables up to 10 welds and adjustments per second
- Increases productivity and minimizes misalignment
- Continuous quality monitoring ensures consistent, high-quality results

AI-Based Weld Seam Inspection

- Uses advanced 2D and 3D vision systems to automatically inspect welds immediately after welding
- Built-in AI vision allows it to be trained without programming, using good and bad weld examples
- Highly transparent decision making and reliable results
- Optimized algorithms for short cycle times and seamless integration into the production process

BMG | Battery
InFly Battery Laser Welding

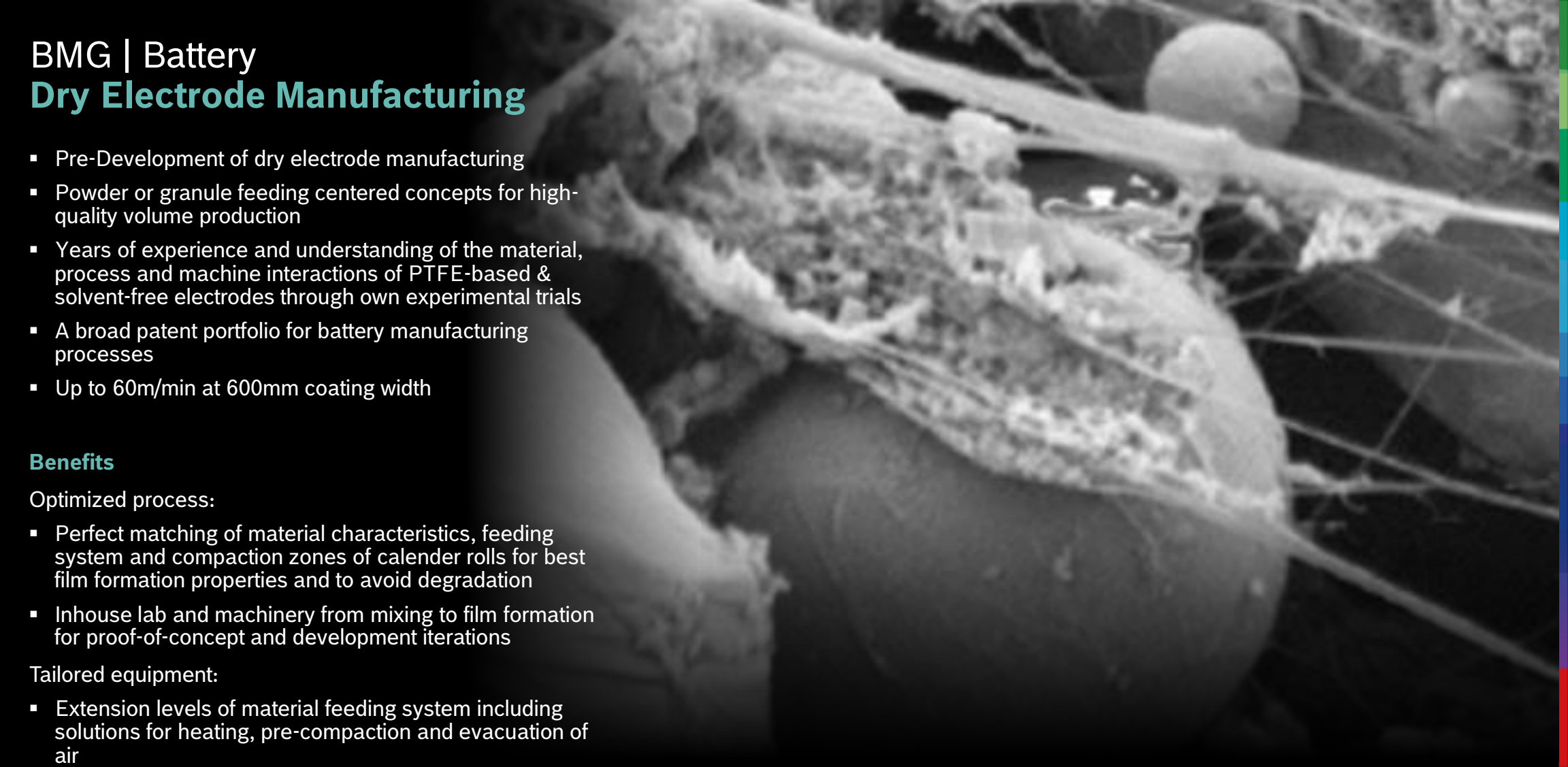


On-the-fly laser welding with position correction for battery cell connectors

Benefits

- Increased safety due to “on-the-fly” movement
- Lower cycle time up to 30% compared to conventional systems
- Low defect rate up to 0% due to specially adapted laser welding process: Immediate feedback regarding weld quality → immediate rework
  → target Zero IDC for laser welding
