PHOTONICS AUSTRIA

JOANNEUM RESEARCH MATERIALS

Photonics as enabler for green production

Paul Hartmann

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MATERIALS
Organization, Structure of Research Groups

- Director:
  - Paul Hartmann
- 5 Research Groups
  ~ 100 Employees
- 3 Locations in Austria
  - Weiz
  - Niklasdorf
  - Pinkafeld

Hybrid Electronics and Patterning
Barbara Stadlober

Light and Optical Technologies
Christian Sommer

Laser and Plasma Processing
Wolfgang Waldhauser

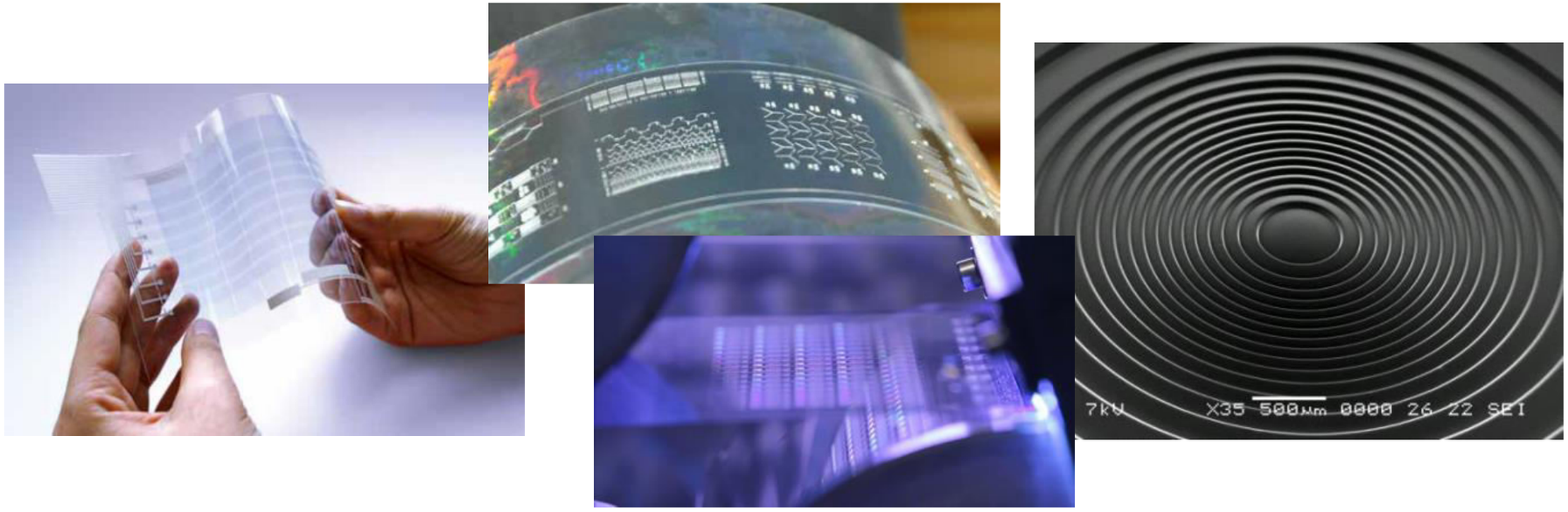
Sensors and Functional Printing
Jan Hesse

Smart Connected Lighting
Franz-Peter Wenzl

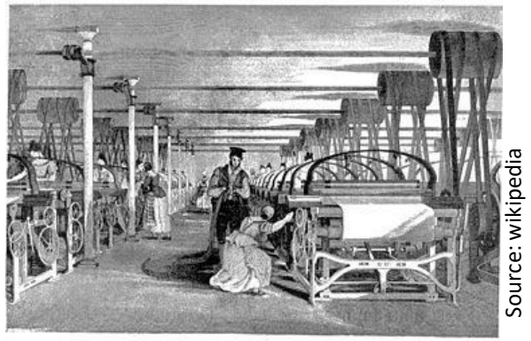
Vision

Nano goes Macro

MATERIALS – the leading research center for advanced materials and manufacturing solutions is your research and development partner for innovative processes and products



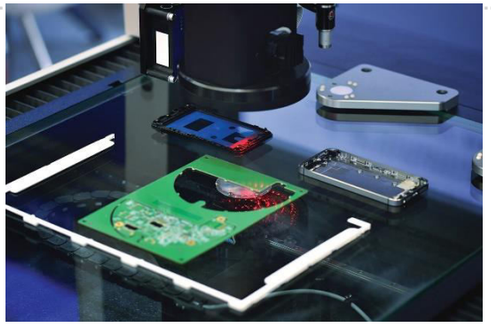
The 4th industrial revolution is already ongoing



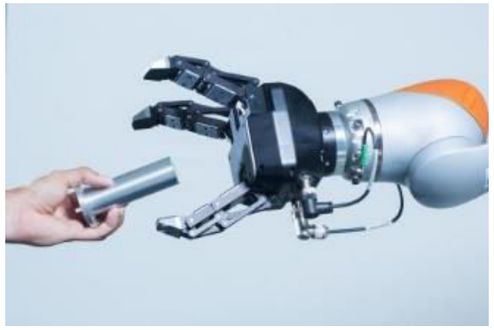
Source: wikipedia

Photonics is one of its driving technologies

- First Industrial Revolution: use of water and steam power to mechanize production
- Second Industrial Revolution: use of electric power to create mass production
- Third Industrial Revolution: use of electronics and information technology to automate production
- **The fourth Industrial Revolution** is building on the Third, characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. (Klaus Schwab, World Economic Forum)
- But this change process is going on under drastically different boundary conditions: the need to respect ecological and sustainability criteria, summarized on the political level as the **European Green Deal**.



