ADVANCED DIGITAL MANUFACTURING

Chaired by:

George Chryssolouris
Professor at the Laboratory for Manufacturing Systems and Automation, University of Patras

Rikardo Bueno
CEO at BRTA Basque Research and Technology Alliance

Björn Sautter
Executive Expert Industrie 4.0 Ecosystems at Festo

Riikka Virkkunen
Professor of Practice at VTT Technical Research Centre of Finland

Ioanna Zergioti
Professor at National Technical University of Athens

IndTech 2022

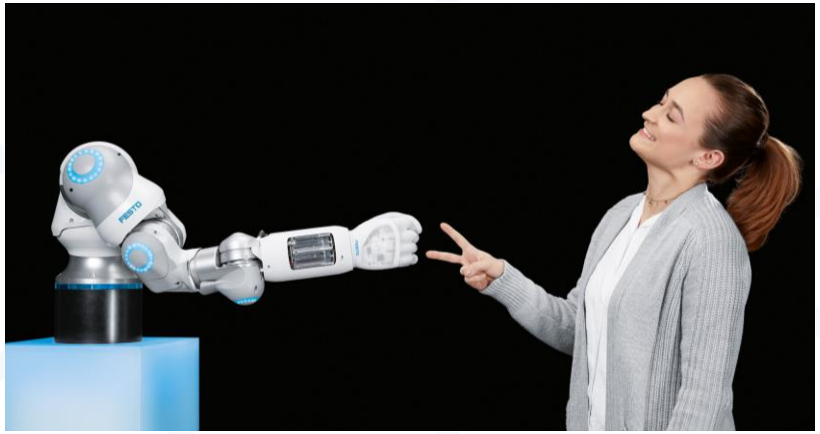
FESTO

Experience the Future -

Digital solutions for a future-oriented, competitive and sustainable industry

Dr. Björn Sautter
Festo SE & Co. KG
28.06.2022 in Grenoble

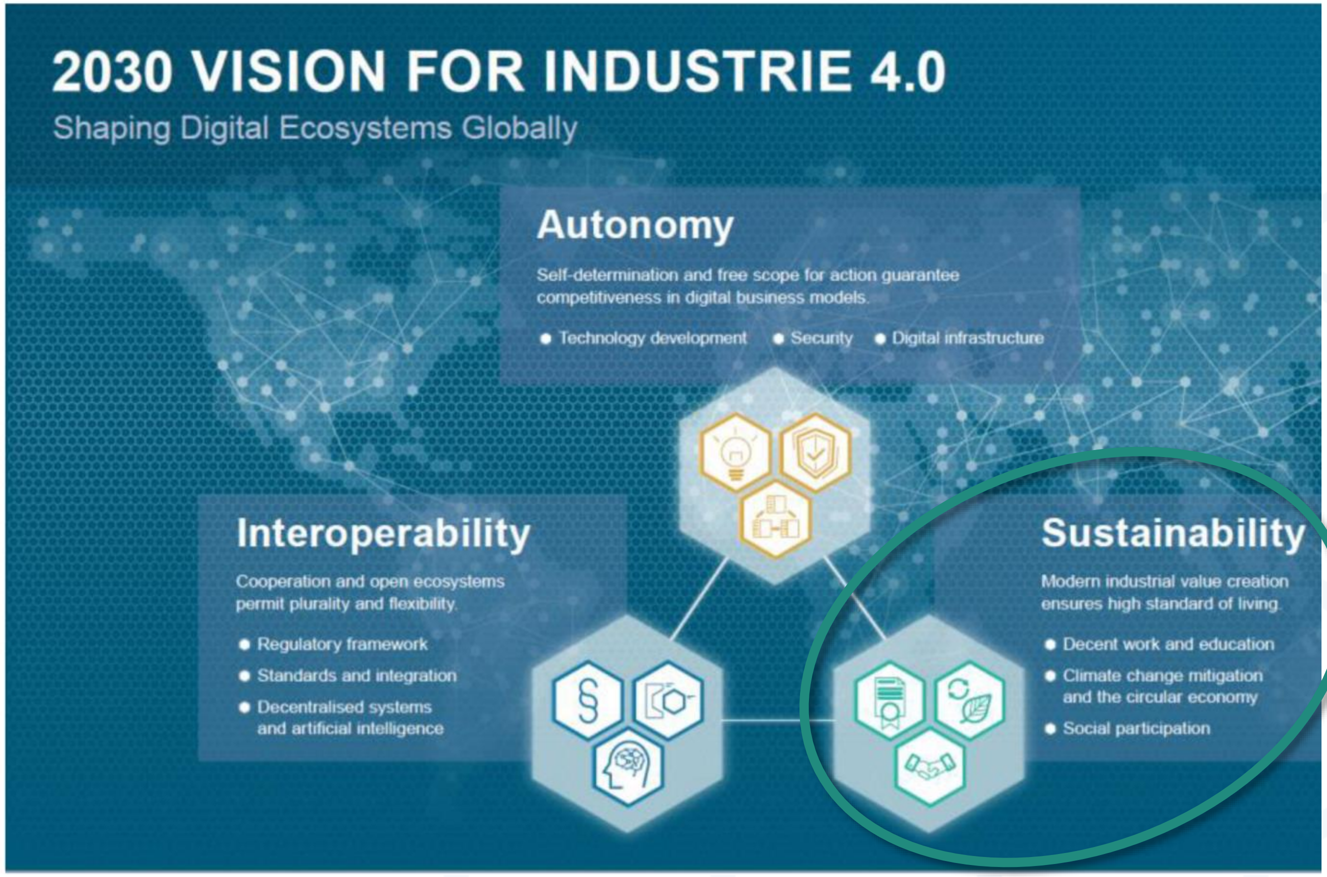
First of all: Human Experience matters …



… for successfully implementing new technologies

Presentation of world‘s first pneumatic cobot at Hannover Fair 2022

Industrie 4.0 and Europe's 2030 sustainability goals



Link to download the 2030 vision for Industrie 4.0: Plattform Industrie 4.0 - 2030 Vision (plattform-i40.de)
Link to article on Shaping Digital Ecosystems for Sustainable Production: Assessing the Policy Impact of the 2030 Vision for Industrie 4.0 (mdpi.com)

Digital transformation paths to sustainable production

Path 1: Reduce consumption, increase impact: towards resource-efficient and carbon neutral, digitalised manufac-turing.

Path 2: From mass production to transparent service offer-ings: how a changed value proposition influences digital business models.

Path 3: Sharing and network-ing sustainable digital busi-ness means cooperating and operating in circular eco-nomic systems.

Link to download this paper: [Plattform Industrie 4.0 - Sustainable production: actively shaping the ecological transformation with Industrie 4.0 (plattform-i40.de)]

Path 1: Reduce consumption, increase impact

41,6% of global electricity consumption and

79,8% of global coal consumption can be attributed to industry.

Source: IASS

Great savings potential through digitization - especially in energy consumption

From energy management to ressource efficiency

Digital data acquisition and monitoring tools check material flows and energy processes

Targeted data processing, not more computer capacity

Computing capacities and their energy consumption are reduced through intelligent analysis and advance planning

CO2-neutral = normal

CO2 neutrality to become the new normal – even in industrial production

Sustainability Ledger

Sustainability indicators become an integral part of accounting

Example for industrial data analytics

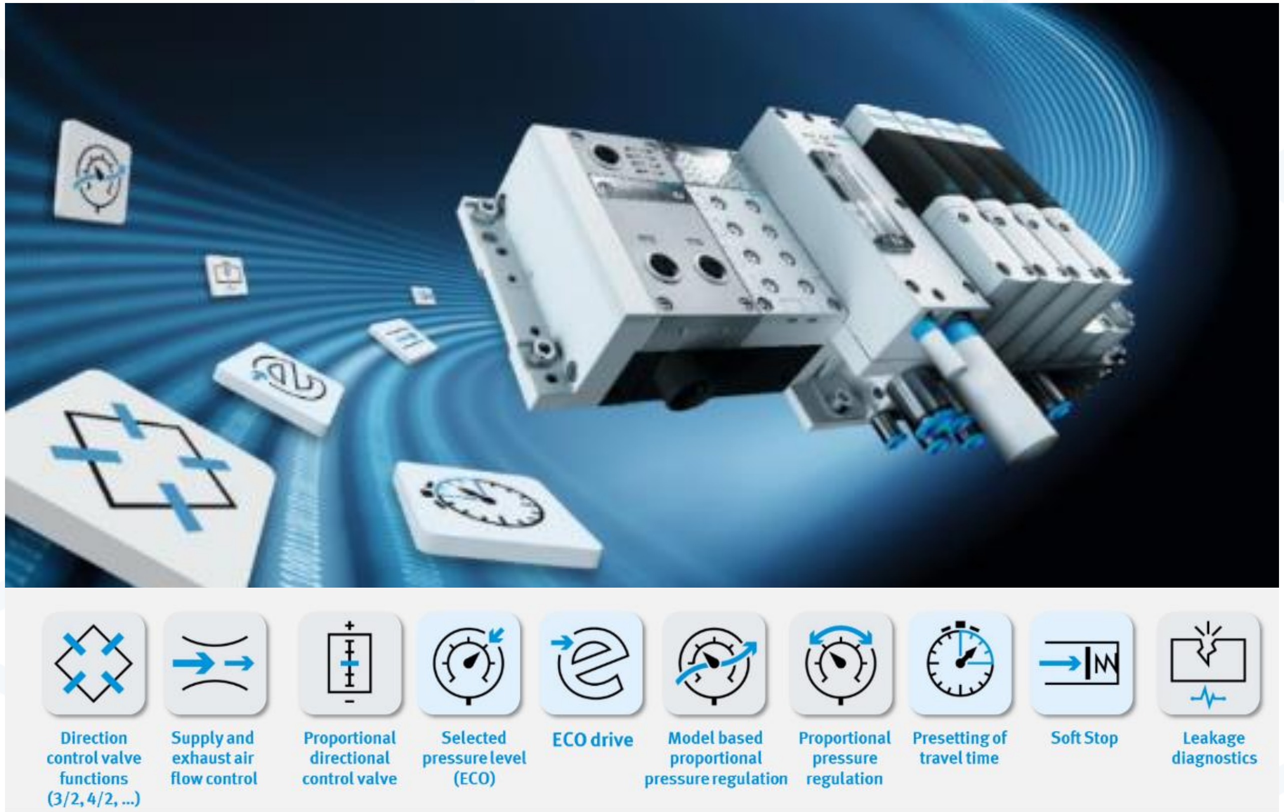
Festo **Automation Experience**

- Easy-to-use digital solution
  on premises, on edge or in the cloud
- Predictive energy
- Predictive maintenance
- Predictive quality
- Real-time **artificial intelligence**
- **Human-in-the loop**:
  incorporating human expertise
- …

Example for intelligent components with software based functions

Festo Motion Terminal

- One mechanical structure fits all applications: software replaces hardware (resource efficiency)
- Wide range of functions via motion apps (flexibility of digital solutions)
- Minimal energy consumption with piezo technology & apps for efficient operation (energy efficiency)
- Intuitive user interfaces
- …



Path 2: From mass production to transparent service offerings

51% of industrial companies are developing new products and services or are planning to do so.

45% of them have implemented Pay-Per-Use or Production-as-a-Service models.

Source: BITKOM

How a changing value proposition is influencing digital business models.

Sustainable Twin
All products have a digital twin that is enriched with sustainability factors and travels with the product

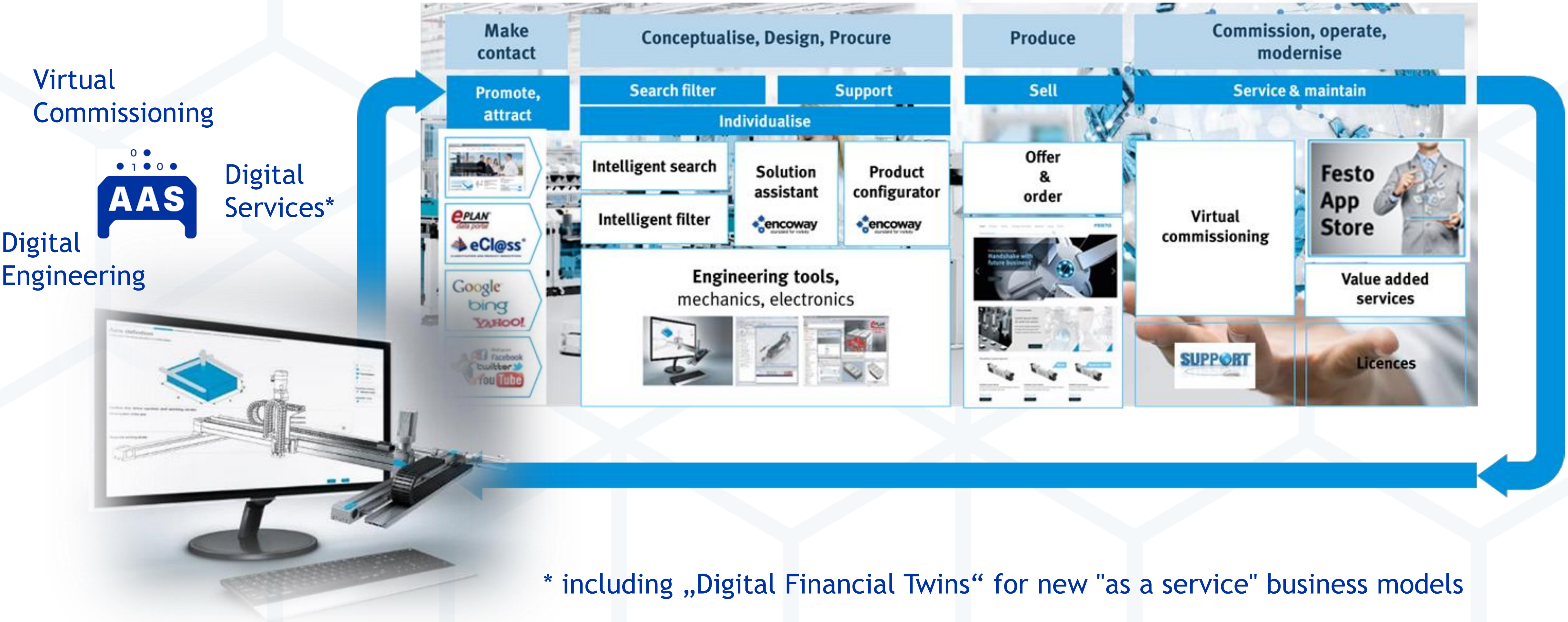
Material Pass
Physical products will have their own ID card: the Material Passport will accompany them throughout their complete life cycle

Re-Manufacturing
Close the (inner) loops and extend life cycles: companies provide e.g. continuous predictive maintenance

Reverse Logistics
Goods are sent back towards the source by the customer at the end of their life to be recycled

Example for digital twin based services along the life cycle

Festo **Online Experience** for the digital customer journey



* including „Digital Financial Twins“ for new "as a service" business models

Path 3: Sharing and Networking

Over **7 billion tonnes** of natural raw materials will be missing without smart circular economy.

Every **fourth** mashine is already smart today.

Source: Accenture, 2015; BITKOM 2018

Sustainable digital business means cooperating and operating in circular economic systems.