- High speed welding up to 1m/s with single mode fiber laser results in stable welding depth
- High welding quality with high position accuracy <0.1mm of laser beam
- Lower maintenance due to automatic cleaning of clamping fingers
- Integration of inline process monitoring through various sensors and post-measurement
- Use of data to optimize previous manufacturing processes (e.g. stacking)
- Fast, fully automatic checking and, if necessary, recalibration without operator influence

BMG | Battery
Dry Electrode Manufacturing



- Pre-Development of dry electrode manufacturing
- Powder or granule feeding centered concepts for high-quality volume production
- Years of experience and understanding of the material, process and machine interactions of PTFE-based & solvent-free electrodes through own experimental trials
- A broad patent portfolio for battery manufacturing processes
- Up to 60m/min at 600mm coating width

Benefits

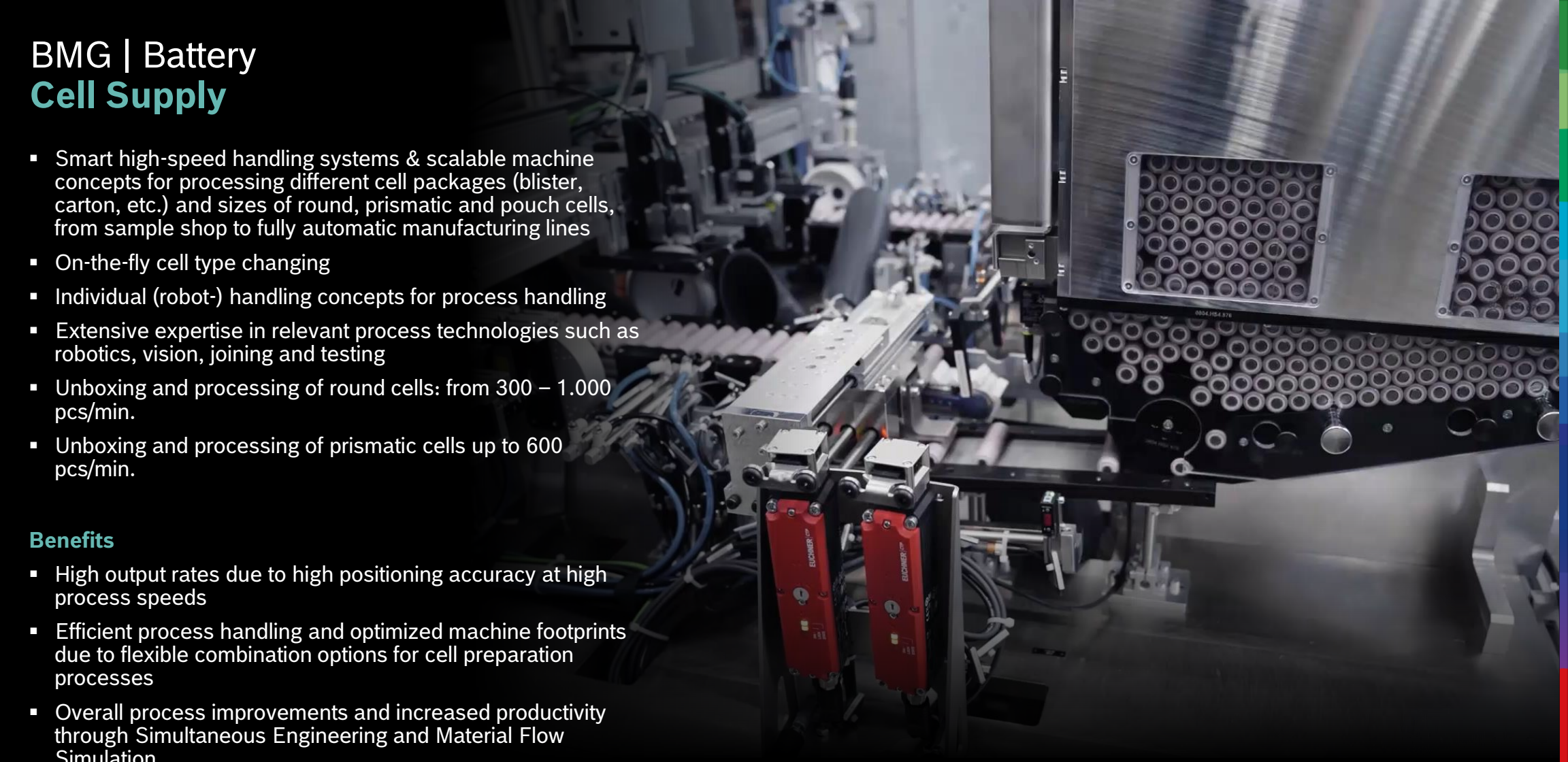
Optimized process:

- Perfect matching of material characteristics, feeding system and compaction zones of calender rolls for best film formation properties and to avoid degradation
- Inhouse lab and machinery from mixing to film formation for proof-of-concept and development iterations

Tailored equipment:

- Extension levels of material feeding system including solutions for heating, pre-compaction and evacuation of air

BMG | Battery
Cell Supply



- Smart high-speed handling systems & scalable machine concepts for processing different cell packages (blister, carton, etc.) and sizes of round, prismatic and pouch cells, from sample shop to fully automatic manufacturing lines
- On-the-fly cell type changing
- Individual (robot-) handling concepts for process handling
- Extensive expertise in relevant process technologies such as robotics, vision, joining and testing
- Unboxing and processing of round cells: from 300 – 1.000 pcs/min.
- Unboxing and processing of prismatic cells up to 600 pcs/min.

Benefits

- High output rates due to high positioning accuracy at high process speeds
- Efficient process handling and optimized machine footprints due to flexible combination options for cell preparation processes
- Overall process improvements and increased productivity through Simultaneous Engineering and Material Flow Simulation

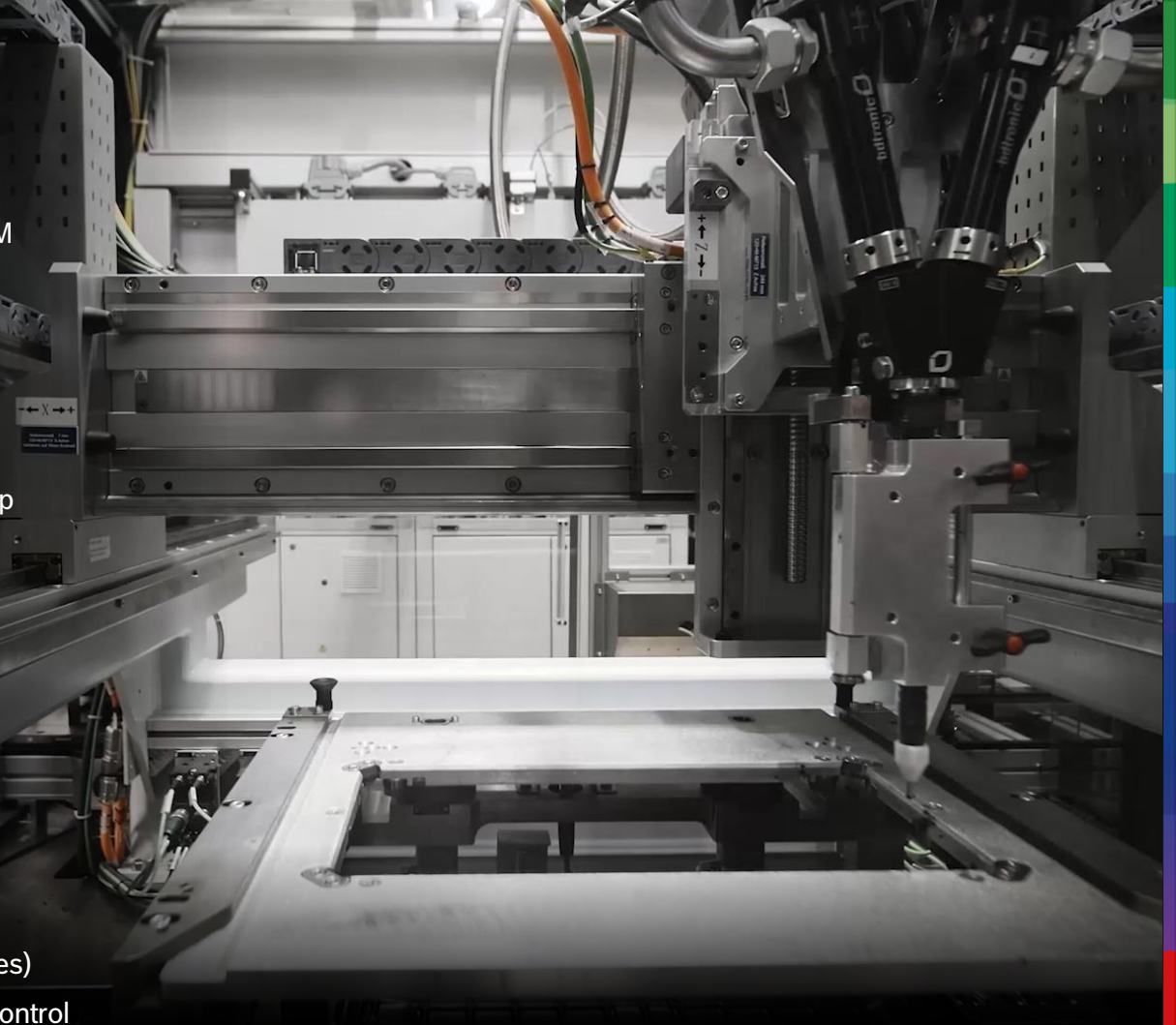
BMG | Battery
Battery Cell Plasma Cleaning