Source: ams



Source: Joanneum Research

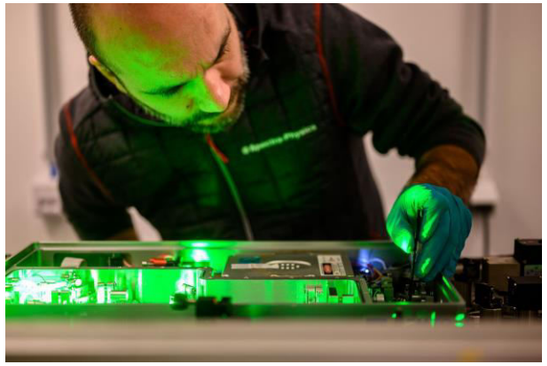
Source: EC

The challenges of green manufacturing according to the Photonics 21 Roadmap "Europe's age of light"

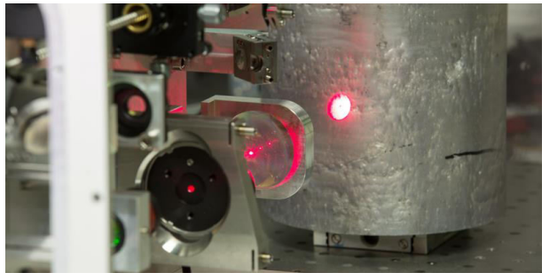
- Goal: Realising the technical and economic potential of sustainable production and highly efficient and emission-free production in urban environments
- European factories should be fast, green and flexible by 2030
- Photonic technologies inherently support a goal orientation towards
  - increased efficiency
  - resource conservation
  - environmental compatibility, and
  - the mission of a "true circular economy"

The challenges of green manufacturing according to the Photonics 21 Roadmap "Europe's age of light"

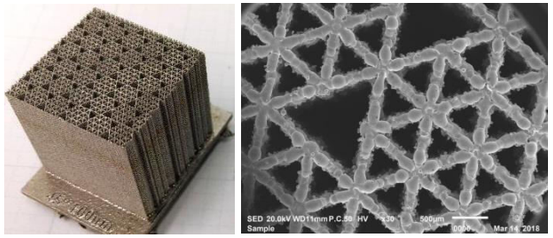
- Photonics specifically limits CO_2 emissions, enables weight reduction and material savings, replaces chemical treatments and increases product life cycles and sustainability.
- Current examples
  - novel gallium arsenide-based lasers have been developed that are the most efficient light sources in the world.
  - without process-integrated monitoring by photonic sensors, "zero-defect production" to avoid rejects would be inconceivable.
  - many of the additive manufacturing methods are based on photonic technologies that enable revolutionary lightweight construction and efficient rapid prototyping.



Source: TU Wien



Source: RECENDT



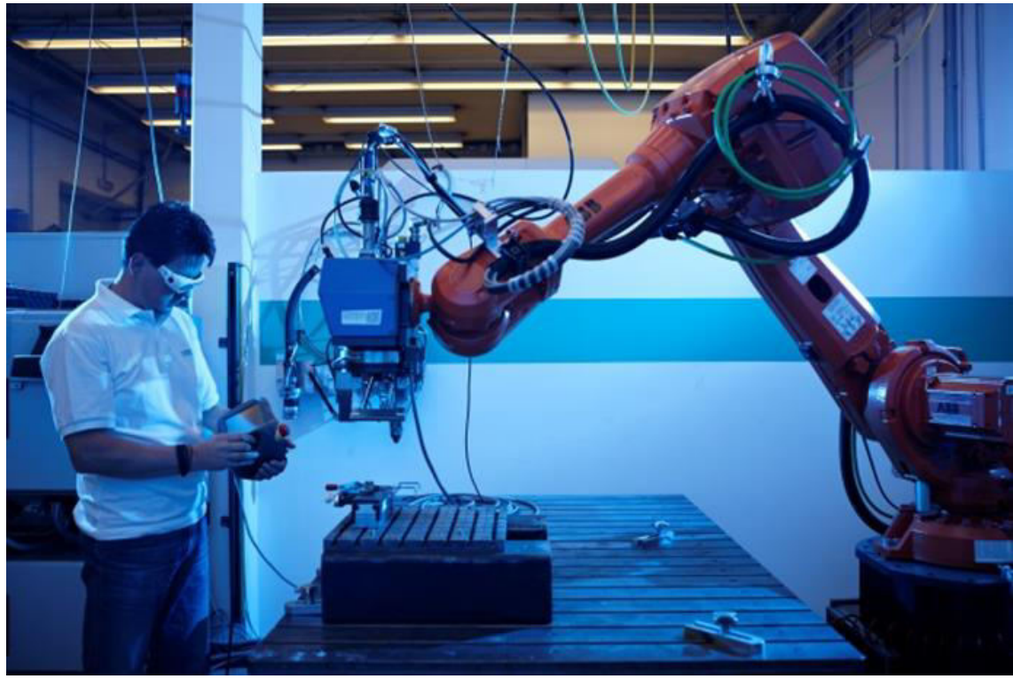
Source: Joanneum Research

Some technologies that enable the 4th industrial revolution

- Artificial Intelligence
- Robotics
- Internet of Things
- Autonomous vehicles
- 3-D printing
- Nanotechnology
- Biotechnology
- Materials science
- Energy storage
- Quantum computing

So where does Photonics fit in?