Circular value added networks

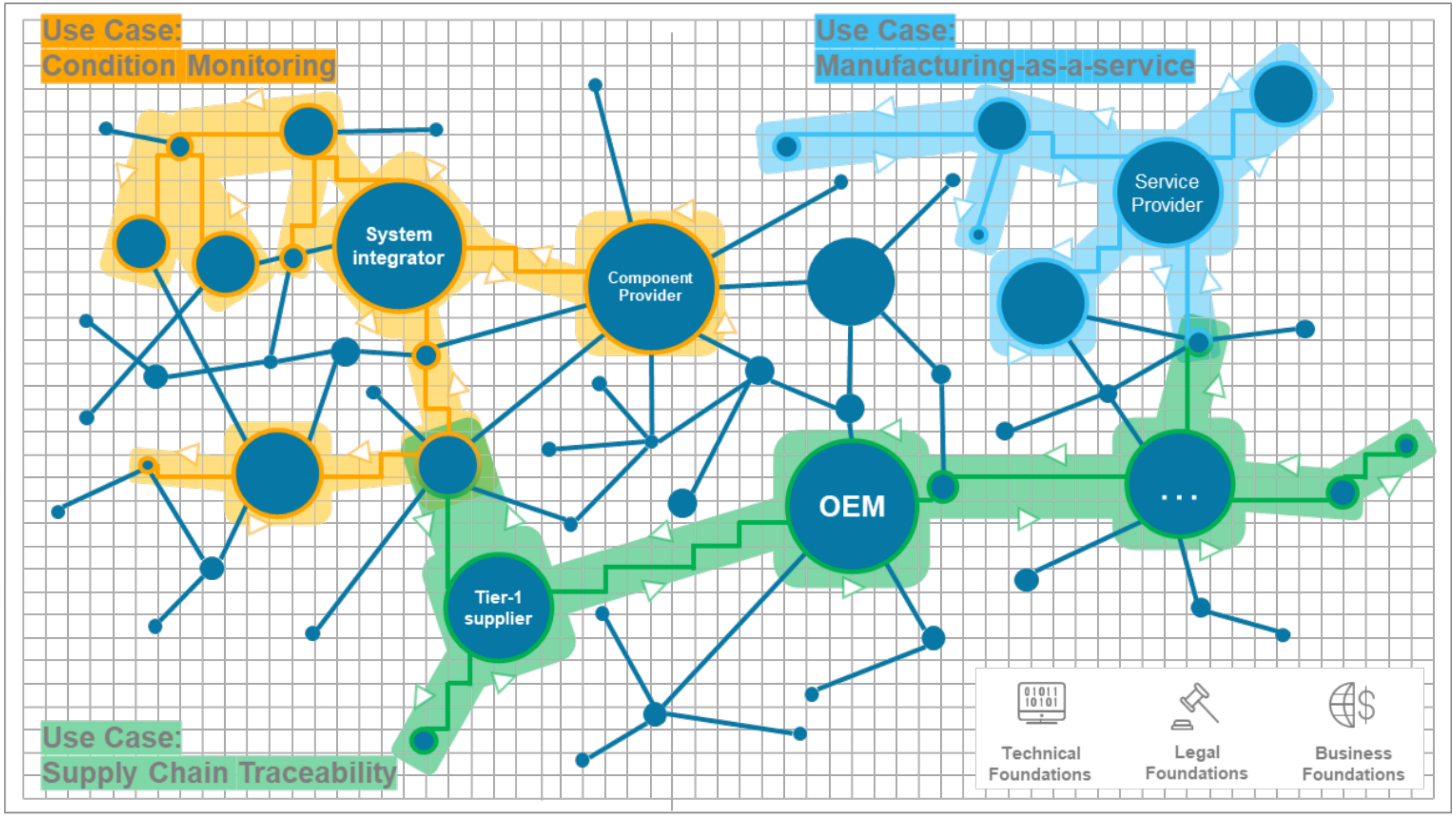
Value networks will take the place of value chains. The network idea means that specialization of individual companies and operations will be broken up and machines can be used more flexibly

From the (proprietary) production plant to shared value added factor

Digital production platforms will bundle relevant production processes. Value-adding factors and production data will be shared and used jointly.

Use cases for multilateral collaboration and data-sharing

- shared/ modular production
- smart supply & logistics
- end-to-end transparency
- data plat-forms & AI
- collaborative product design



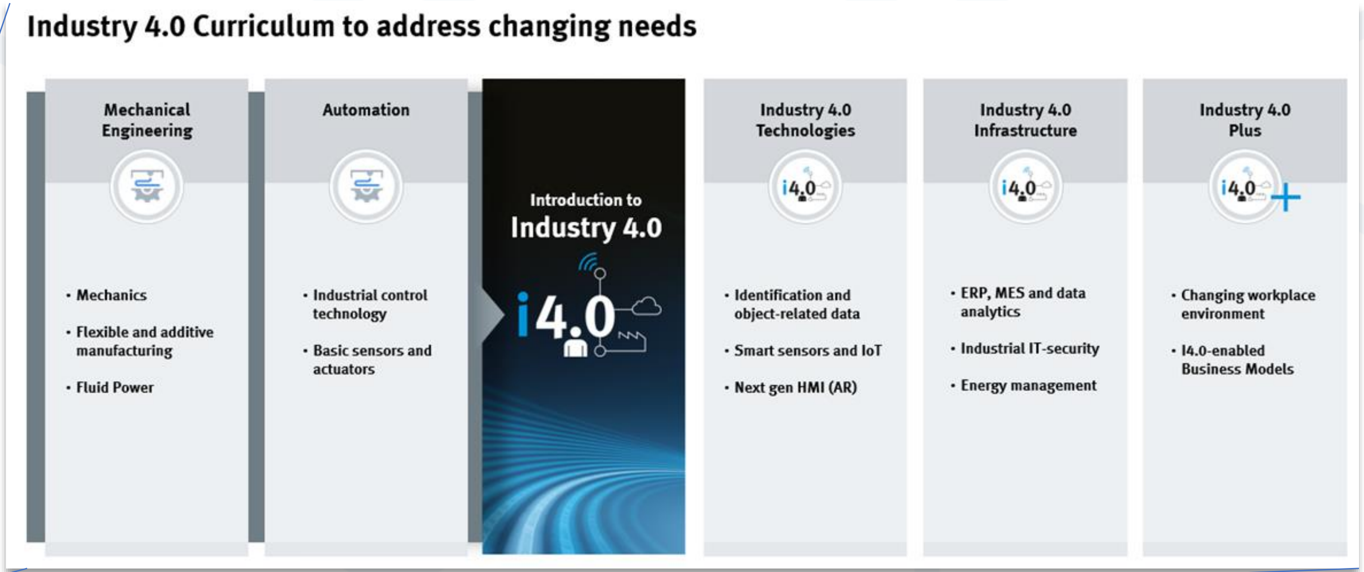
Production Value Network Actors — Business Relation — Use cases — Data flow within use cases

Link to download position paper: [Plattform Industrie 4.0 - Creating the DataSpace Industrie 4.0 (plattform-i40.de)](plattform-i40.de)

Example for platform-based life long learning

Festo **Learning Experience**

- Online portal for teachers & learners
- “Learning nuggets” for continuous micro learning on the job
- Individual learning paths for customized training
- …
- …

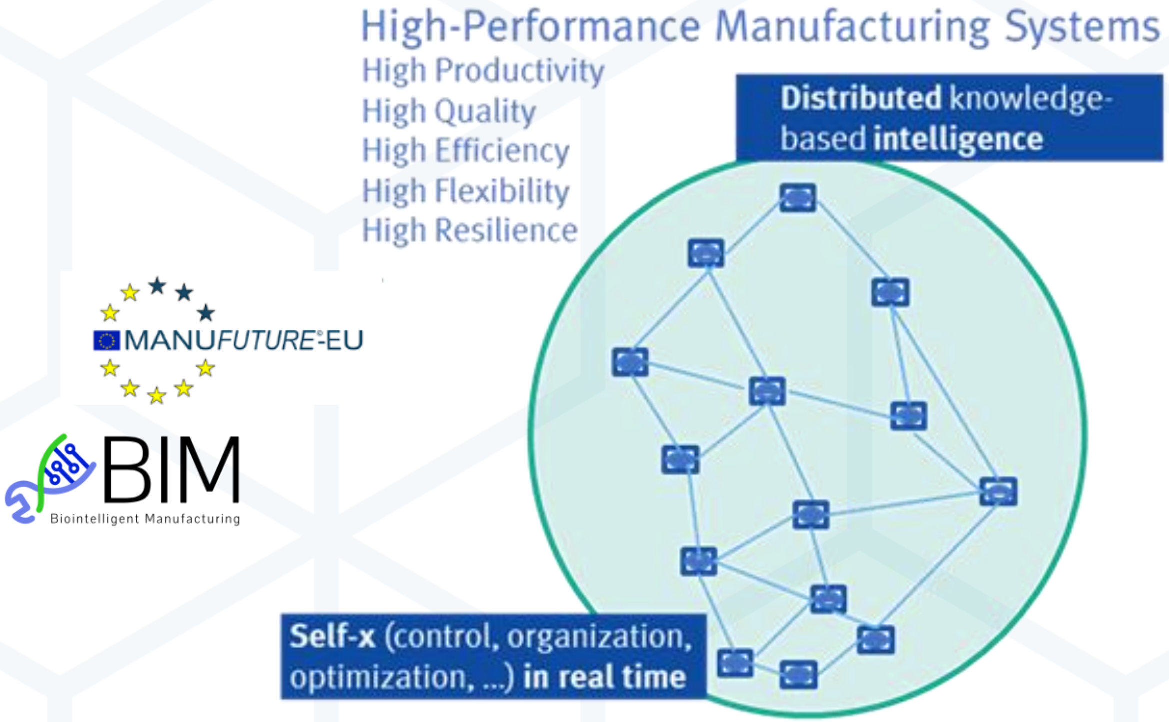


Learning Experience

Next steps: bio-inspired production systems

Festo PhotoBionicCell equipped with appropriate sensors (incl. quantum sensor), control technology and automation.

Concept of Decentralised Technical Intelligence (DTI) for „neuronal“ high-performance manufacturing systems.



Make your own Experience in our Festo Experience Centers

Thank you!

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BRTA
BASQUE RESEARCH & TECHNOLOGY ALLIANCE

Intelligent manufacturing industry: smart processes, machines and products

Rikardo Bueno
BRTA – Basque Research and Technology Alliance
June 2022, Grenoble

Global context

Manufacturing is the backbone of the European economy with 26% of value added in the economy.

Europe is the world's largest exporter of manufactured goods and is the global market leader in products and services with high added value and sustainability standards.

All major industrialised economies are developing major strategies to seize the opportunities of the new industrial age:

1. IT is transforming traditional manufacturing processes and the nature of work. Services account for an increasing share of industrial business, integrating global value chains. Data is becoming the new competitive factor in our connected world.
2. The demand for sustainable products and circular consumption will be key drivers of economic and social development

Trends

The European Green Deal is the new growth strategy. Europe's industry will become increasingly productive with less consumption of both materials and energy.

European industry needs to improve sovereignty in certain technologies, strengthen its position in critical value chains and reduce its consumption of resources, materials and energy. This generates important challenges and opportunities:

- Changes in manufacturing processes, improving their flexibility and efficiency.
- A digital transformation by developing smart and connected machines, equipment, products and components that enable the implementation of artificial intelligence technologies.
- Creating new products with high added value that will allow us to continue to lead the global market.

Socio-economic challenge: Intelligent Industry

- The aim is to move from a focus on production and manufacturing to the incorporation of related services to industry, with support not only from ICT technologies and the 4.0 paradigm, but also from Artificial Intelligence, as a new key KET for the development of our industry.
- Smart Industry is therefore the generation and application of innovation and cutting-edge sustainable and digital manufacturing technologies for the creation of products and services with high added value.
- It includes the use of sustainable materials and processes, the design of products and processes from a life cycle perspective and the application of digital technologies that improve functionality, efficiency, and/or user experience, and/or add value through the exploitation of data.

Sustainable, flexible and zero-defect processes

The transformation of production processes, both nuclear and auxiliary, is manifested in three fundamental characteristics:

1. More digitised and interconnected production processes. All data and parameters linked to the processes are available in an integrated manner for intelligent analysis at all times and thus improve the efficiency of the processes.
2. More automated and flexible production processes. Plants can produce both very small and customised batches as well as large volumes, with greater capabilities for unattended operation and remote control.
3. More efficient and sustainable production processes. Minimising environmental impact and implementing circular models are strategic priorities for the industry..

Sustainable, flexible and zero-defect processes. Main future research lines

- Ensuring digital production quality
- Advanced real-time data simulation and visualization (Production system Digital Twin)
- Flexible production systems
- Energy and raw material efficiency
- Processes for advanced materials, composites and surfaces

TECNALIA - BRTA

Intelligent and connected machines

Machines, as a central element of smart industry, will evolve their level of intelligence to adapt to more predictive planning and more flexible social, market and industrial needs:

- More autonomous, reconfigurable and flexible machines that respond quickly and efficiently to new demands and with an increasing capacity for self-adjustment and self-calibration.
- More efficient and sustainable machines that minimise their environmental footprint, reduce energy consumption and thus the total cost of operation and impact on the environment.
- Human-centred machines that facilitate interaction and communication with people by focusing on their capabilities and needs, thereby improving user satisfaction and machine accessibility.

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Intelligent and connected machines. Main research lines

Connected machine
- Sensorisation, connectivity and data conditioning
- Analysis, diagnosis and quality control

Smart machine
- High precision and sensitivity machines
- Autonomous and adjustable machines

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Intelligent product

A smart product has processing capabilities that enable it to perform a variety of additional functions. Three clear trends in the evolution of smart products will define the transformation of industrial manufacturing:

1. Smarter and more interactive products. In the era of Industry 4.0, manufacturing systems are able to make intelligent decisions through real-time communication and cooperation with humans, machines, sensors, etc.
2. More traceable and sustainable products. Thanks to end-to-end traceability, companies can take control of the carbon footprint of their products being the key to product lifecycle analysis and allowing to understand and control the environmental and social impact of the product.
3. More embedded and connected products. In the future, machines and products must be able to control each other by means of new information and communication techniques. Embedded systems will provide a key enabling technology in this respect.

Intelligent product. Main research lines

- Digitised product
- Trazability
- 360 Digital Twins
- Active product

IDEKO - BRTA

Thank you!