- Plasma cleaning of surfaces in preparation for gluing and laser welding processes
- Different cleaning purposes covered – from removal of contamination to surface texturing
- Cleaning parameters adapted to specific requirements from compressed air, plasma-treatment to laser cleaning
- Robot guided laser cleaning process of 3D surface
- Combination of laser cleaning and laser polishing
- Area rate up to 30 cm²/s
- Advanced suction devices for removing 100% process emission

Benefits

- High degree of cleanliness and the best possible customer result thanks to high process expertise and holistic system understanding
- Extensive experience with several cleanroom compliance requirements
- Short pulse laser treatment up to 30 cm²/s with oxide layer removal / regrowth
- Small cleaning areas possible
- High throughput with fast cell exchange, cycle time per cell ≤ 1 s

BMG | Battery
Dispensing for battery



- High-precise dispensing of various 1C or 2C materials such as adhesives, TIM (Thermal Interface Material), sealing or potting materials
- In-house labs for design of overall dispensing process including pre- and postprocessing, pre-testing, sampling and start of series production
- High dynamic movements with linear driven axis up to 1,5 m/s
- Integrated scale with up to 0,1 mg resolution
- Product handling with robot, AGV or individual transfer system, product size up to 2000 mm and > 500 kg
- Precise dispensing, from 350 mg to > 30 kg
- Precise dynamic positioning repeatability of +/-0,2 mm
- High precision SPC equipment – scale up to 0,1 mg resolution, needle measurement with 0,01 mm repeatability
- Alignment & quality check with 2D,3D vision – inline or postprocess

Benefits

- High solution competence from > 50 stations / year delivery
- Precise dynamic positioning repeatability of +/-0,3 mm (excl. product tolerances)
- Complete integration of individual dispensing components into one machine control
- Customized & unbiased process consulting for specific needs – independent from component suppliers or processes