Source: Joanneum Research



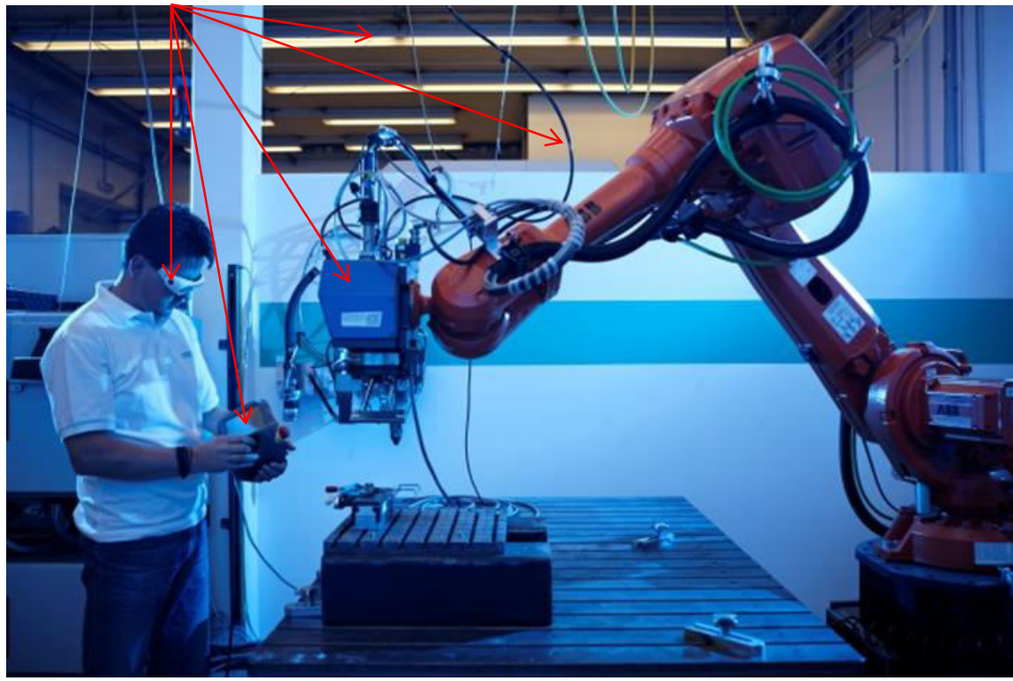
Some technologies that enable the 4th industrial revolution

- Artificial Intelligence
- Robotics ← Photonics inside
- Internet of Things ← Photonics inside
- Autonomous vehicles ← Photonics inside
- 3-D printing ← Photonics inside
- Nanotechnology ← Photonics inside
- Biotechnology ← Photonics inside
- Materials science ← Photonics inside
- Energy storage
- Quantum computing ← Photonics inside

So where does Photonics fit in?
Perhaps it would be easier to ask where doesn't photonics fit in. (Photonics Hub UK)

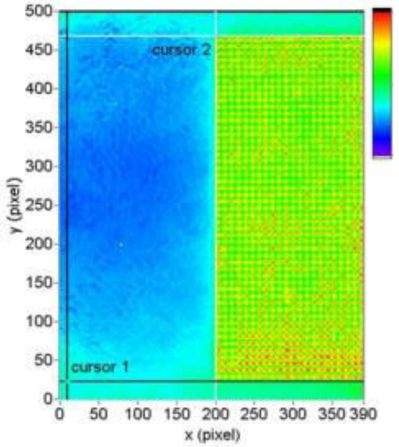
Photonics inside

Source: Joanneum Research



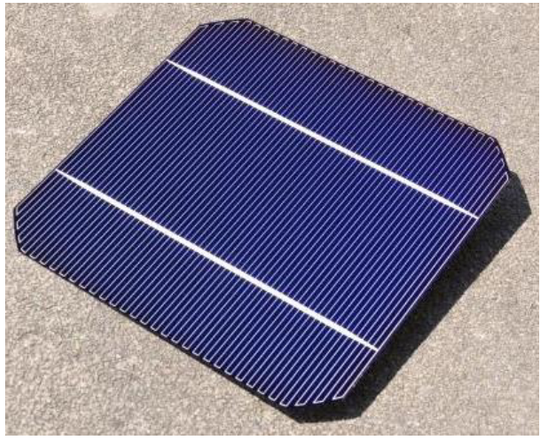
Photonics: a Key Enabling Technology as enabler of modern industrial processes

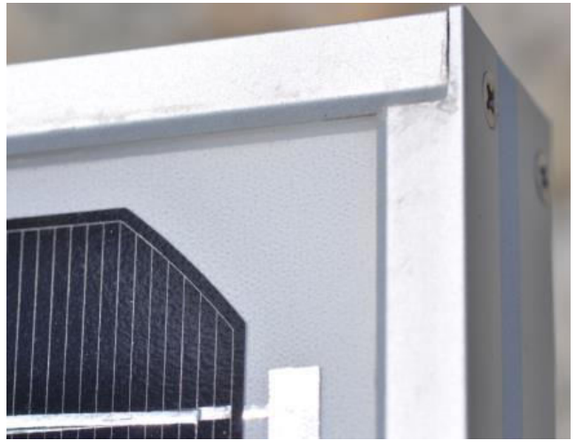
Photonic Technologies		**Production Aspects / Applications**
Laser based processing	→	Additive Manufacturing
Optical sensors	→	Data for Cyber Physical Systems
Visual Light Communication	→	Data transfer for CPS
Non-destructive testing	→	Energy efficient production
In-line optical spectroscopy	→	Reduced scrap
Image analysis	→	Zero defect production
Imaging optics	→	Virtual reality (VR) and Augmented reality (AR)
Optical lithography	→	Micro-optics
.....		