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Laser Induced Forward Transfer: a Digital Additive Manufacturing solution for electronics processing and packaging

Ioanna Zergioti,
National Technical University of Athens
June 28 2022, Grenoble

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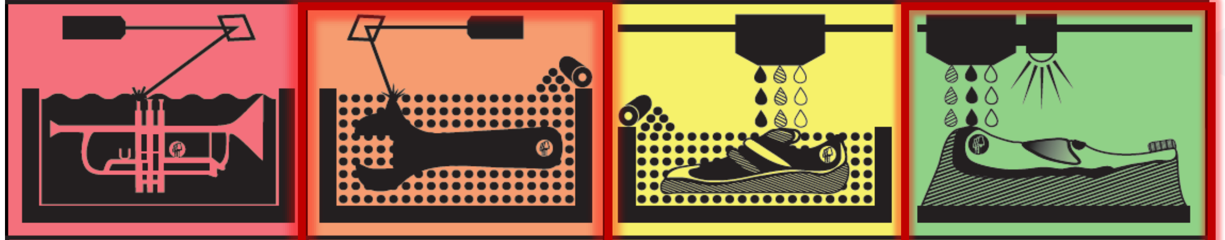
AM families according to the American Society for Testing and Material (ASTM)

7 Families of Additive Manufacturing

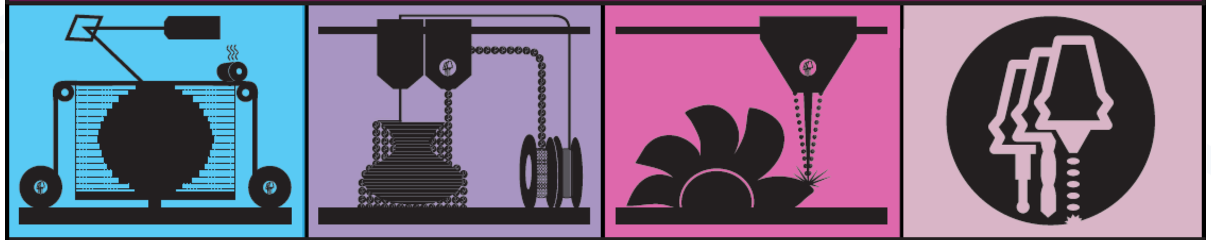
According to ASTM F2792 Standards



	VAT Photopolymerization	Powder Bed Fusion (PBF)	Binder Jetting	Material Jetting
Alternative Names:	SLA™ - Stereolithography Apparatus DLP™ - Digital Light Processing 3SP™ - Scan, Spin, and Selectively Photocure CLIP™ – Continuous Liquid Interface Production	SLS™ - Selective Laser Sintering; DMLS™ - Direct Metal Laser Sintering; SLM™ - Selective Laser Melting; EBM™ - Electron Beam Melting; SHS™ - Selective Heat Sintering; MJF™ - Multi-Jet Fusion	3DP™ - 3D Printing ExOne Voxeljet	Polyjet™ SCP™ - Smooth Curvatures Printing MJM - Multi-Jet Modeling Projet™
Description:	A vat of liquid photopolymer resin is cured through selective exposure to light (via a laser or projector) which then initiates polymerization and converts the exposed areas to a solid part.	Powdered materials is selectively consolidated by melting it together using a heat source such as a laser or electron beam. The powder surrounding the consolidated part acts assupport material for overhanging features.	Liquid bonding agents are selectively applied onto thin layers of powdered material to build up parts layer by layer. The binders include organic and inorganic materials. Metal or ceramic powdered parts are typically fired in a furnace after they are printed.	Droplets of material are deposited layer by layer to make parts. Common varieties include jetting a photocurable resin and curing it with UV light, as well as jetting thermally molten materials that then solidify in ambient temperatures.
Strengths:	• High level of accuracy and complexity • Smooth surface finish • Accommodates large build areas	• High level of complexity • Powder acts as support material • Wide range of materials	• Allows for full color printing • High productivity • Uses a wide range of materials	• High level of accuracy • Allows for full color parts • Enables multiple materials in a single part
Typical Materials	UV-Curable Photopolymer Resins	Plastics, Metal and Ceramic Powders, and Sand	Powdered Plastic, Metal, Ceramics, Glass, and Sand.	Photopolymers, Polymers, Waxes

7 Families of Additive Manufacturing

According to ASTM F2792 Standards



	Sheet Lamination	Material Extrusion	Directed Energy Deposition (DED)	Hybrid
Alternative Names:	LOM - Laminated Object Manufacture SDL - Selective Deposition Lamination UAM - Ultrasonic Additive Manufacturing	FFF - Fused Filament Fabrication FDM™ - Fused Deposition Modeling	LMD - Laser Metal Deposition LENS™ - Laser Engineered Net Shaping DMD™ - Direct Metal Deposition (DM3D) LENS™ – Laser Engineered Net Shaping DMD™ – Direct Metal Deposition DM3D,	AMBIT™ - Created by Hybrid Manufacturing Technologies
Description:	Sheets of material are stacked and laminated together to form an object. The lamination method can be adhesives or chemical (paper/plastics), ultrasonic welding, or brazing (metals). Unneeded regions are cut out layer by layer and removed after the object is built.	Material is extruded through a nozzle or orifice in tracks or beads, which are then combined into multi-layer models. Common varieties include heated thermoplastic extrusion (similar to a hot glue gun) and syringe dispensing.	Powder or wire is fed into a melt pool which has been generated on the surface of the part where it adheres to the underlying part or layers by using an energy source such as a laser or electron beam.This is essentially a form of automated build-up welding.	Laser metal deposition (a form of DED) is combined with CNC machining, which allows additive manufacturing and 'subtractive' machining to be performed in a single machine so that parts can utilize the strengths of both processes.
Strengths:	• High volumetric build rates • Relatively low cost (non-metals) • Allows for combinations of metal foils, including embedding components.	• Inexpensive and economical • Allows for multiple colors • Can be used in an office environment • Parts have good structural properties	• Not limited by direction or axis • Effective for repairs and adding features • Multiple materials in a single part • Highest single-point deposition rates	• Smooth surface finish AND High Productivity • Geometrical and material freedoms of DED • Automated in-process support removal, finishing, and inspection
Typical Materials	Paper, Plastic Sheets, and Metal Foils/Tapes	Thermoplastic Filaments and Pellets (FFF); Liquids, and Slurries (Syringe Types)	Metal Wire and Powder, with Ceramics	Metal Powder and Wire, with Ceramics

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Digital Additive Manufacturing

Material Jetting "Drop on demand":

an additive manufacturing process in which droplets of build material are selectively deposited

- Inkjet printing
- Aerosol Printing
- Laser Printing

Powder Bed Fusion:

An additive manufacturing process in which thermal energy selectively fuses regions of a powder bed

- Direct Metal Laser sintering
- Multi-Jet fusion
- Electron Beam Melting
- Selective Laser Sintering

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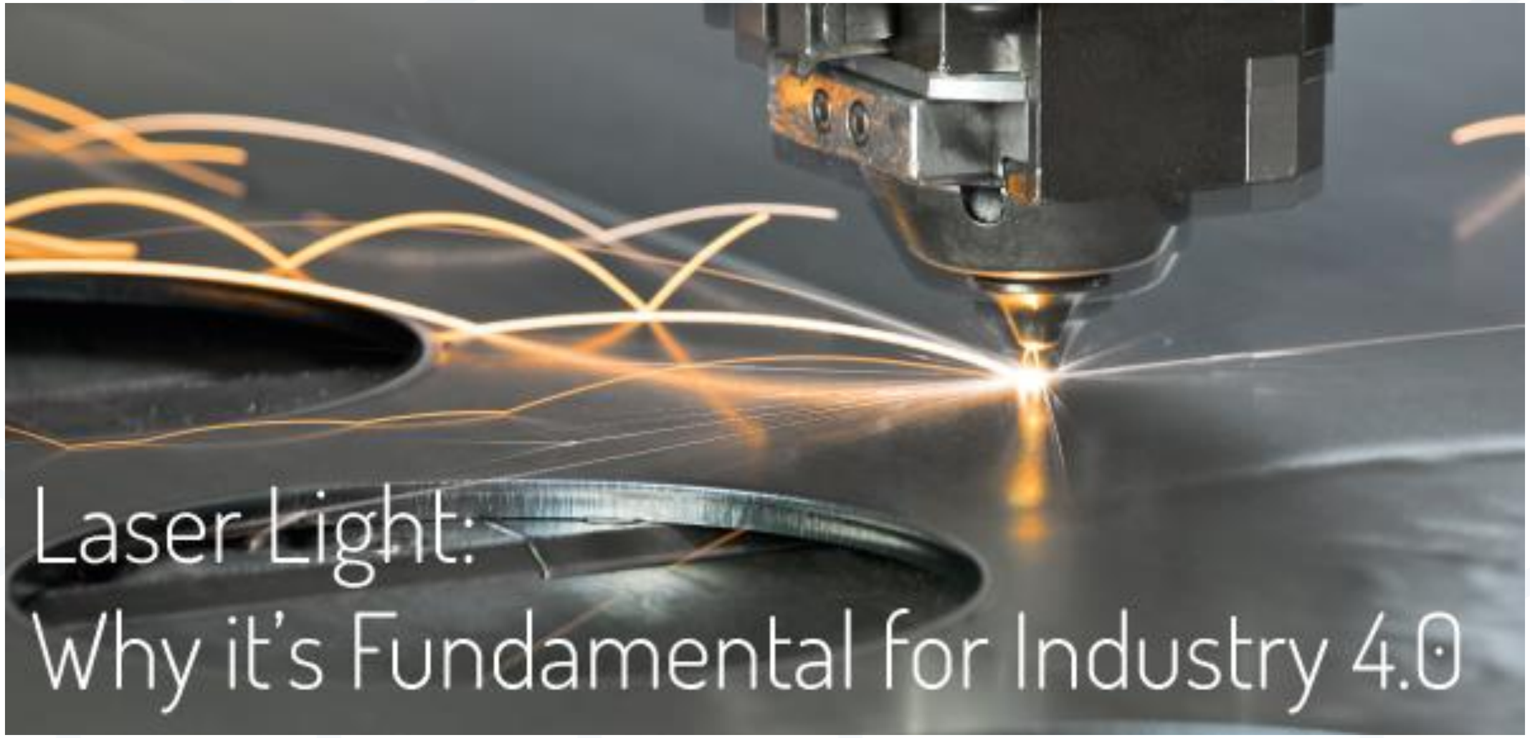
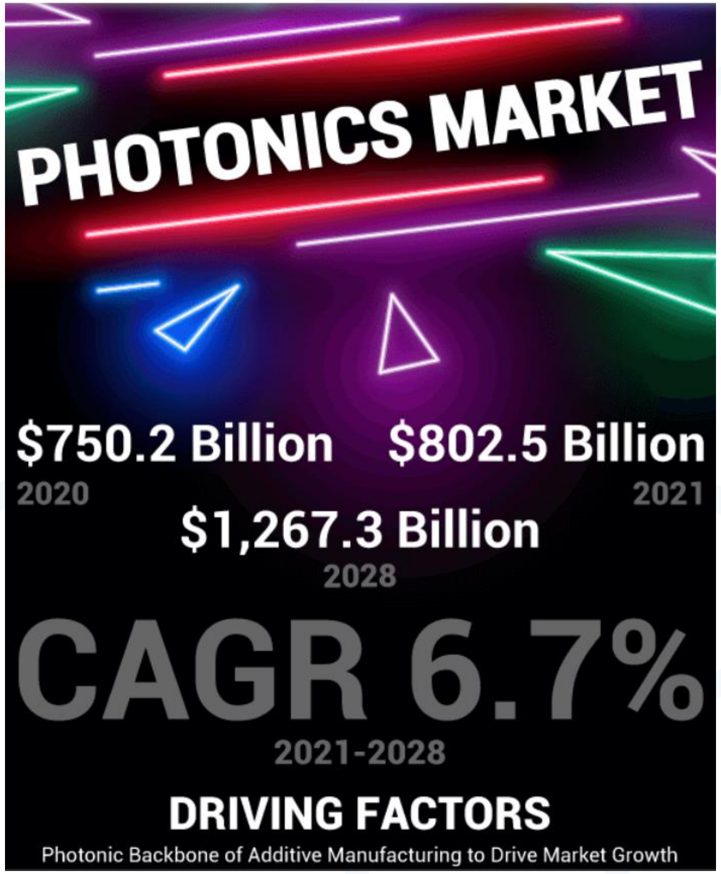
Why is laser additive manufacturing a key-enabler for Industry

“Europe’s age of light!
How photonics will power growth and innovation”
Photonics 21 Strategic Roadmap 2021–27

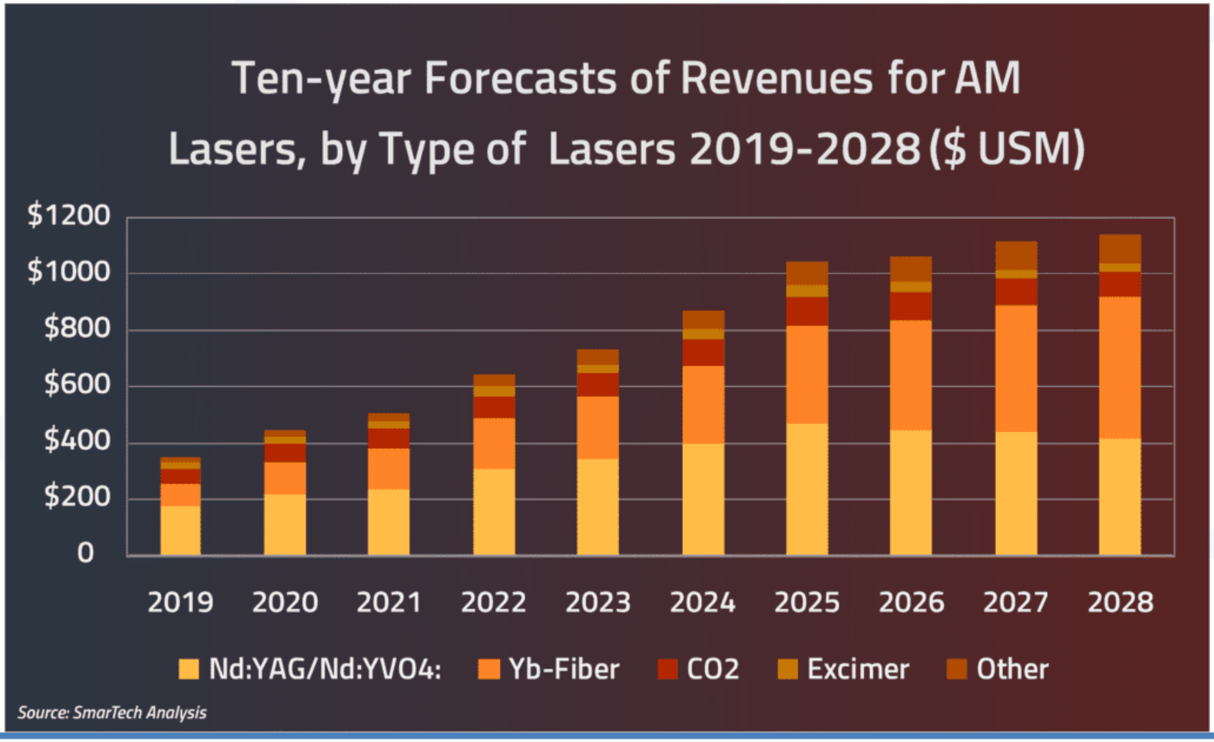
“Photonic technology is the bedrock of additive manufacturing”
Laser Focus World, Sep. 21 2021



Photonics and Laser AM Market size



"Photonics technologies are opening up new manufacturing paradigms, such as 3D additive manufacturing, which will secure renewed growth in European manufacturing"
Photonics21 Multiannual Strategic Roadmap 2021-2027



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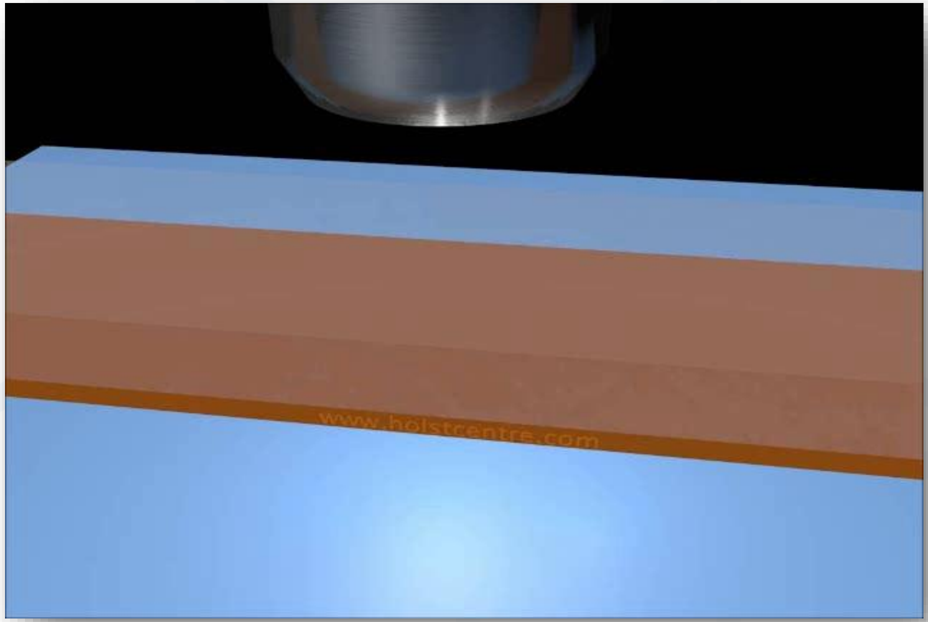
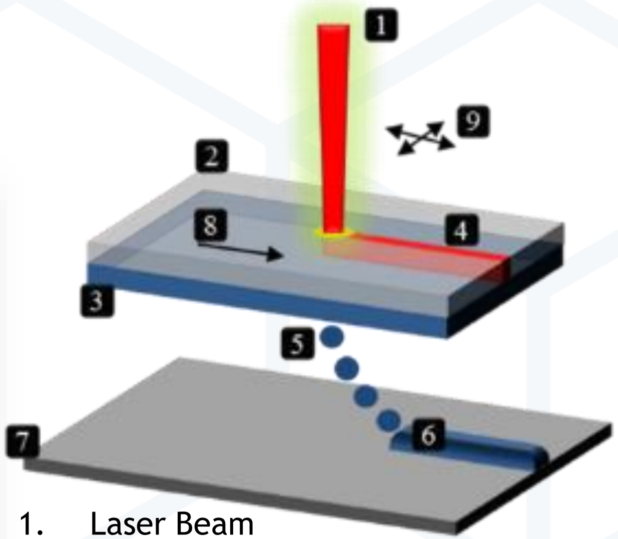
Laser Induced Forward Transfer for the fabrication of metallic micro patterns as components in flexible electronics