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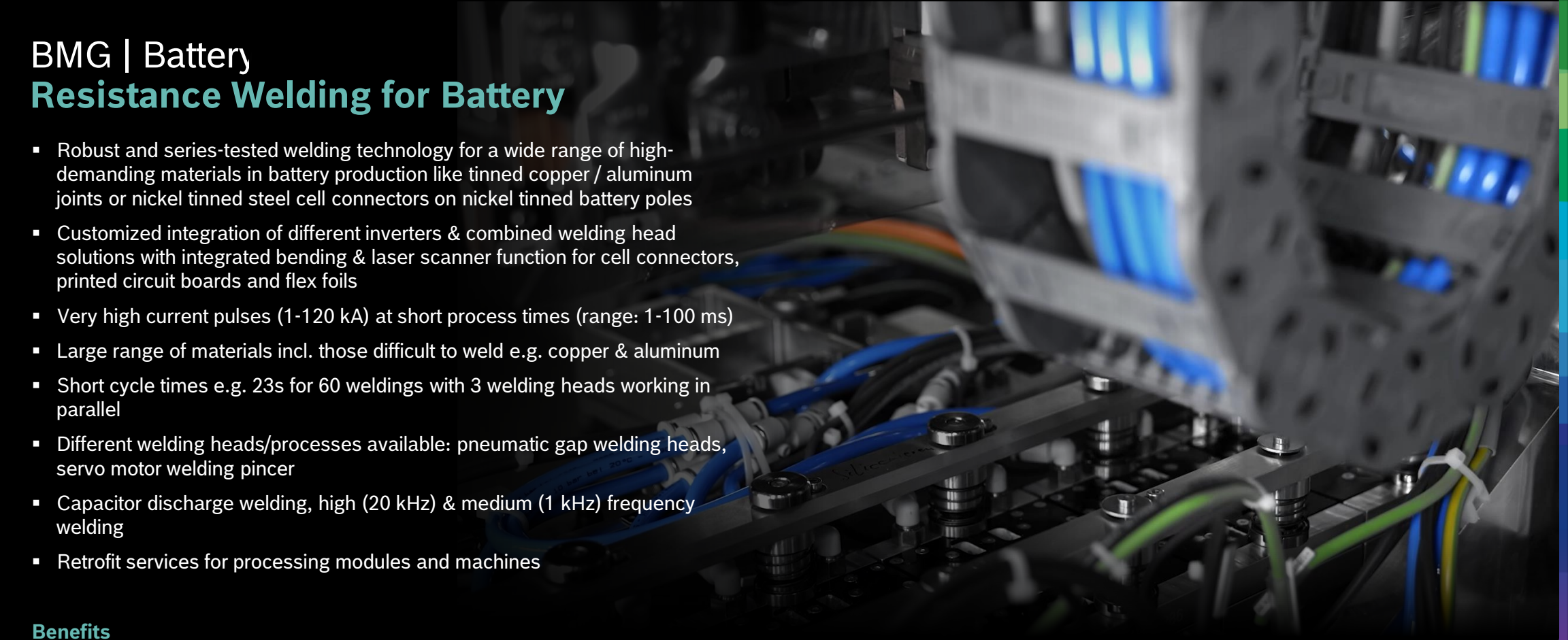
BMG | Battery
Resistance Welding for Battery