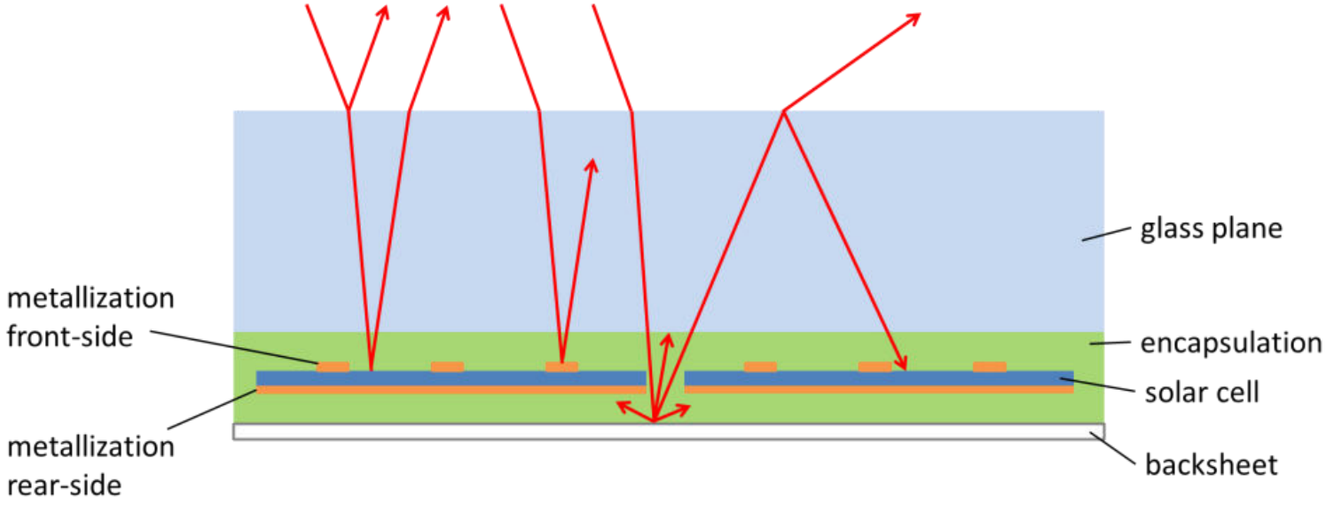


Source: Joanneum Research

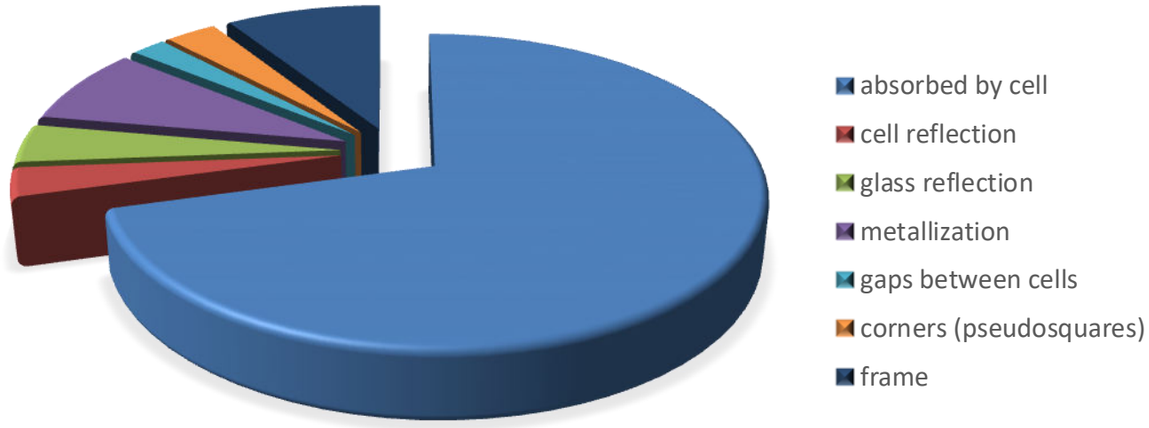
Example: Light Guiding Structures for Solar PV Modules to enhance Module Efficiency





