

A close-up photograph of a laser diagnostic component, likely a lens or filter, mounted on a brass-colored metal housing. The component is part of a larger assembly, possibly a laser beam diagnostic system, used in battery manufacturing. The background is blurred, showing various mechanical parts and a red surface.

LASER BEAM DIAGNOSTICS IN BATTERY MANUFACTURING PROCESSES

Dr. Thomas Umschlag

EPIC Meeting on Laser Applications along Battery Manufacturing Process at ARENA2036

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The logo for PRIMES, featuring a white horizontal line above the word "PRIMES" in a bold, white, sans-serif font. A small white dot is positioned above the letter "I".

PRIMES

COMPETENCE IN BEAM DIAGNOSTICS

Outline

- Introduction // PRIMES at a glance
- Laser processes in E-Mobility – an overview
- Challenges for laser application
- Constraints - Why beam diagnostics?
- Examples for beam diagnostic solutions
 - Production ramp-up and installation
 - Production environment // Offline vs Inline
- Summary and conclusion

PRIMES is a leading company for laser beam diagnostics.

For 30 years now, PRIMES has developed and produced systems for the characterization of industrially employed laser beams as used in the automotive industry, industrial machinery, additive manufacturing as well as R & D and laser manufacturing.

- Competence for beam diagnostics in the processing zone
- Systems for multi-kilowatt laser power and high densities
- More than 30000 installed systems worldwide
- Owner operated business with approximately 130 employees, 32 of which in R & D
- Worldwide distribution via subsidiary in Japan and network of distributors



Overview PRIMES portfolio / Measuring Task

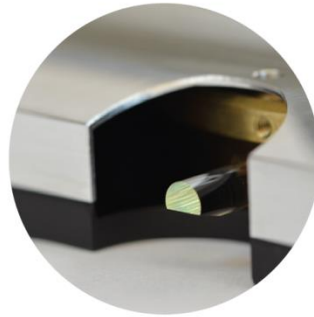


Power Measurement



From a compact mobile device to a system for continuous process monitoring up to 25 kW

Beam Analysis



Measurement of focused and unfocused laser radiation from free beam to direct fiber measurement

System Integration



Systems for integration: robust, versatile and established in industrial production with industry standard interfaces

All-in-one-Systems

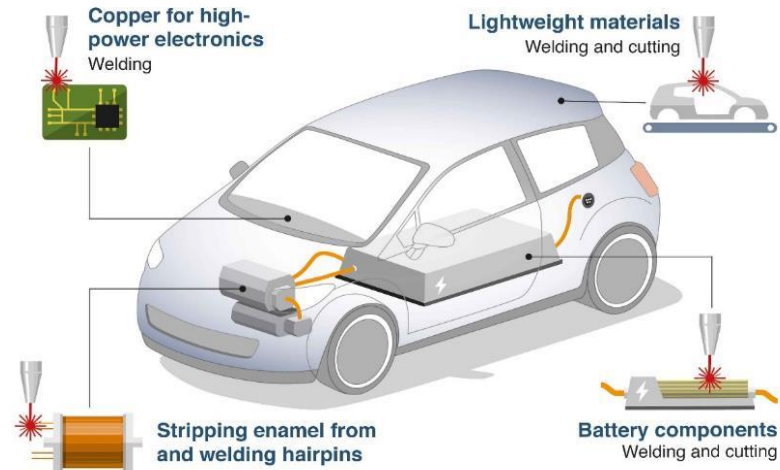


Combinations of systems for the comprehensive analysis of laser power and beam geometry

Laser processes in E-Mobility

- **Up to 30 different laser applications in battery production**
- Foil cutting
- Welding foil stacks
- Hairpin Welding
- Can caps / cell sealing
- Welding bus bars / contacts
- Packing of modules
- Welding of crash protection frames
- Foil / slurry drying with diode- or VCSEL-lasers (up to 120 kW!)

High-precision laser technology is enabling the mass production of electric cars



Source: TRUMPF Group

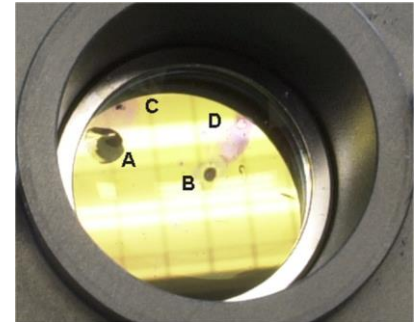
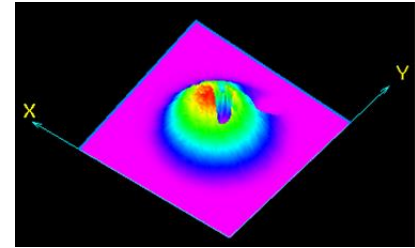
Source: TRUMPF Group

Challenges for laser processes in E-Mobility

- **Quantity:** 10–100 times more laser welds per car
- **Smaller process windows**
 - due to increased speed
 - New / thinner material composition
 - Reflective components
- **(almost) no failures accepted**
→ one bad weld out of hundreds can lead to a 100% yield hit
- **Cost of scrap** is high, the part price has increased relative to the laser price
- **Beam shape:** much more single mode used, smaller spots, M^2 down means focus shift up
- More **remote optics and scanners**, potentially producing higher focus shift (large lenses, heat conductivity of glass \ll metal)