LIFT



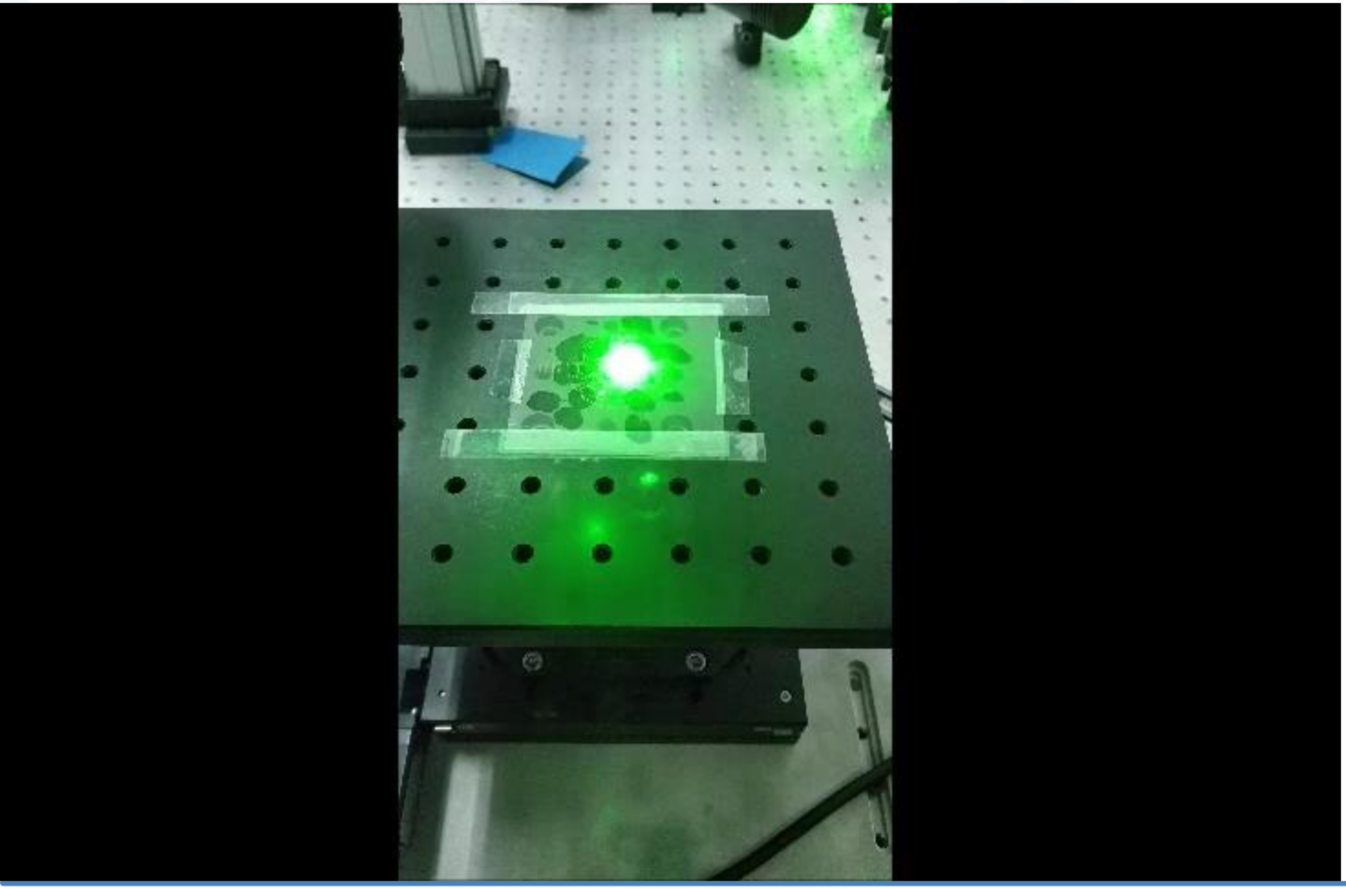


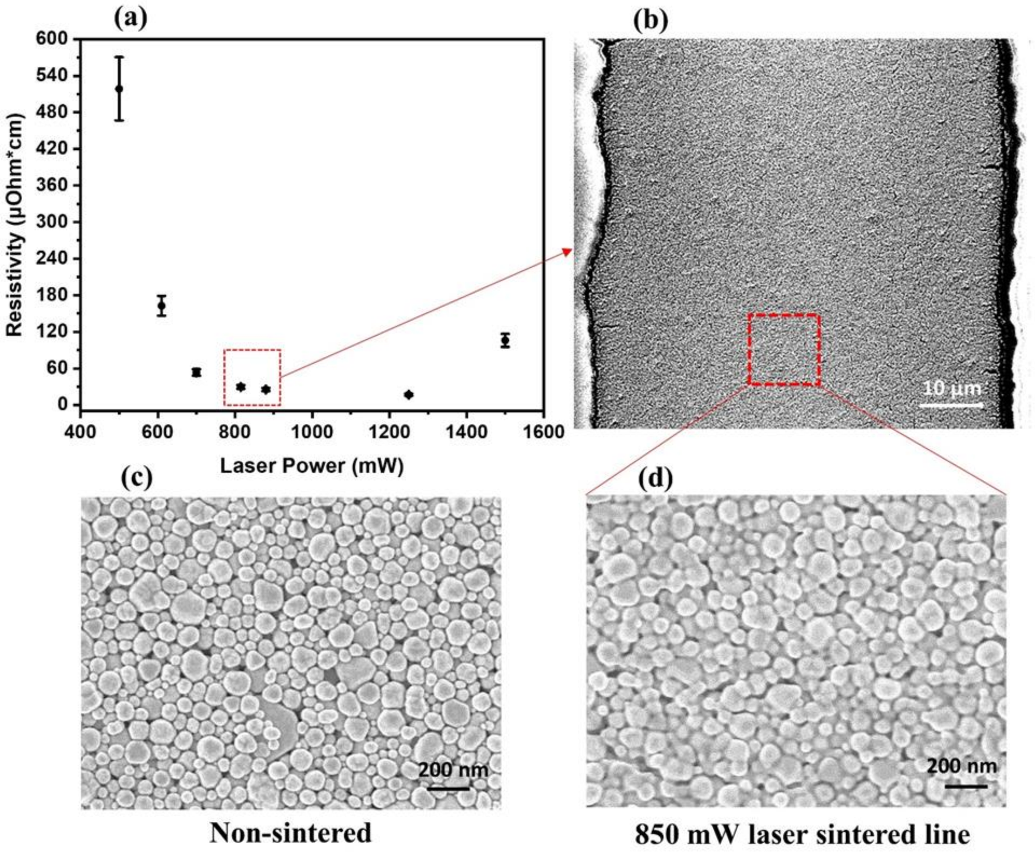
1. Laser Beam
2. Transparent donor foil
3. Coating of functional ink or paste
4. Path traced by laser beam or donor foil
5. Ejected droplets
6. Printed track
7. Receiver substrate
8. Direction of donor web movement
9. Laser beam scanning

Laser Direct Transfer

Courtesy of Dr. Gari Arutinov

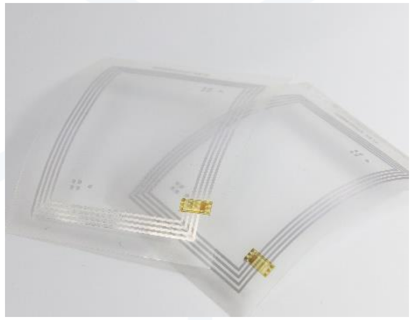
Selective Laser microSintering: transforming nanoparticle deposits to solid metal tracks

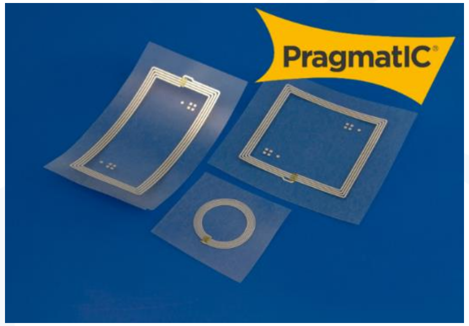




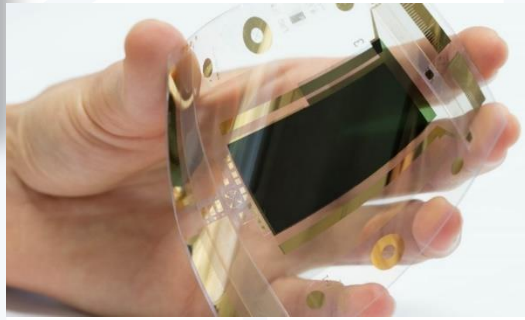
Example I:
HIgh PERformance Laser-Additive Manufacturing for Industrial electronic applications

Application 1: Laser printed RFID antenna





Application 2: Laser printed Fingerprint sensors

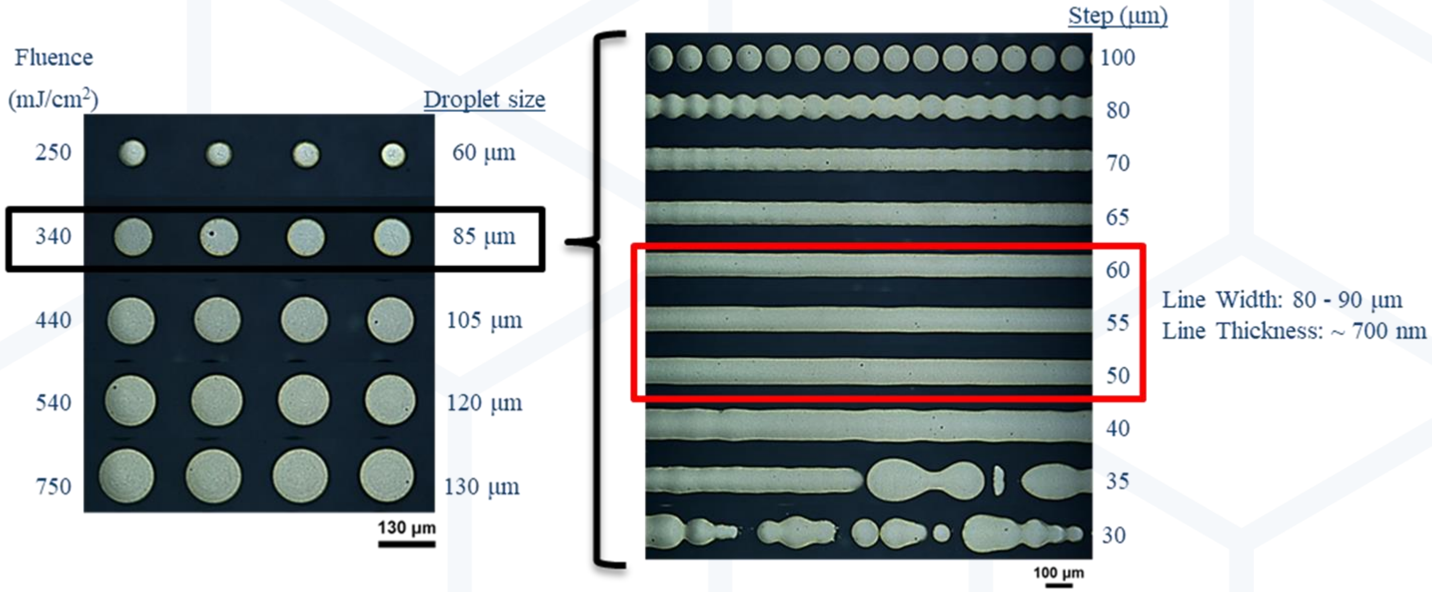


H2020-FOF-13-2017-2019

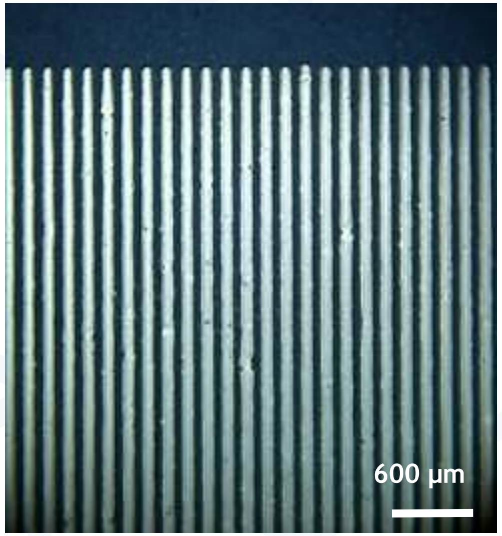
Use case Ia. Laser printed and sintered linear patterns for fingerprint sensors

HiperLAM

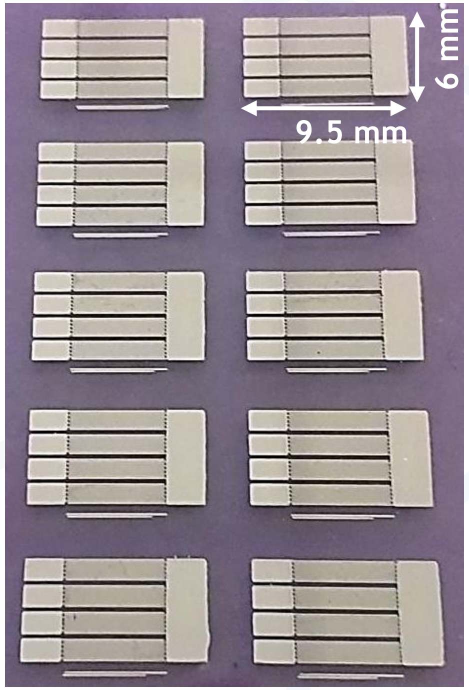
Laser printing process development



Resulting conductive patterns (fingerprint sensors)