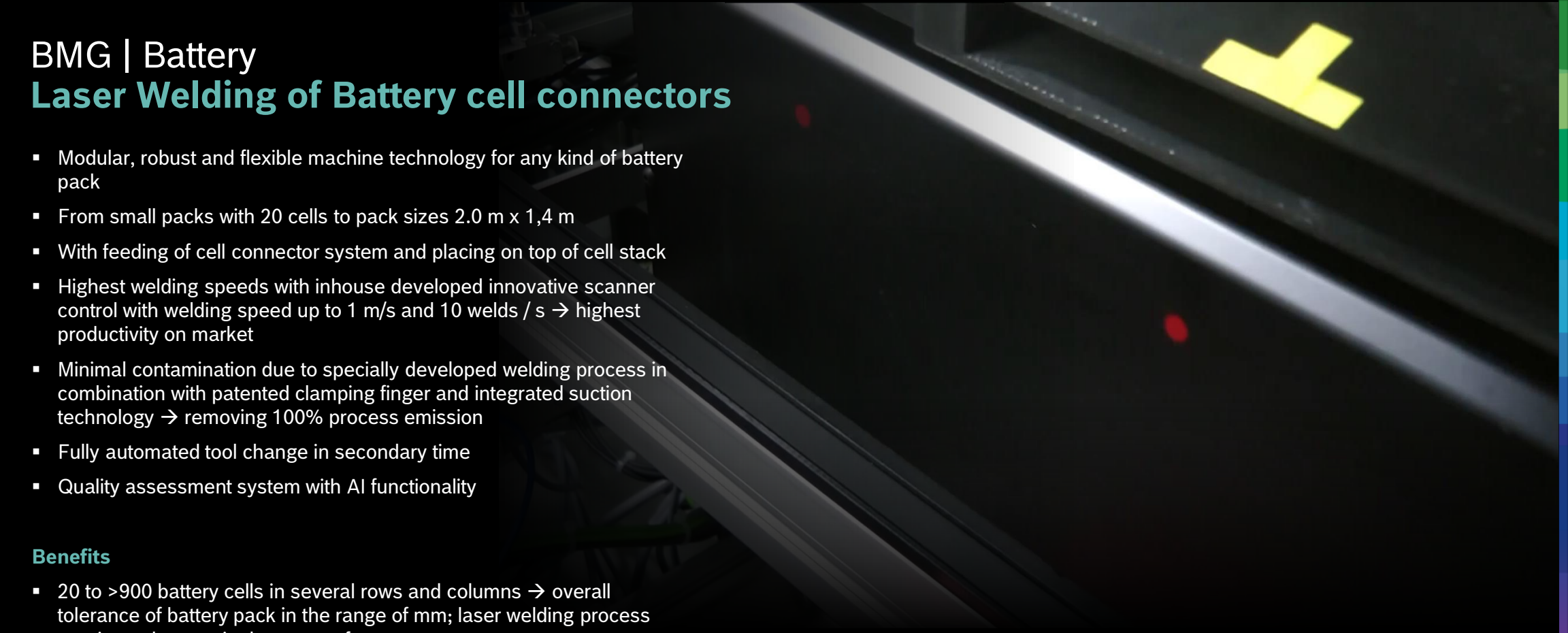


- Robust and series-tested welding technology for a wide range of high-demanding materials in battery production like tinned copper / aluminum joints or nickel tinned steel cell connectors on nickel tinned battery poles
- Customized integration of different inverters & combined welding head solutions with integrated bending & laser scanner function for cell connectors, printed circuit boards and flex foils
- Very high current pulses (1-120 kA) at short process times (range: 1-100 ms)
- Large range of materials incl. those difficult to weld e.g. copper & aluminum
- Short cycle times e.g. 23s for 60 weldings with 3 welding heads working in parallel
- Different welding heads/processes available: pneumatic gap welding heads, servo motor welding pincer
- Capacitor discharge welding, high (20 kHz) & medium (1 kHz) frequency welding
- Retrofit services for processing modules and machines

Benefits

- Flexible welding process for cell connectors, printed circuit boards or flex foils
- Automated verification of the single electrode forces for process validation
- Possibility of process development with own lab. welding machine with as well as prototype and sample production

BMG | Battery
Laser Welding of Battery cell connectors



- Modular, robust and flexible machine technology for any kind of battery pack
- From small packs with 20 cells to pack sizes 2.0 m x 1,4 m
- With feeding of cell connector system and placing on top of cell stack
- Highest welding speeds with inhouse developed innovative scanner control with welding speed up to 1 m/s and 10 welds / s → highest productivity on market
- Minimal contamination due to specially developed welding process in combination with patented clamping finger and integrated suction technology → removing 100% process emission
- Fully automated tool change in secondary time
- Quality assessment system with AI functionality

Benefits

- 20 to >900 battery cells in several rows and columns → overall tolerance of battery pack in the range of mm; laser welding process requires tolerance in the range of µm
- Materials and material combinations: Cu/Cu, Cu/Al, Al/Al Cu/St, Al/St
- Thickness: from 20 µm (e.g. Cu flex foils) to several millimeters
- Laser sources: fiber laser (multi-mode, single-mode), disc laser
- Processing optics: e.g. 2D/ 3D scanning optics

More details about

InFly – Intelligent, optical guided, on-the-fly Laser Welding

BMG | Battery
Optical inspection for battery

- High quality optical inspection machines as well as highly capable measurement systems for high quality control of cell contacting system including cells, active joining and weld seam monitoring
- Inline measuring of battery and cell contacting system for on-the-fly laser welding
- Full-equipped machine vision lab for development of innovative applications
- 30 years experience in close integration of machine vision systems for inspection and process guiding into handling and process technology

Benefits

- Short cycle time, maximum cost-effectiveness and best inspection quality due to high-speed and high-resolution sensor systems
- High quality and cost-effectiveness due to fast and reliable detection if OK and NOK parts
- Suitable, cost-effective solution for specific requirement thanks to broad technology portfolio

BMG | Battery
Electrical Testing for battery

- Electrical testing based on recognized industry standards for production, development and quality assurance of cells, modules & packs – including BMU functional testing
- Testing solutions for BOL, in-line, and EOL applications
- Abuse testing and preparation for recycling (deep discharge)
- Safety enclosures and environmental simulation systems

Benefits

- All-in-one solution for electrical testing
- Support and consulting from development through to series production
- Fast and precise testing of battery parameters (OCV, ACIR, DCIR, etc.) across various models using modern methods
- Holistic safety concept design including expert reports and certification readiness