Constraints for laser application in battery manufacturing

- Aging of optics
 - Contamination of optics
 - Focus shift due to thermal effects in optics
 - Reduced laser power in process zone
- More rigid processes by using tailored beam shapes (rectangular or ring-modes or others)
- More laser diagnostic measurements to control the laser parameters, enable feedback to the laser machine and to allow a tighter quality control
- Machine-integrated laser diagnostic tools needed → regular control of laser parameters to ensure stable process environment



Measurement results of a collimator burn-in

Beam diagnostics during installation / setup / process ramp-up

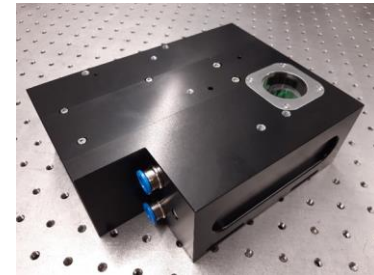
- Power measurement
 - Sensing of optics contamination which might lead to power losses
 - Avoidance of adjustment failures
- Beam propagation / distribution measurement
 - Focused & collimated beam
 - Beam divergence
 - Homogeneity and power distribution
 - ...
- Laser- & Machine parameters (in scanfield)



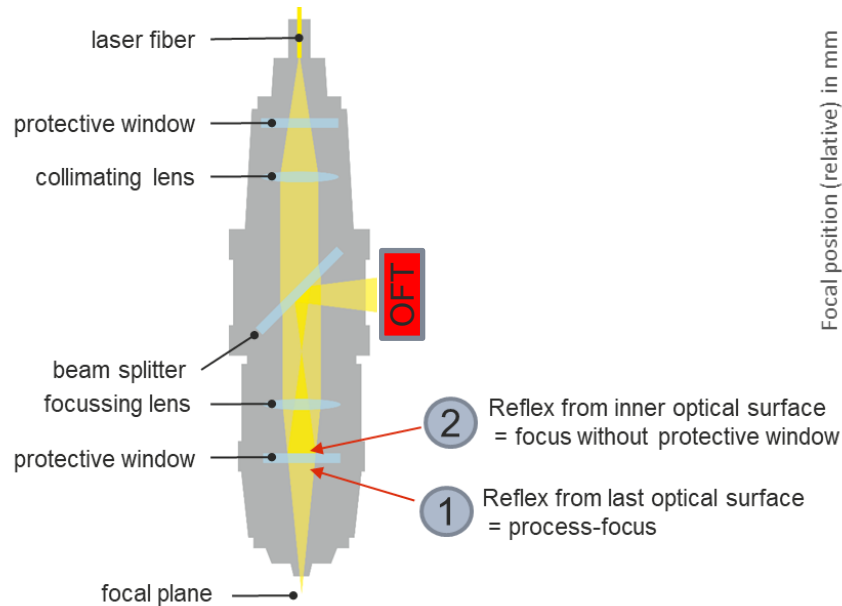
PRIMES – Integrated solutions

Monitoring of laser parameters during secondary time:

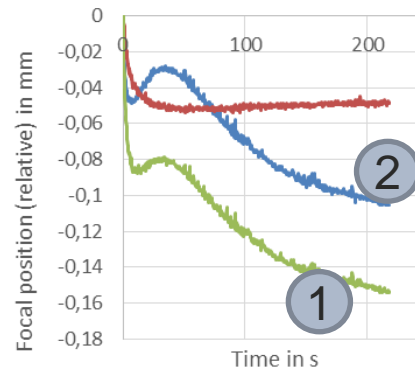
- Machine integrated power measurement – PMM (PowerMeasuringMonitor)
- Machine integrated power measurement and beam diagnostics – FPM (FocusParameterMonitor)
- PRIMES FocusTracker for time resolved focus shift analysis
 - Real production conditions
 - Laser in use (changing cycle time, power level)
 - Aging of protective window of processing head



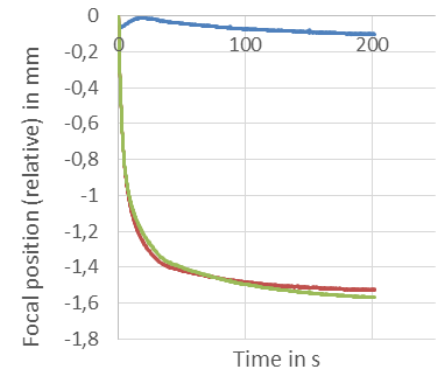
Focus Shift tracking during production PRIMES OFT (OnlineFocusTracker)



Clean protective window



Used protective window



With integrated focus tracking

- Gain process robustness by online focus shift monitoring
- Gain productivity by reduced safety margins

Summary / the Future

- Increasing cost pressure will require higher process yield, system availability for any equipment in battery manufacturing
- Gaining importance of preventive and predictive maintenance → Need for remote diagnosis
- Closed loop (self-teaching) systems for continuous process monitoring (online-tracking)

- More Quality Control is needed to reduce downtime and avoid scrap
 - Active control of focus position might be needed

- PRIMES is the solution provider for laser beam diagnostics in battery manufacturing processes

Thank you for your attention

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