Lines' width ~ 90 µm
Lines' gap ~ 60 µm



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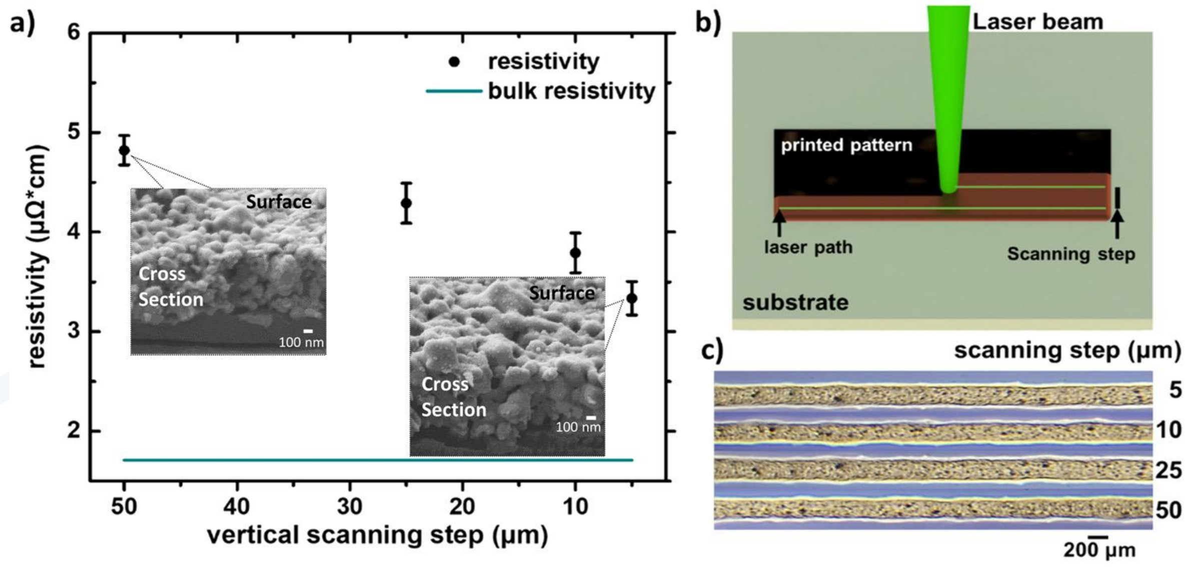
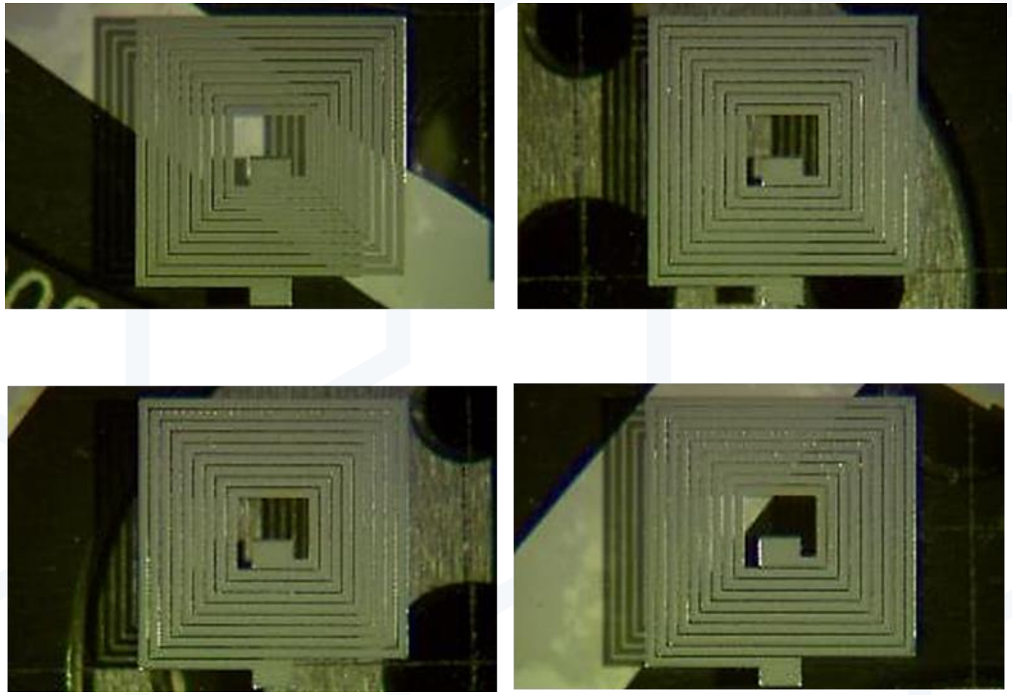
High speed laser printing and sintering of flexible RFID antennas and fingerprint sensors, I. Theodorakos et al., Proc. SPIE 11267, Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XXV, 1126709 (11 March 2020)

Use case Ib. Laser printed, low-cost, flexible RFID antennas made of Cu nanoparticles

SLS of Cu nanoparticle inks

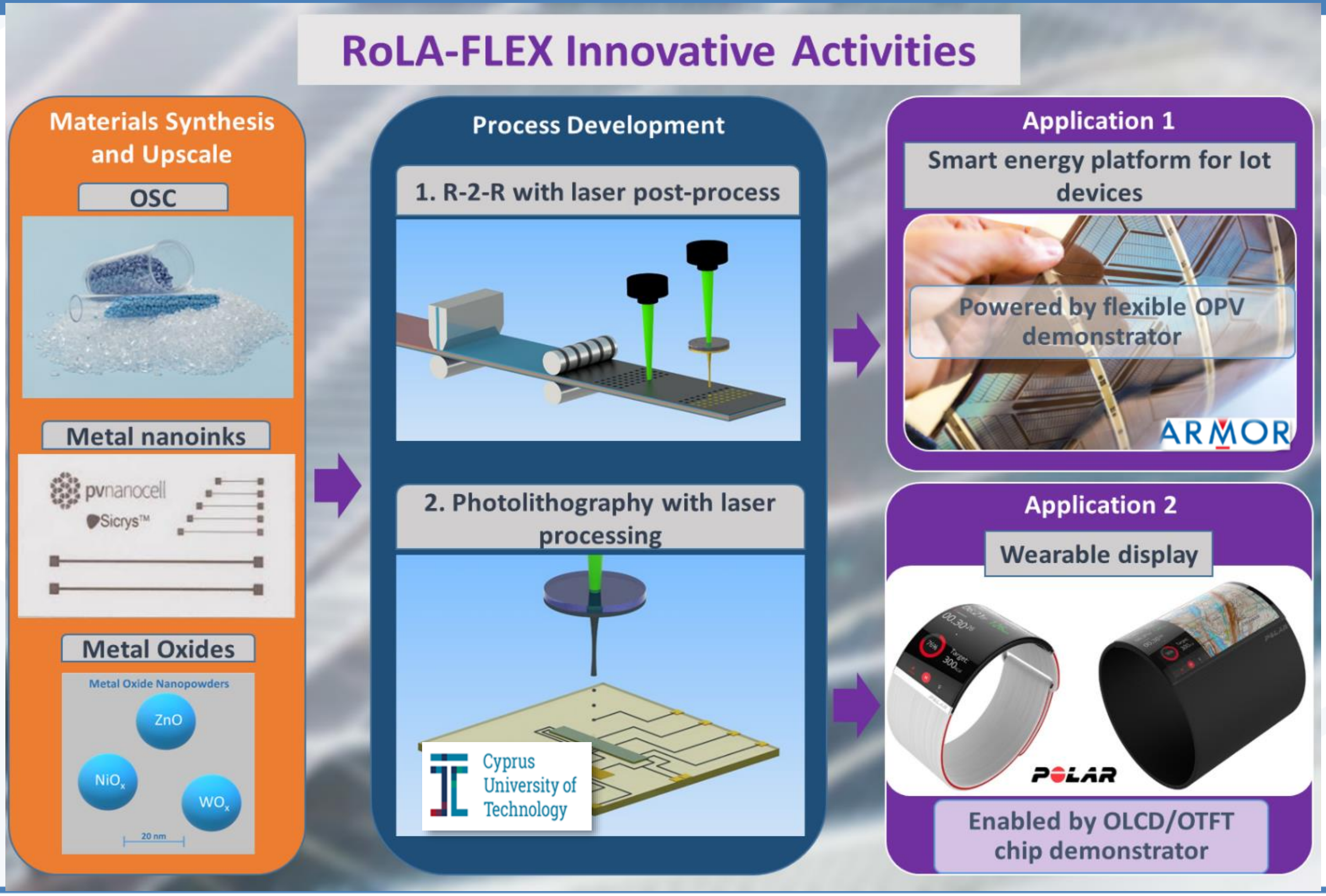


Resulting conductive patterns (RFIDs)



"Copper micro-electrode fabrication using laser printing and laser sintering processes for on-chip antennas on flexible integrated circuits", O. Koritsoglou et al. , Opt. Mater. Express 9, 3046-3058, (2019),

Example II: Roll-2-Roll and Photolithography post-processed with LAser digital technology for FLEXible photovoltaics and wearable displays

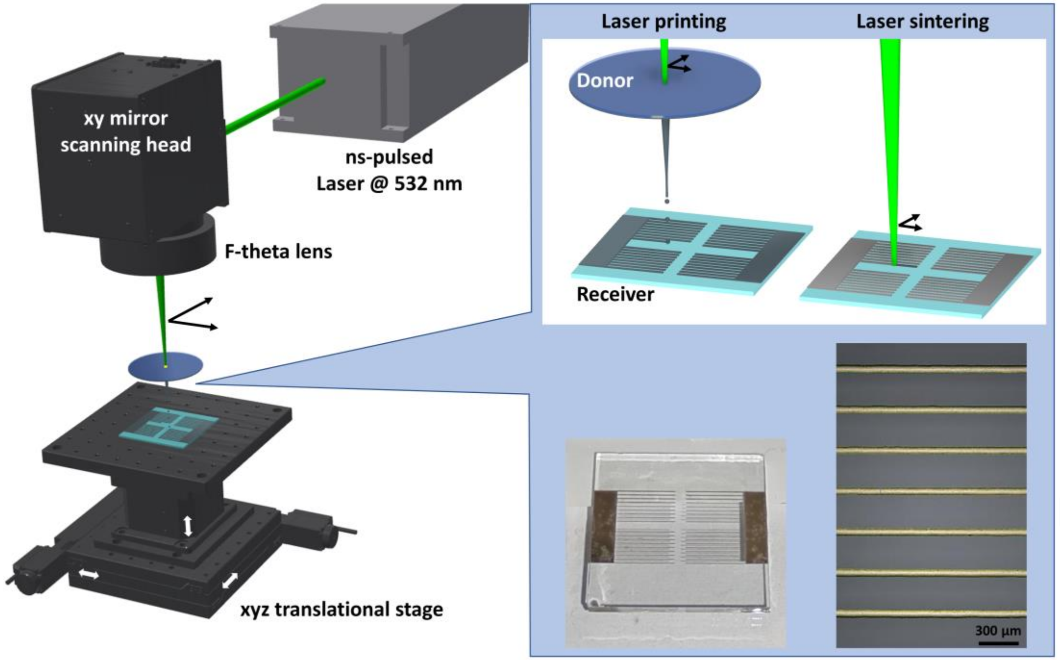


01/05/2020-30/10/2023

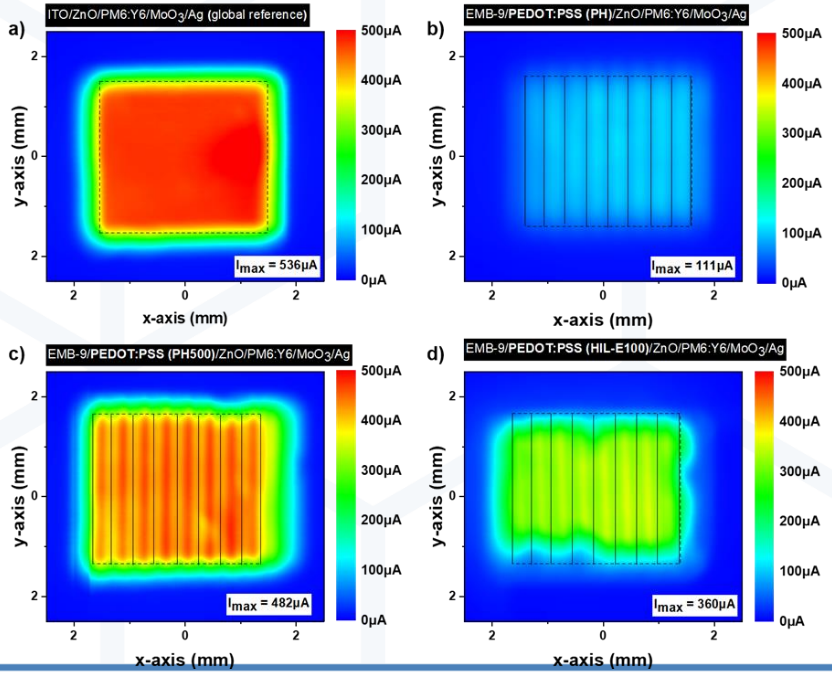
Topic: H2020-DT-NMBP-18-2019 (IA)

Use case IIa. Flexible, ITO-free OPVs

Laser printing and laser sintering of metal grids as transparent and conductive electrodes of OPVs



Photocurrent mapping of resulting inverted OPV devices



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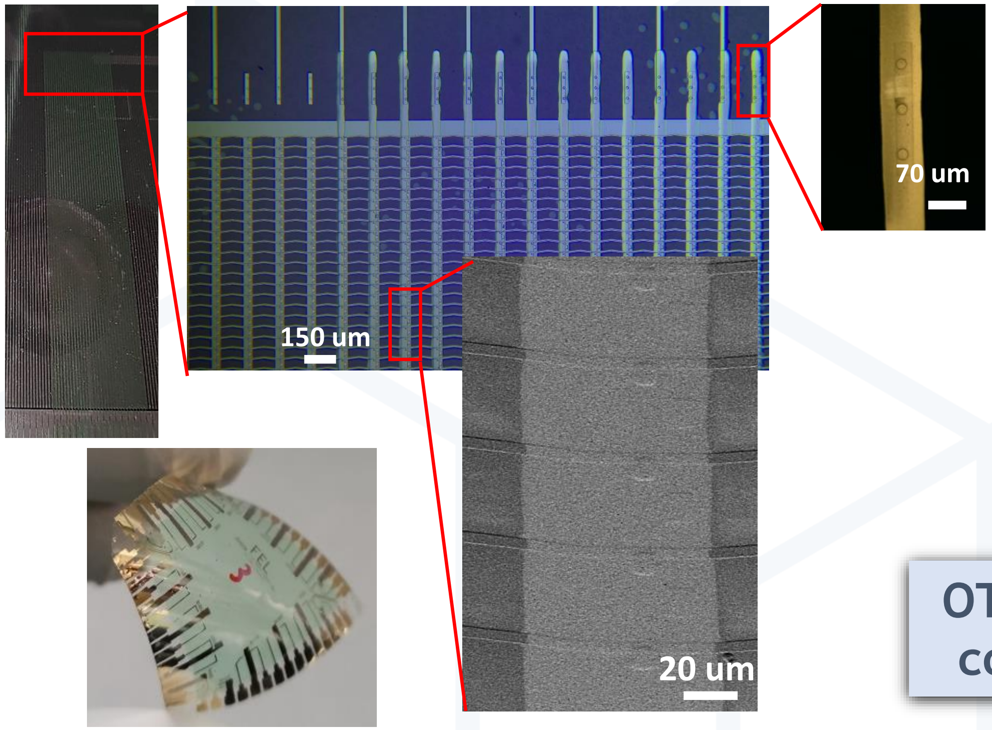
S. Pozov *et al*. "Highly Efficient Indium Tin Oxide-Free Inverted Organic Photovoltaics using Laser Induced Forward Transfer Silver Nanoparticle Embedded Metal Grids, accepted for publication, ACS Appl. Electron. Mater. 2022"