Technical Data

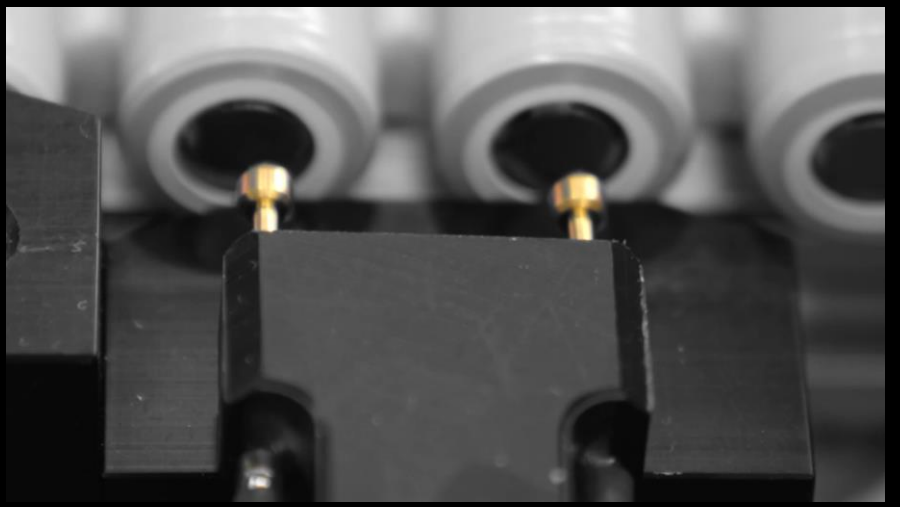
- Max current: up to 1000 A
- Max voltage: up to 1000 V (pack voltage)
- High-voltage testing: up to approx. 3.6 kV
- ACIR at 1 kHz, DCIR
- Communication with CMC (SPI, Iso-SPI, UART, etc.) and BMS (CAN)

Safety & Climate Chambers

- Testing of up to 2 battery packs, up to 800 V / 600 A
- Temperature range: –40°C to +120°C
- HZ level 5 to 7
- Additional features: failure detection, nitrogen inerting, extinguishing systems, fire protection

BMG | Battery
Battery BOL/EOL Testing

- Testing battery cells from a single source: Current, voltage, temperature and SOC
- Identification of battery cell parameters: OCV, ACIR, DCIR, SOC



Benefits

- Integration in production line and stand-alone station possible
- Many years of experience in electrical battery testing technology
- In-house laboratories and test benches
- Modular architecture for several cell types & compact design
- Experience in different applications: UN38-3 test sequences, abuse test, endurance test, safety chamber, temperature and humidity control
- Integration in production line and stand-alone station possible
- In-house laboratories and test benches
- Detection of assembly errors
- High voltage test
- Manufacturer-typical test specimen/product communication
- Parameters and properties of battery modules measured and evaluated according to customer specifications

BMG | Battery

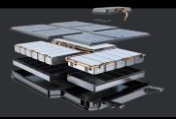
Battery Measurement & Data Acquisition with FIPS – Flexible Intelligent Power Stage

- A measuring device for the EOL / BOL testing of battery cells and modules that measures the quality characteristics OCV, DCIR and ACIR of a cell / module
- Seamless transferability from development to series production for EOL / BOL
- Scalable Analog power stage +/-120 V and +/- 30A with accuracy: +/- 20mV and +/- 10 mA
- Internal sampling of voltage/current: 10MHz, voltage / current is freely configurable
- Reaction times of 1us, integration in matlab is possible

Benefits

- A measuring device for all quality characteristics of a cell
- Reduction of measurement time by 50%
- Through simple integration, a cost reduction of up to 20% is possible
- Measurement process is quickly portable from the development to the production
- Integration of new functionality is ready to use