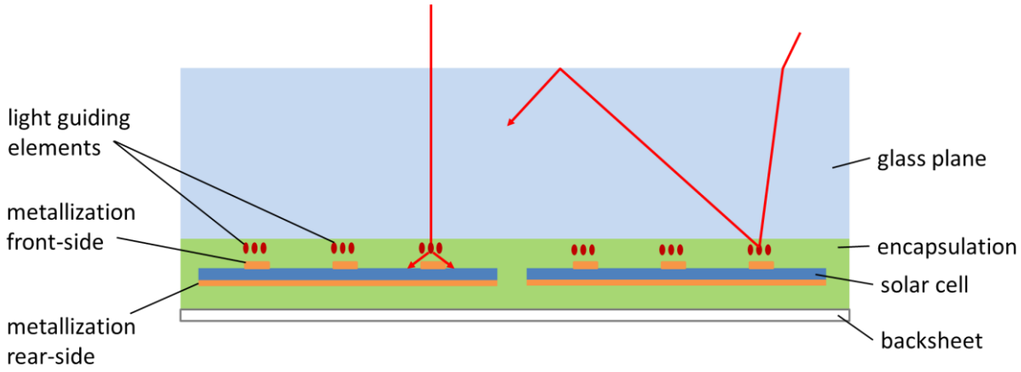


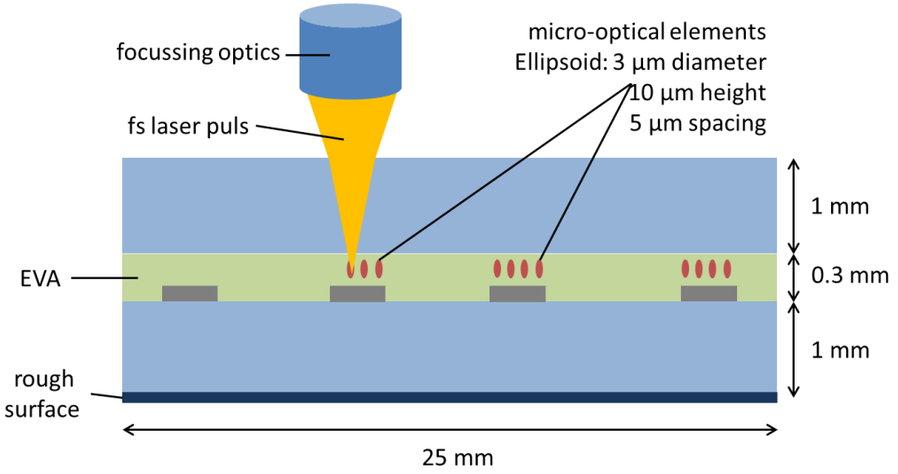
Aim:
Reduction of optical loss

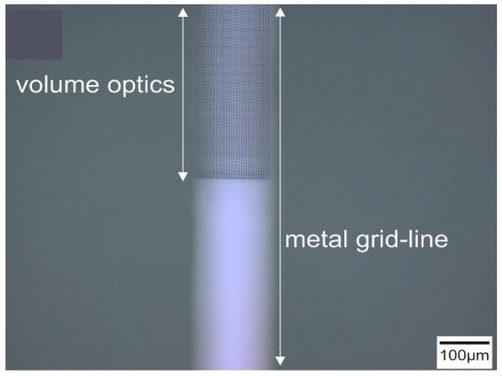


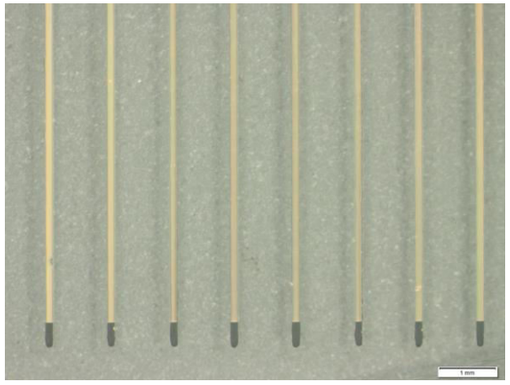
Reducing optical losses at front side metallization of c-Si solar cells

- Embedding **light guiding elements** in the volume of encapsulation → reduction of optical shadowing
- Formation by **laser scribing process**
- Alignment with **confocal microscope**
- Fields of **micro-optical elements** are written with **fs Lasers** into the bulk of EVA – right above the metal grid lines