Use case IIb. Conformal laser printing & sintering for OTFT gate electrodes

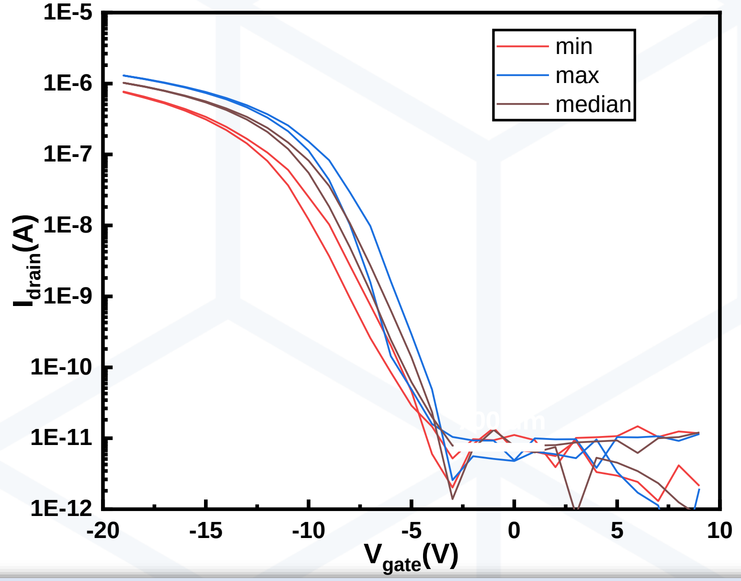
ROLA-FLEX

Resulting gate electrode lines

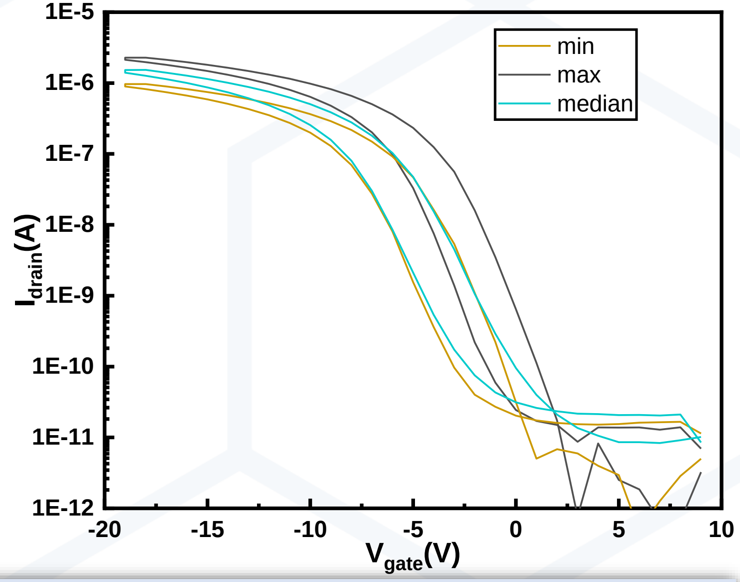


Performance evaluation comparison

Devices with LIFT printed gate



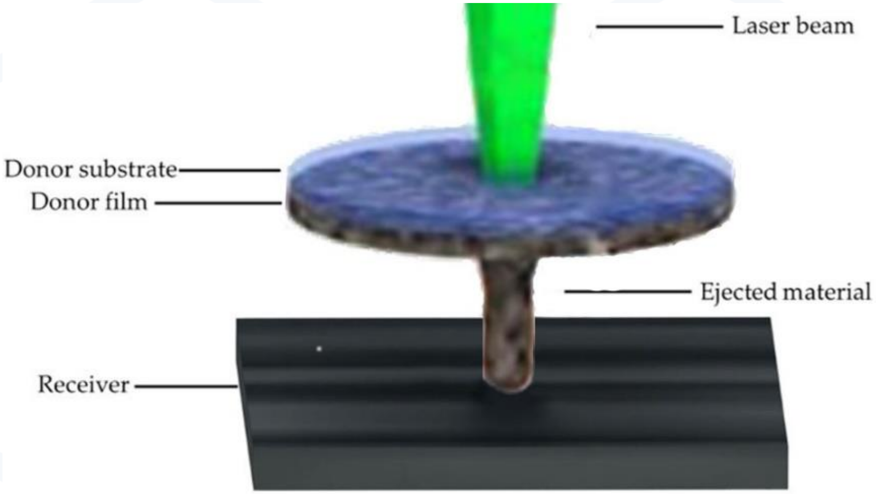
Devices with sputtering deposited gate



OTFTs with LIFT printed and laser-sintered gate electrodes exhibited comparable performance with respect to standard fabrication steps

SYN-LASER: Assembly and wire-bonding of electronic circuits using laser printing processes

SYN-LASER aims at the development of new processes for the assembly and the wire bonding of electronic circuits with digital laser printing and sintering technology, in order to integrate them into industrial processes of packaging and production of electronic circuits.



The project has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE with budget 857.679,30 € (project code:T1EDK-00814)

PLiN Nanotechnology S.A.

National Technical University of Athens

Prisma Electronics S.A.

Aristotle University of Thessaloniki

Use case III: – assembly of microelectronic components using laser printing of solder paste

ΣYN-LASER

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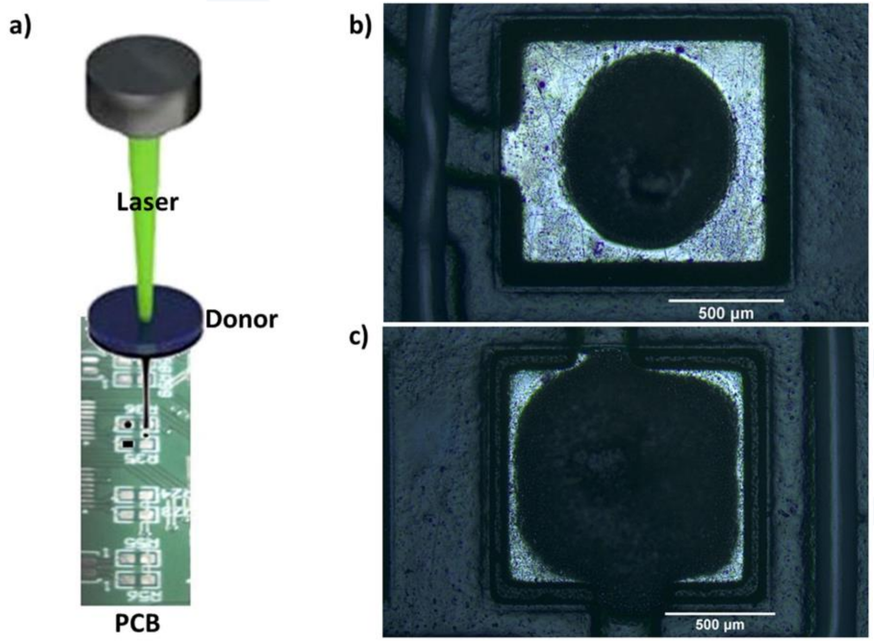
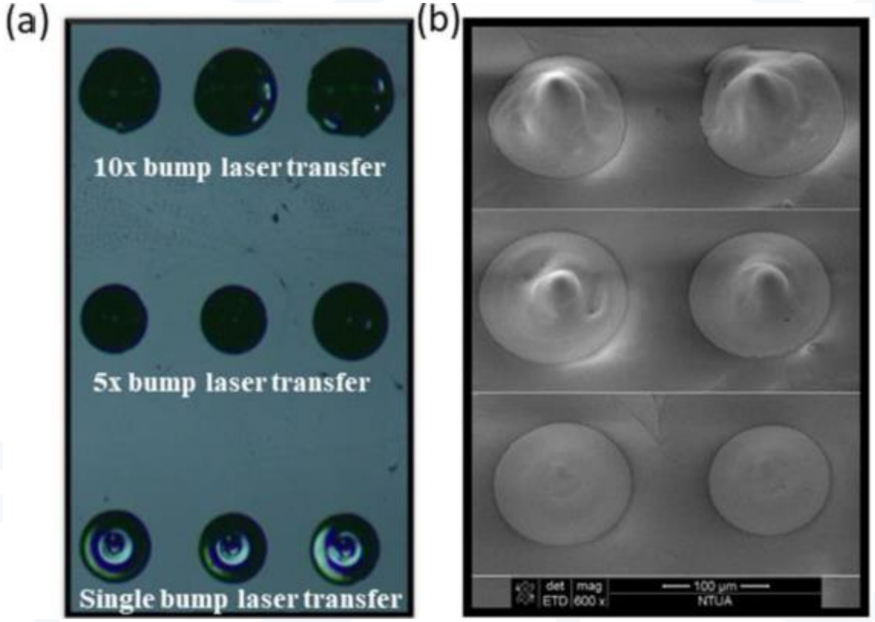
Printing and shaping of solder paste on PCB pads via LIFT



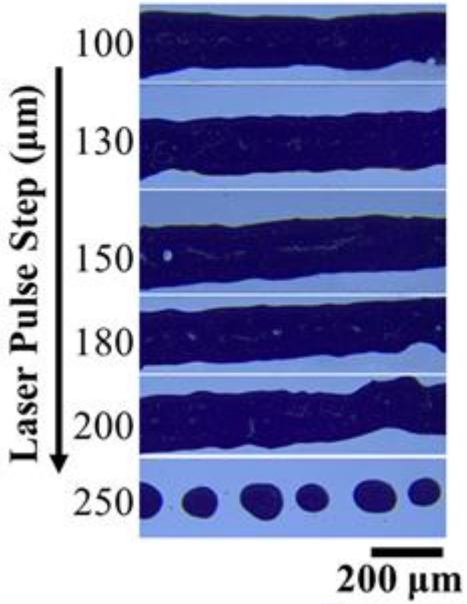
F. Zacharatos, M. Makrygianni and I. Zergioti, / IEEE Journal of Selected Topics in Quantum Electronics, vol. 27, no. 6, pp. 1-8, (2021)

Vertical stacking of Ag paste bumps via LIFT



Eco-Friendly Lead-Free Solder Paste Printing via Laser-Induced Forward Transfer for the Assembly of Ultra-Fine Pitch Electronic Components, M. Makrygianni *et. al*, Materials, 14, 3353, (2021)

Linear patterns of solder paste via LIFT



M. Makrygianni, E. Margariti, K. Andritsos, D. Reppas, F. Zacharatos *et al.* / JLMN, vol. 15, no. 3 (2020)

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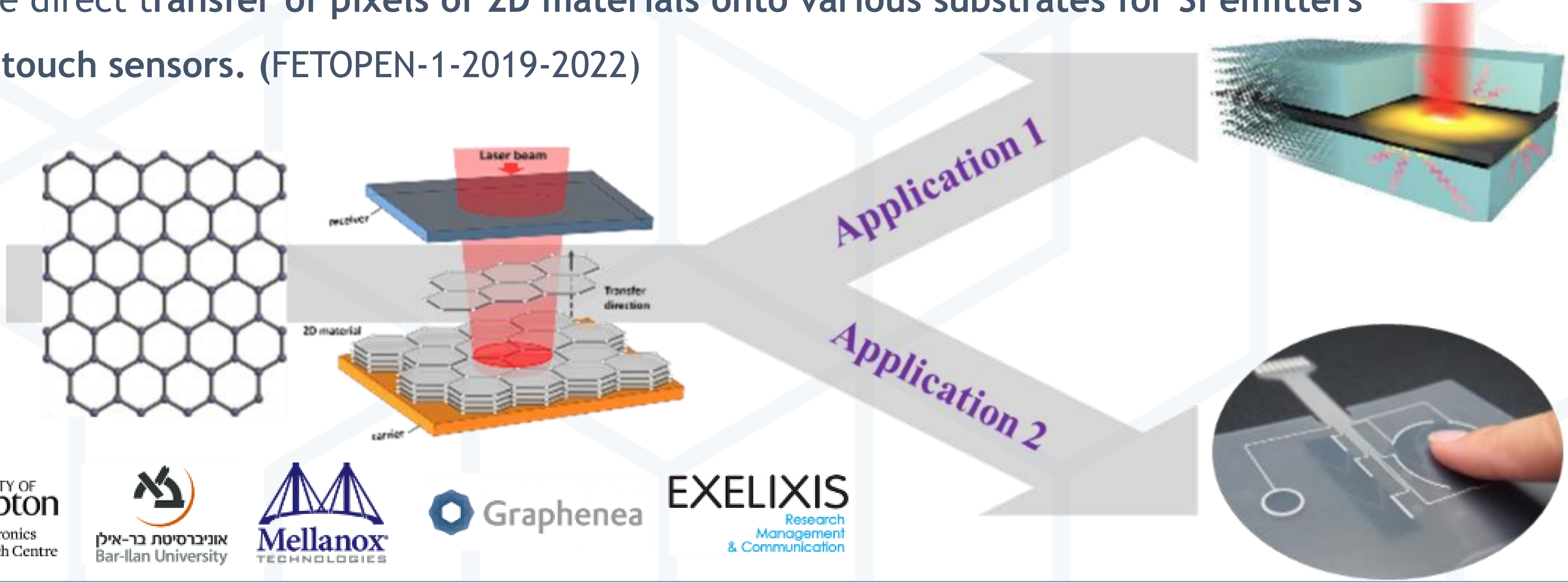
Example IV: Laser EnAbled TransFer of 2D Materials: "LEAF-2D"

Introduction of Laser Direct Transfer processes (LIFT, LIBT) as a novel nano-manufacturing platform for the direct **transfer of pixels of 2D materials onto various substrates for Si emitters and Graphene touch sensors.** (FETOPEN-1-2019-2022)



UNIVERSITY OF Southampton Optoelectronics Research Centre

אוניברסיטת בר-אילן Bar-Ilan University

Mellanox TECHNOLOGIES

Graphenea

EXELIXIS Research Management & Communication

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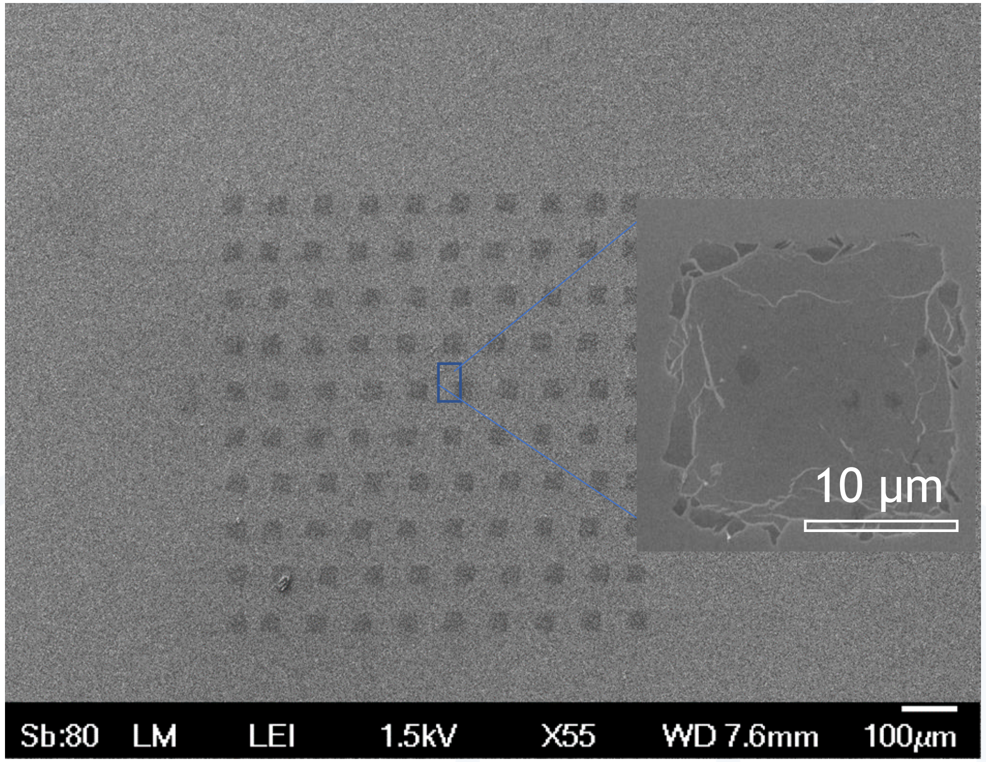
leaf 2D

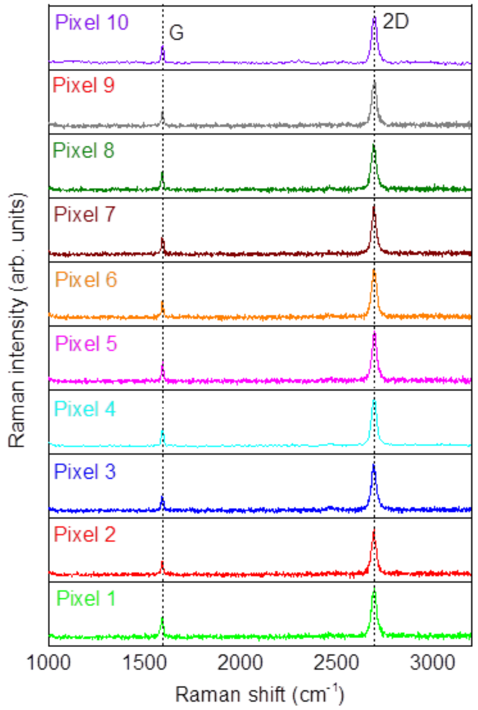
Use case IV: LIFT of single layer graphene pixels

Scanning Electron Microscopy

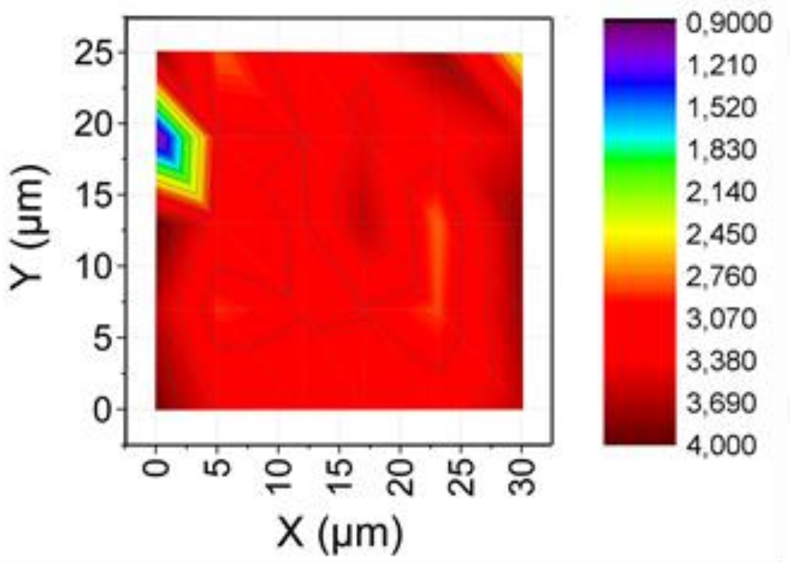


Receiver substrate: SiO_2/Si

Raman spectra of 10 graphene pixels



Raman color mapping of I_{2D}/I_G ratio



I_{2D}/I_G: 3.24±0.57

A direct transfer solution for digital laser printing of CVD graphene", S. Papazoglou *et al.*, in 2D Materials, 8(4), 045017, (2021).