BMG | Battery
Gas & Leakage Testing for battery – overview

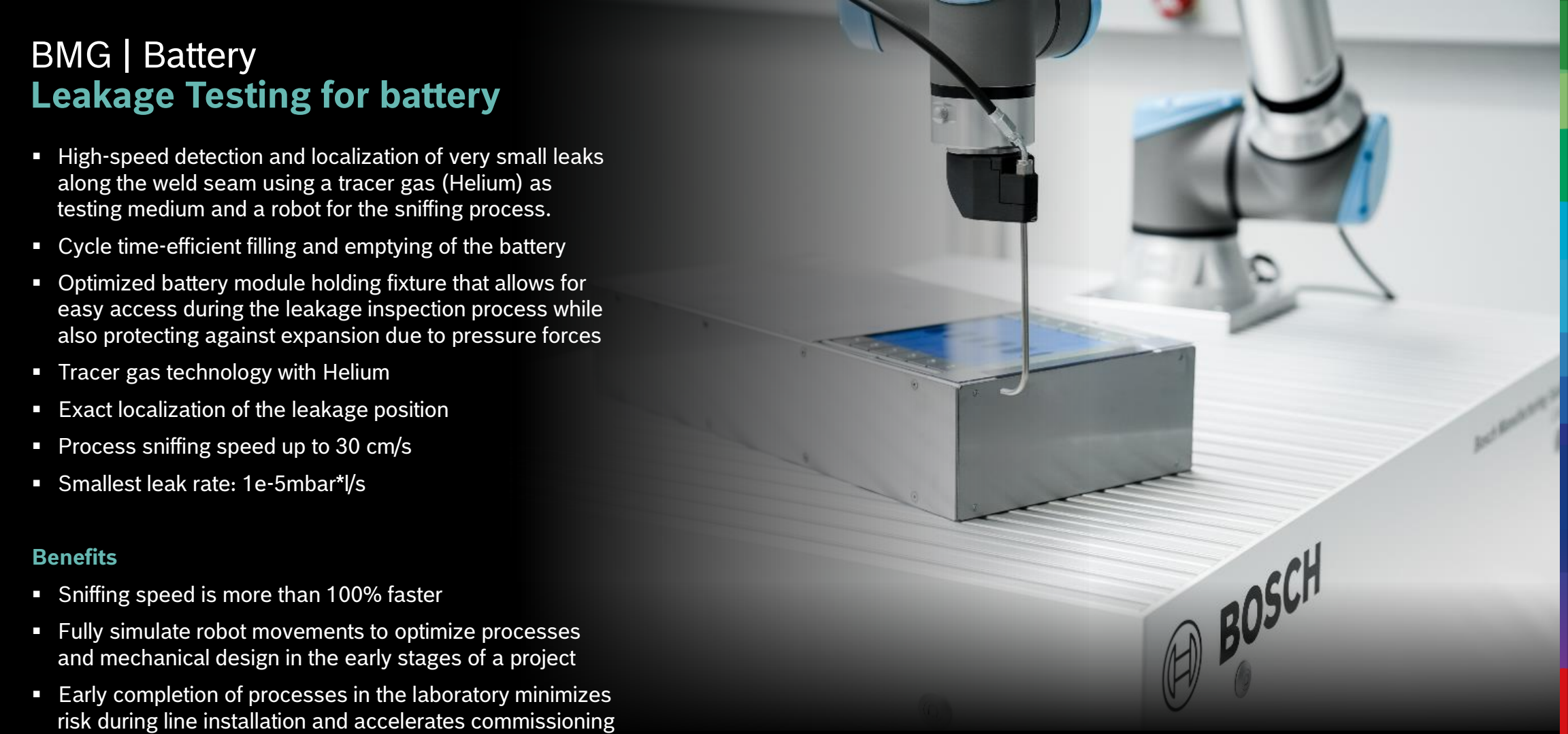
	Cell	Module	Pack
Application	 ▪ Testing before and after cell filling ▪ Cylindric and prismatic cells	 ▪ Leakage measurement & localization ▪ Housing, Cooling Circuit and other components	 ▪ EOL testing in different mounting stages of the FCPM
Target leak rate	▪ 10^{-3}...10^{-6} mbar*l/s	▪ 1...10^{-5} mbar*l/s	▪ 1...10^{-5} mbar*l/s
Testing method	▪ Direct electrolyte ▪ Helium-in-Air ▪ Helium Vacuum	▪ Massflow/pressure drop ▪ Helium sniffing ▪ Helium-in-Air	▪ Massflow/pressure drop ▪ Helium sniffing ▪ Helium-in-Air

BMG | Battery
Leakage Testing for battery

- High-speed detection and localization of very small leaks along the weld seam using a tracer gas (Helium) as testing medium and a robot for the sniffing process.
- Cycle time-efficient filling and emptying of the battery
- Optimized battery module holding fixture that allows for easy access during the leakage inspection process while also protecting against expansion due to pressure forces
- Tracer gas technology with Helium
- Exact localization of the leakage position
- Process sniffing speed up to 30 cm/s
- Smallest leak rate: 1e-5mbar*l/s

Benefits

- Sniffing speed is more than 100% faster
- Fully simulate robot movements to optimize processes and mechanical design in the early stages of a project
- Early completion of processes in the laboratory minimizes risk during line installation and accelerates commissioning



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