Reducing optical losses at front side metallization of c-Si solar cells

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- Formation by laser scribing process
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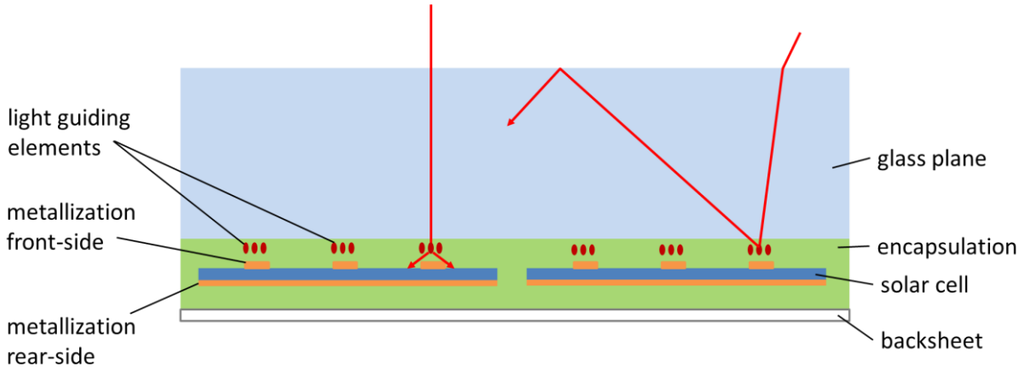
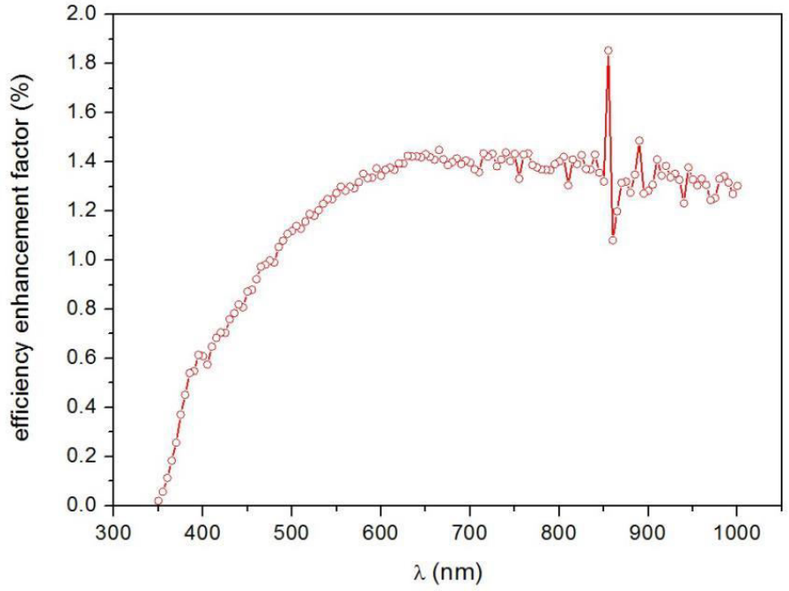
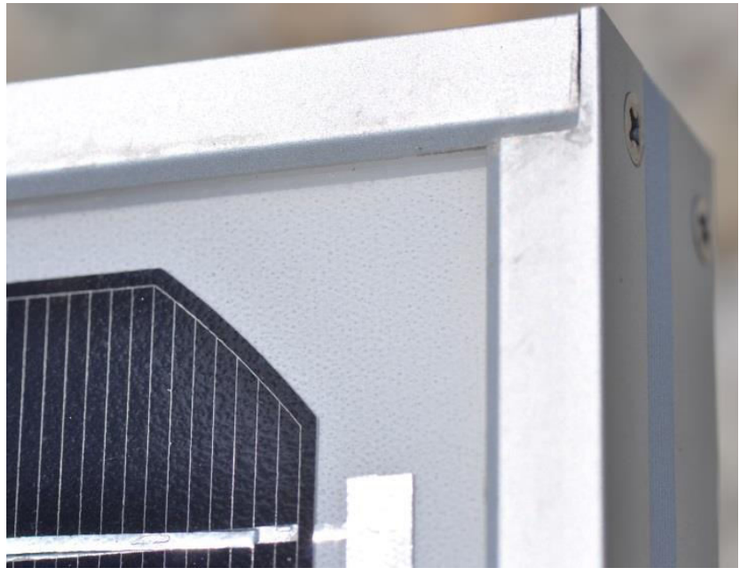
- Significant increase in transmission after insertion of the micro-optics → ca. 1% (abs.) better module efficiency

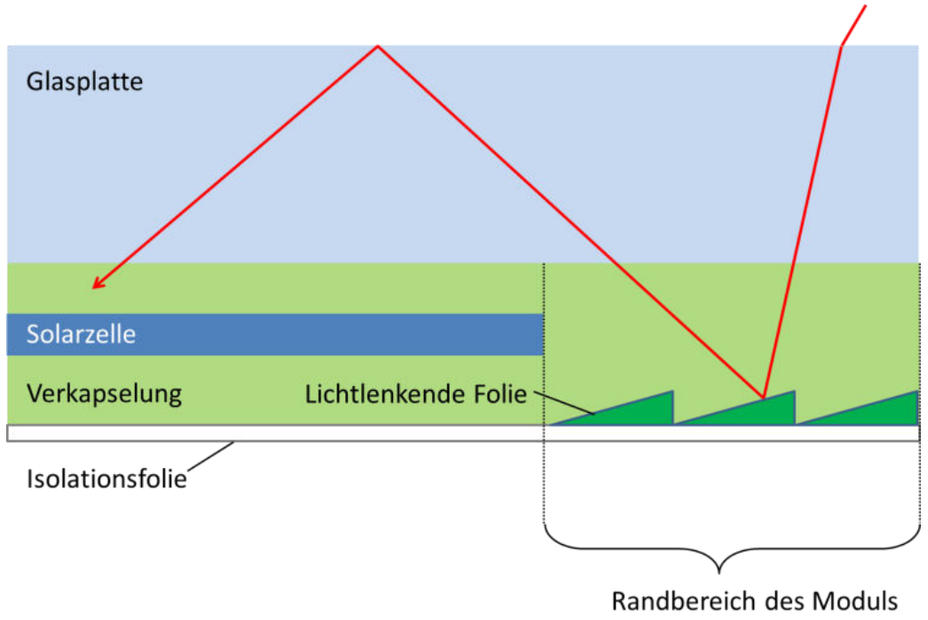




Introducing Light-guiding Films at the edges of the modules further increase the efficiency

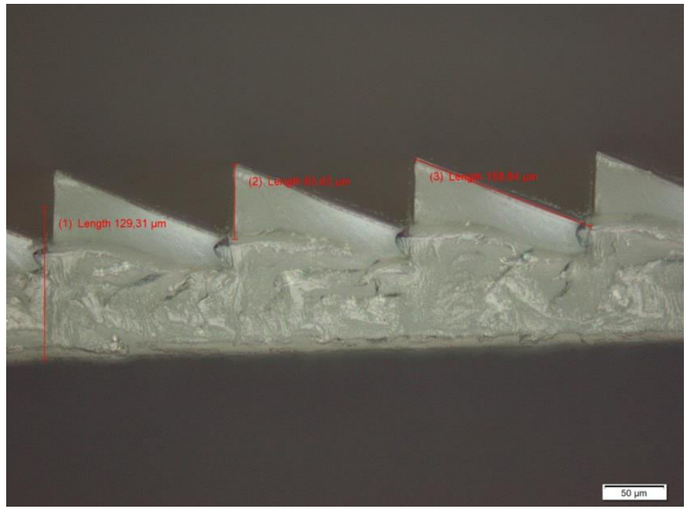
- In particular at the edges of PV modules we have a more or less „dead“ area
- By the use of light-guiding films, more module area can be exploited effectively