Upscaling example: LASER DIGITAL TRANSFER OF 2D MATERIALS ENABLED PHOTONICS: FROM THE LAB 2 THE FAB "L2D2" - EIC Transition

National Technical University of Athens

Bar-Ilan University

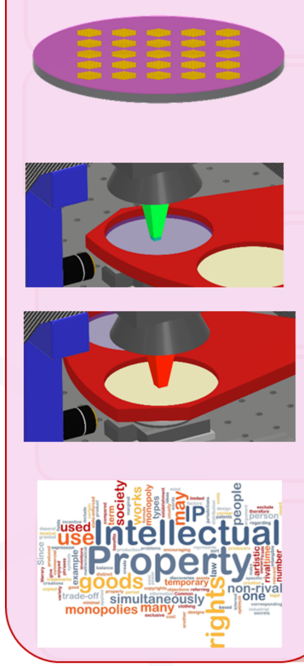
Mellanox Technologies

Graphenea

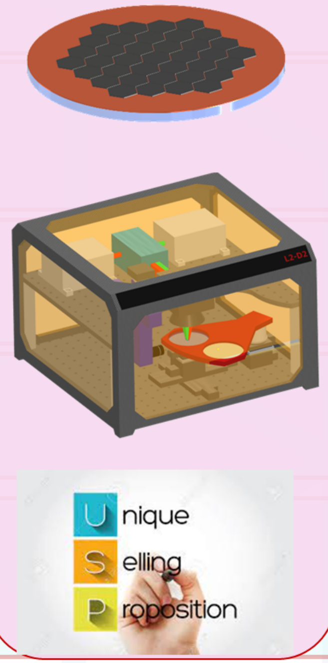
EXELIXIS Research Management & Communication

Within L2D2, we will upscale the laser transfer of intact and pristine Gr and 2D materials pixels in a single step-process, enabling wafer – scale integration and new applications in photonics

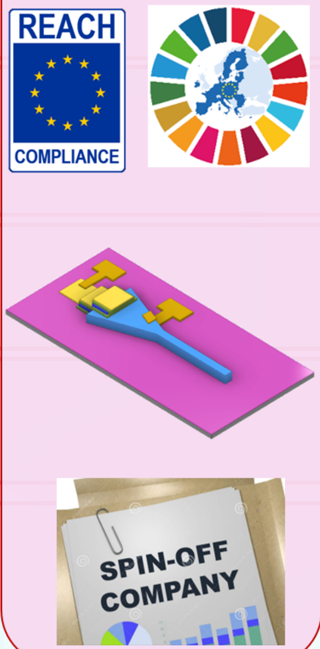
Development



Upscaling-Piloting



TRL6 Validation



Graphene and 2DM
High – quality single layer Graphene, $MoTe_2$, WS_2, grown on 8-inch wafers

LDT Process
Laser Digital Transfer upscaling in terms of throughput and yield for 8-inch wafers processing

LDT printing prototype
An automated printing system implementing the LDT process in pre-industrial setting

Chiplets with integrated emitters
On-chip Si emitters enabled by 2DM

Business case
Securing the IP of the LDT technology
Identify the unique selling proposition
Founding of a spinout

Horizon Europe-EIC-2021-Transition-OPEN-01

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L2D2

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Dr. Filimon Zacharatos
Dr. Marianneza Chatzipetrou
Dr. Chrysa Chandrinou

Prof. D. Tsoukalas
Prod. Y. Raptis
Prof. A. Hatziapostolou

H2020 - FETOPEN-1-2019-2022
Laser-Enabled trAnsFer of 2D materials - "LEAF-2D"

H2020-DT-NMBP-18-2019
Roll-2-Roll and Photolithography post-processed with LAser digital technology for FLEXible photovoltaics and wearable displays- "RoLA-FLEX"

H2020-FOF-13-2017-2019
High Performance Laser-based Additive Manufacturing
"HiperLAM"

Thank you!

Questions?

IndTech 2022

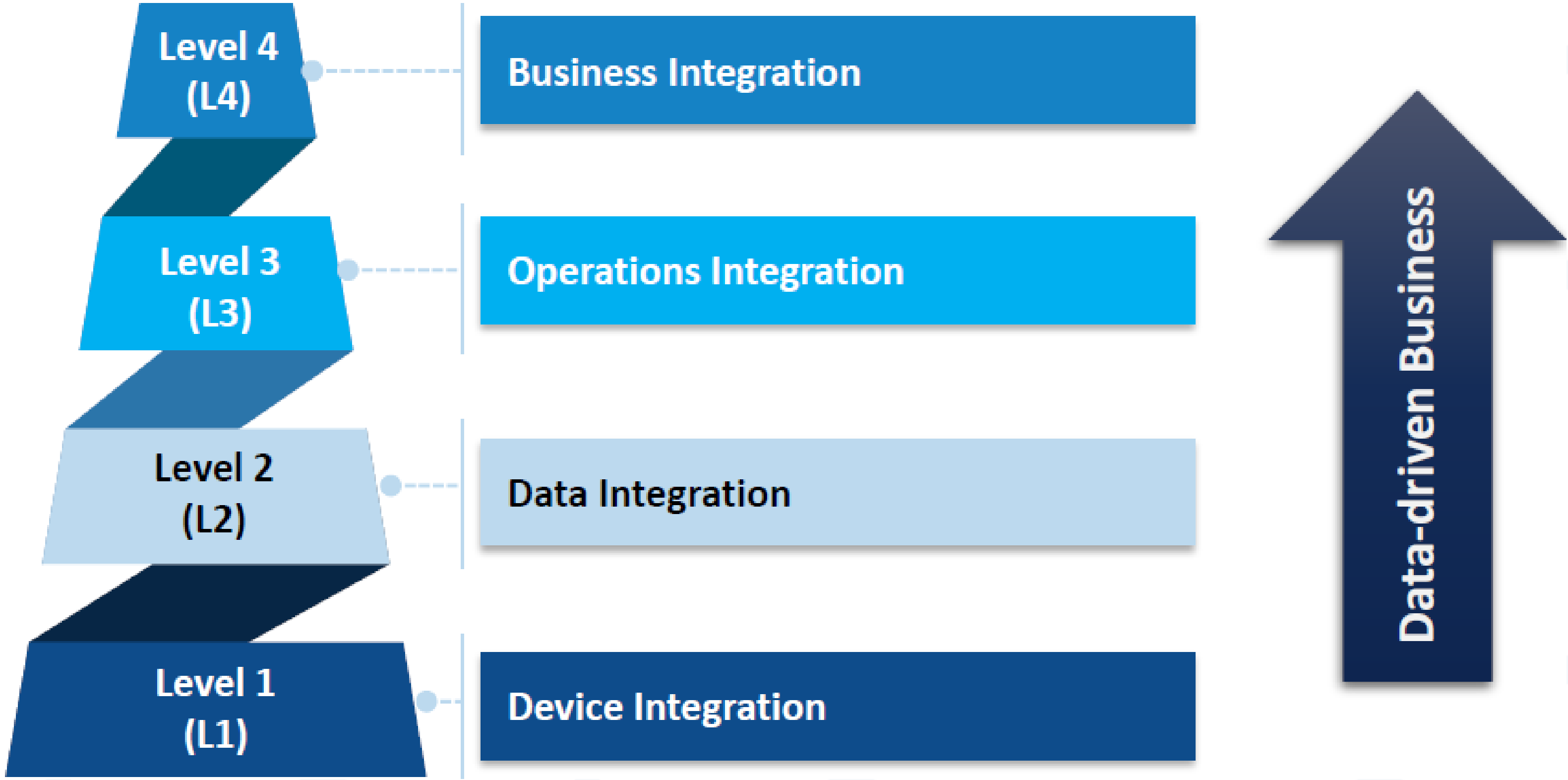
VTT

Digital platforms for green manufacturing

Riikka Virkkunen
Professor of Practice
VTT Technical Research Centre of Finland
June 28, 2022 Grenoble

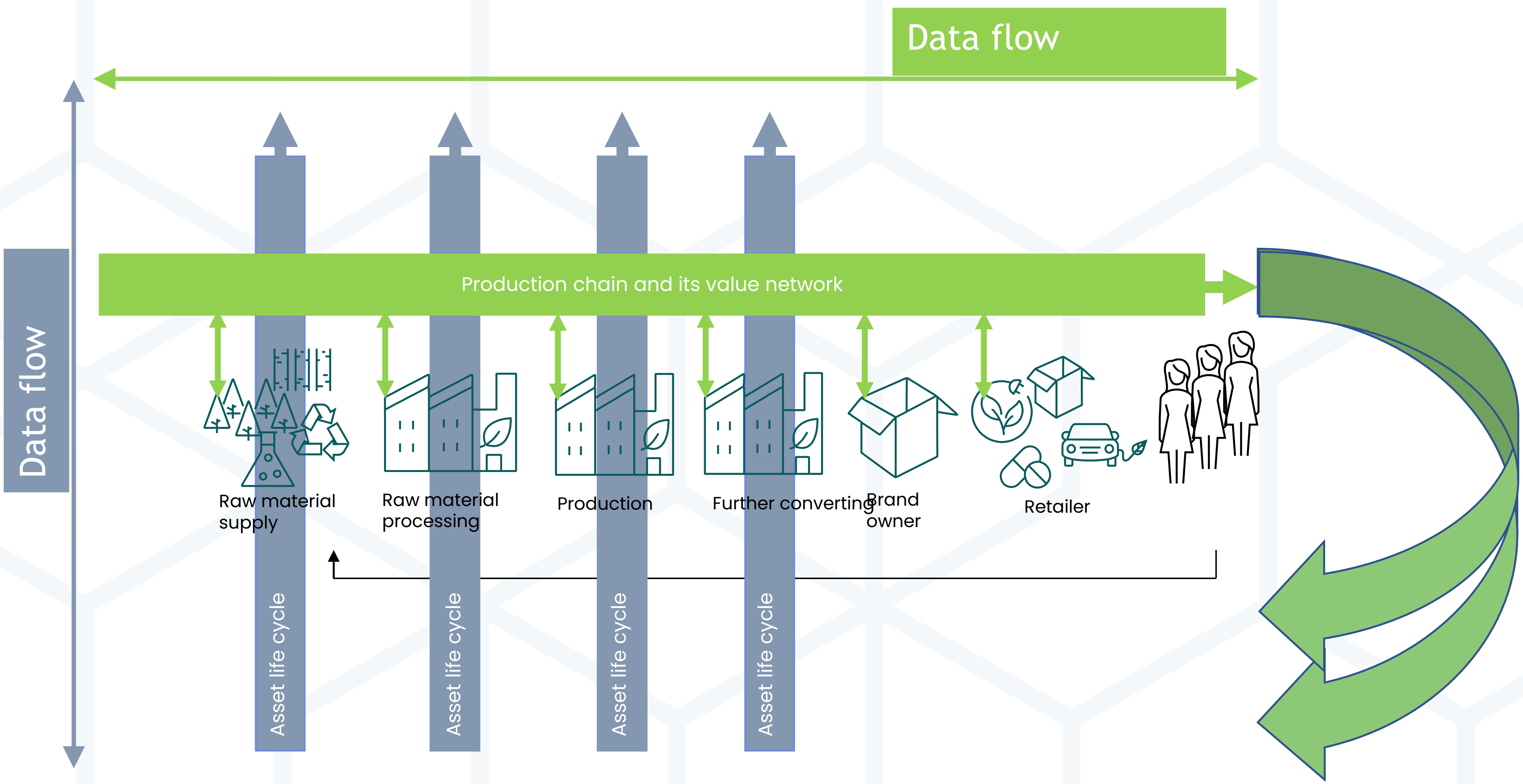
Digital Industrial Platforms

….bridge the physical world with business processes



(Frost, 2022)

Digital Industrial Platforms

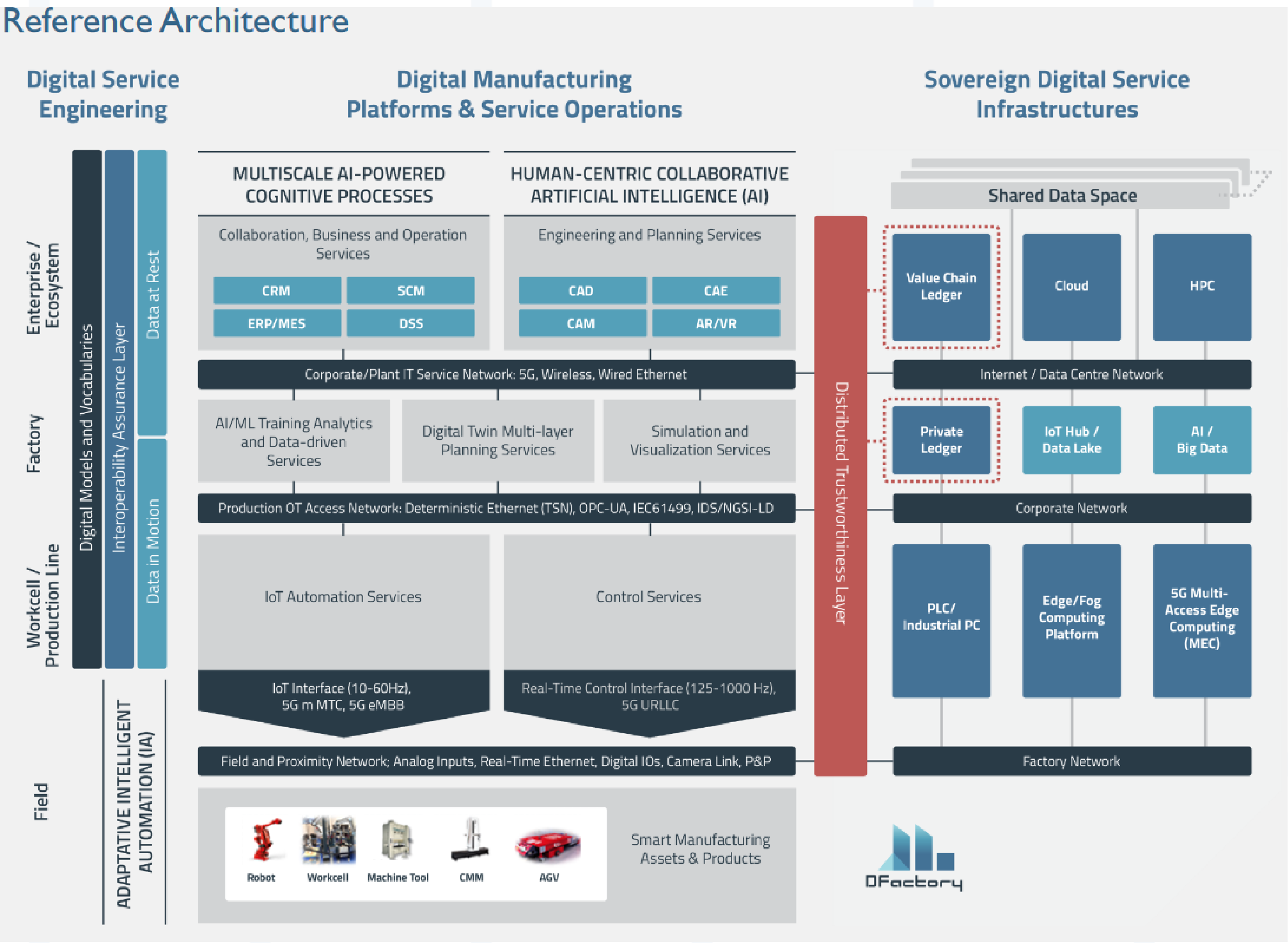


Digital manufacturing platforms

- Digital Manufacturing Platforms project cluster
- Supported by the ConnectedFactories 2 CSA