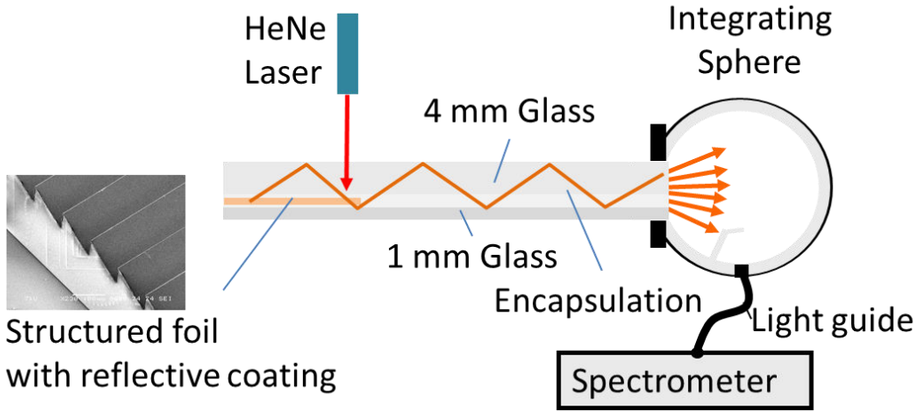




Light-guiding Films produced by Roll-to-Roll UV nanoimprint lithography

- UV Nanoimprint-Lithography uses photopolymerization reactions of polymers on PET substrates
- Curing light source: UV-LEDs
- Optical characterization by determining the TIR efficiency
- Laterally resolved measurements by laser scan





Green Photonics - how Photonics can contribute to more sustainable production processes

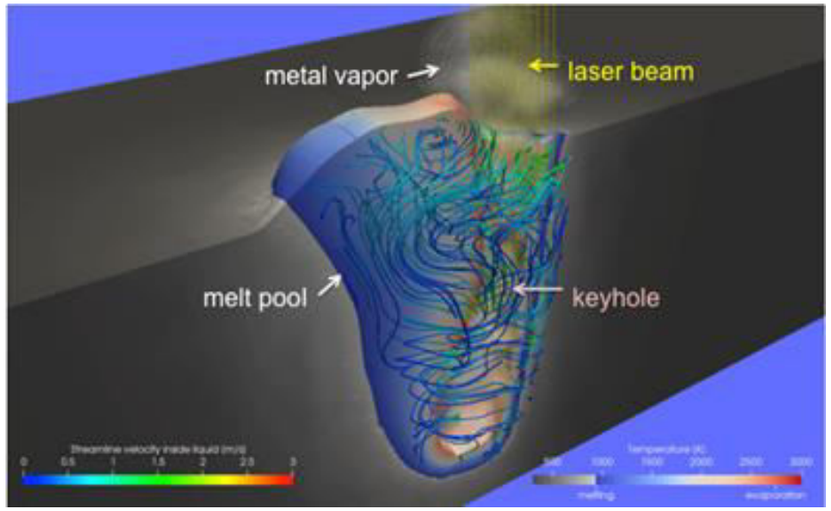
- JOANNEUM RESEARCH and Bionic Surface Technologies developed bionic surfaces for drag reduction of aircrafts (riblets, "shark skin") with the goal to save kerosine in aviation (between 1%-5%)
- The structures are produced by UV-imprint lithography using stamps functionalized with photonic methods of laser processing or structuring
- The effects have initially been proven in the Red Bull Air Race and have been tested by a large European aviation company

Source: Red Bull

Member of

Green Photonics – how Photonics can contribute to more sustainable production processes

- TU Wien, Institute for Production Engineering and Photonic Technologies: multiphysical, numerical simulations of laser material processing for industrial companies worldwide using a software package developed in-house
- These unique simulations support the optimization of products and processes, for example with regard to their environmental compatibility, and contribute directly to increasing resource efficiency



Source: TU Wien

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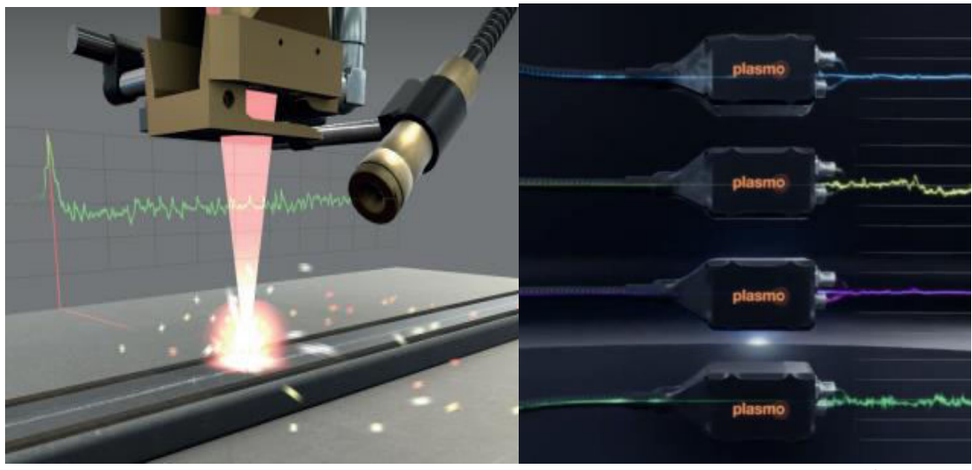
Green Photonics – how Photonics can contribute to more sustainable production processes

- Plasmo is a leading manufacturer of in-line monitoring for laser-based manufacturing processes
- Gas generators for airbags are safety components that require maximum protection of the process steps.
- By means of optical in-line monitoring, a detailed analysis of individual weld seams, but also of many weld seams in comparison, is possible. This process saves the destructive testing of random samples.



Source: Plasmo

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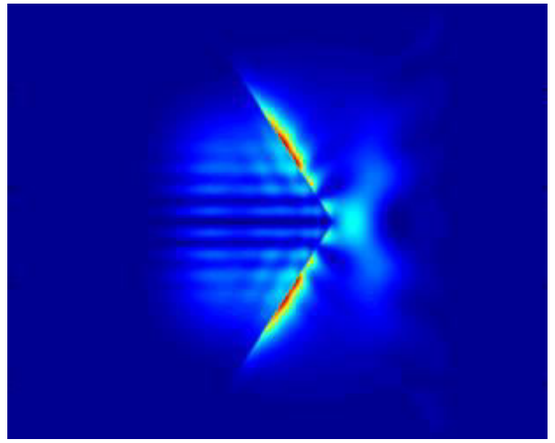
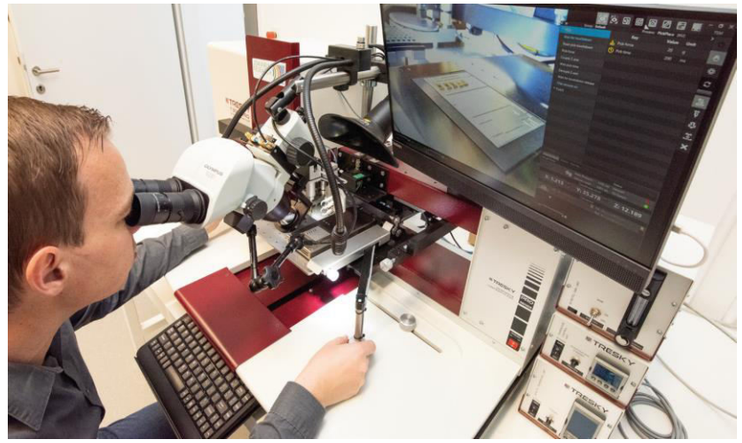
Austrian Fields of Strength in Green Photonics for Production

- High power laser production technology
- Short Pulse Laser Technology
- Lithography Equipment
- In-line process monitoring
- Process Sensors
- Hyperspectral Imaging
- Non-Destructive Testing and Process Analytics
- Additive Manufacturing (LED or laser based)
- Visual Light Communication
- Fiberoptic Networks and Components
- Quantum Technology
- LED and Solid-State Lighting technology
- Infrared Spectroscopy for Identification and Separation of waste





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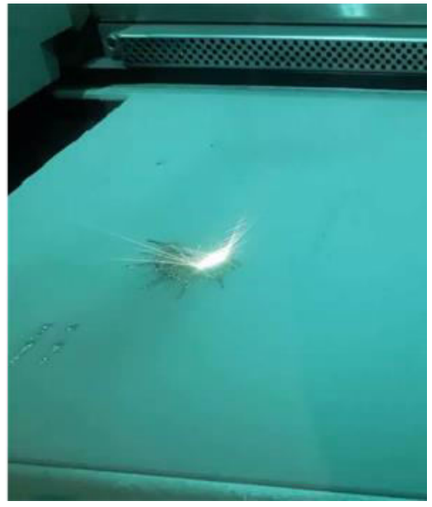
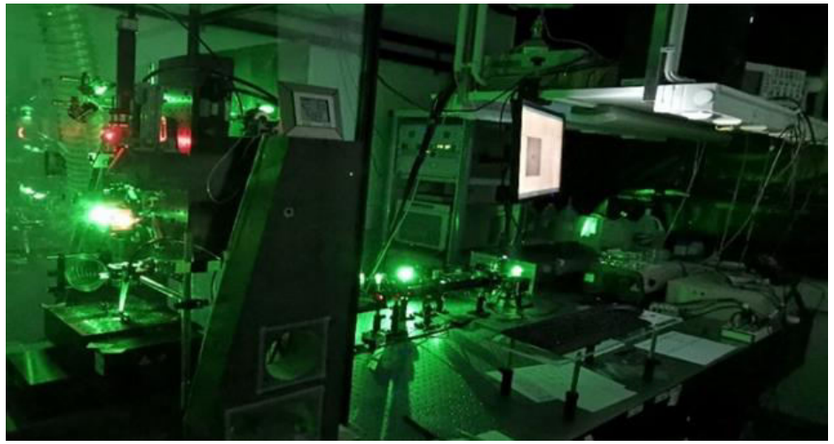


Source: Roadmap Photonics in Austria, in preparation

Summary and Conclusion

- Photonics as a Key Enabling Technology is an indispensable factor especially for the production ecosystem of the 4th industrial revolution
- Its use specifically limits CO_2 emissions, enables weight reduction and material savings, replaces chemical treatments and increases product life cycles and sustainability
- The Austrian Photonics community is especially well set up to tackle the challenges of our production systems towards the European Green Deal.



Source: Joanneum Research

Thank you very much

JOANNEUM RESEARCH
Forschungsgesellschaft mbH

MATERIALS –
Institut für Oberflächentechnologien und Photonik

Franz-Pichler-Straße 30
8160 Weiz

Tel. +43 316 876-3000
materials@joanneum.at

www.joanneum.at/materials

JOANNEUM RESEARCH MATERIALS

PHOTONICS AUSTRIA