Example: QU4LITY for zero-defect manufacturing

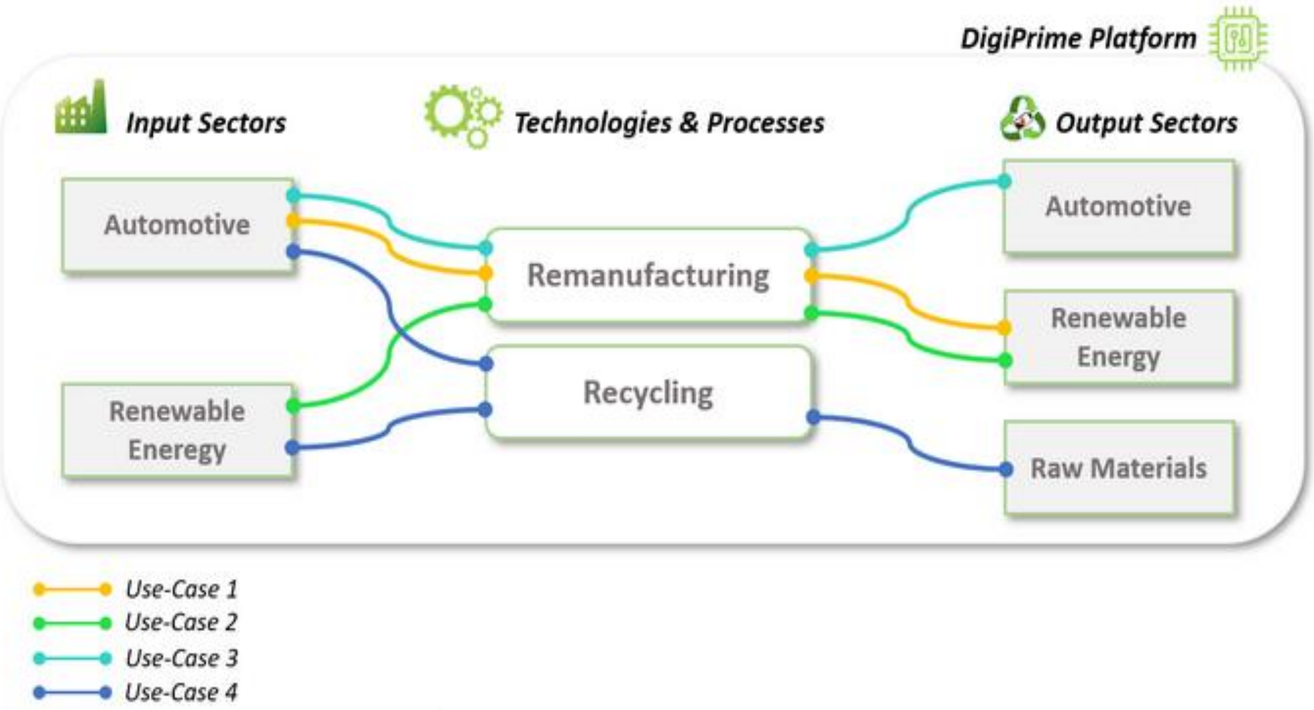
- Shift from state-of-art production quality methods to quality to **disruptive Autonomous Quality**
- Enable manufacturers and solution providers to adopt **Cognitive Manufacturing solutions for Zero-Defect**
- **Digital platform implementations** building on the already ongoing digitalisation efforts



https://qu4lity-project.eu coord. Jorge Rodrigues
Horizon 2020 Framework Programme of the European Union grant No 825030

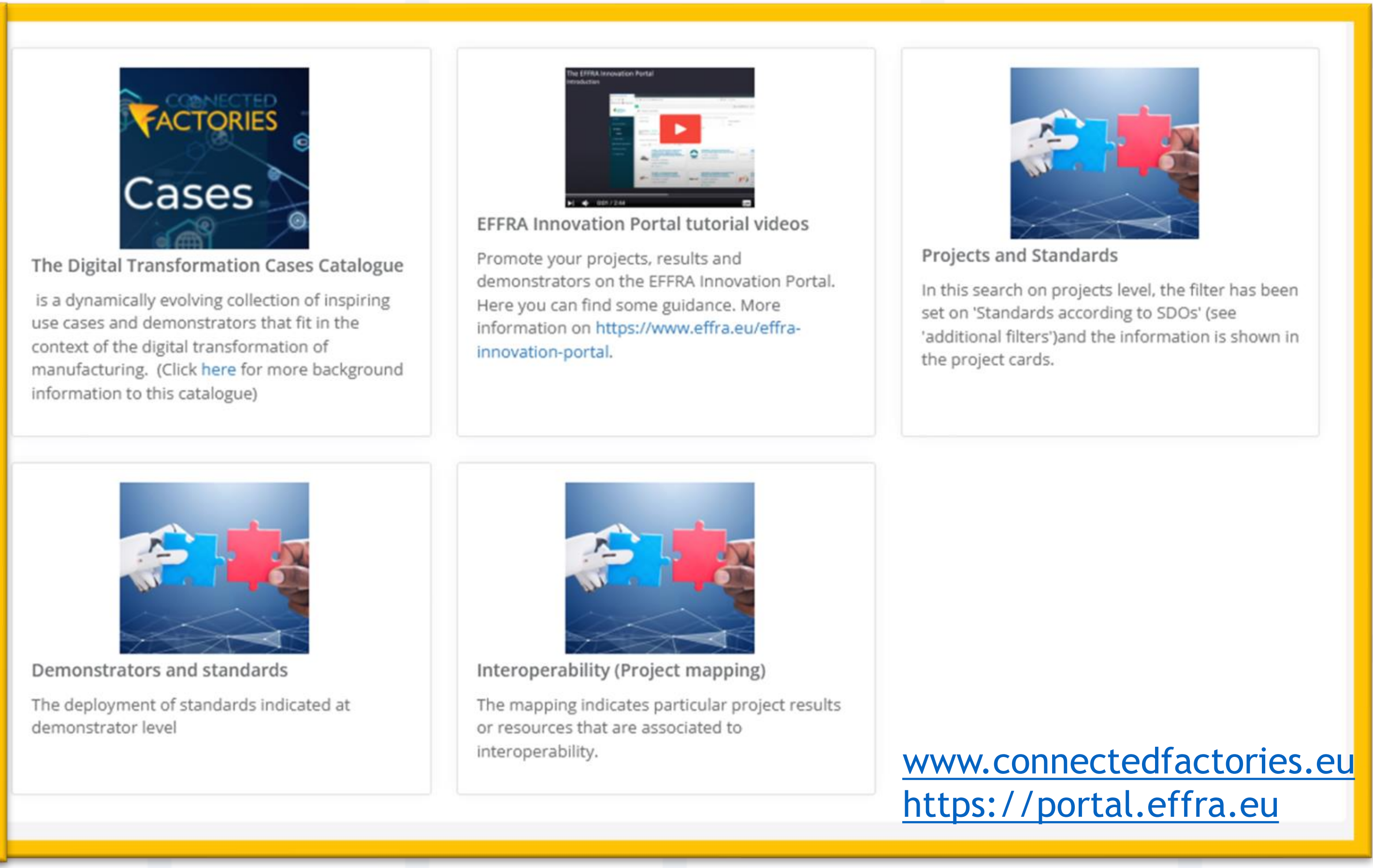
Example: DigiPrime for Digital platform for Circular VCs

- **New cross-sectorial circular value-chains** for remanufacturing / re-use of
- **Example:**
  battery second-life
  in stationary systems:



Funded by the Horizon 2020 (FoF) GA n° 873111
marcello.colledani@polimi.it

Example: Connected Factories - cases in EFFRA portal

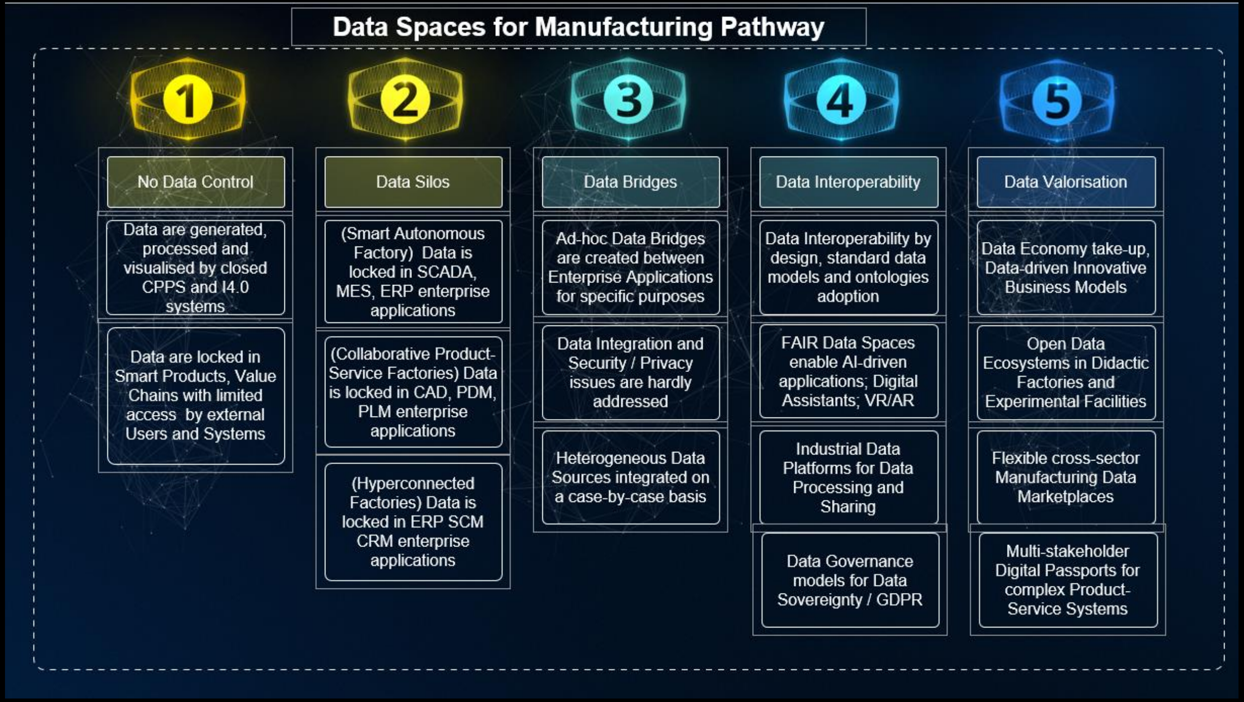


www.connectedfactories.eu
https://portal.effra.eu

Supported by the European Commission through the Factories of the Future PPP
(Grant Agreement Number 873086)

Example: ConnectedFactories Pathways

Data spaces pathway for manufacturing



Circularity pathway for manufacturing

(1) Linearity	(2) Industrial CE Piloting	(3) Systemic Materials Management	(4) Circular Economy Thinking	(5) Ideal circularity
Operations of the company and its value chain meet environmental regulations.	minimise inputs of energy and materials. Materials are shifted from unsustainable to sustainable.	Code of conduct guidelines for circularity and the sustainability of materials launched.	Environmental, social and economic pillars are capitalised	Company and value chains are re-structured for closed/ open (=cross-sectoral) loops (system integration)
CE and sustainability viewpoints are not considered as strategic advantages.	CE piloting activities are planned as part of strengthening the brand image	Multisource product lifecycle data is systematically used for resource efficiency.	LCA or footprints are exploited in collaboration with value chains.	Emphasising positive environmental impacts (in product design and production engineering) Upcycling/upgrading of materials

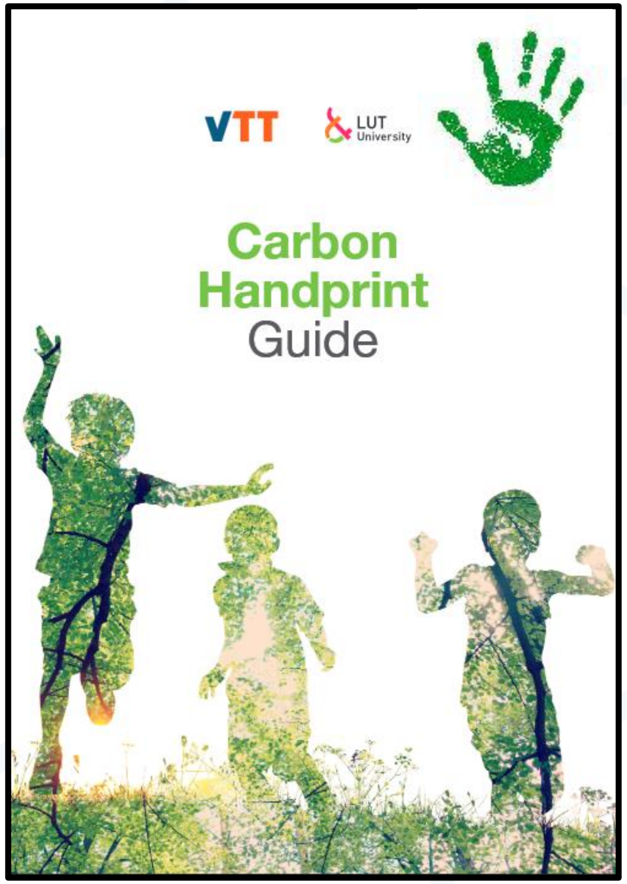
Supported by the European Commission through the Factories of the Future PPP (Grant Agreement Number 873086)

Example: Handprint of manufacturing – a positive indicator

- Ekox Finland Oy remanufactured laptops
- VTT assessed the **environmental handprint** of replacing a typical laptop with a remanufactured laptop
- Savings in primary raw materials and energy
- Handprint to communicate the environmental benefits

69% less minerals and metals
60% less fossils
57% less energy
65% climate change

Ekox Finland



Example: Finnish technology industries low carbon roadmaps

- the road to the implementation of the national 2035 carbon neutrality targets for 14 sectors
- **handprint can be about five times bigger** than industrie's own footprint

https://www.climate2035.fi/roadmaps/technology-industries/

Example: What is the ambition of manufacturing SMEs in 2030?

Based on a survey of 200 Finnish manufacturing SMEs in 2020

Collaboration accross company boundaries enables broad digitalisation

We operate in a network that quickly adapts to customers' personalised needs

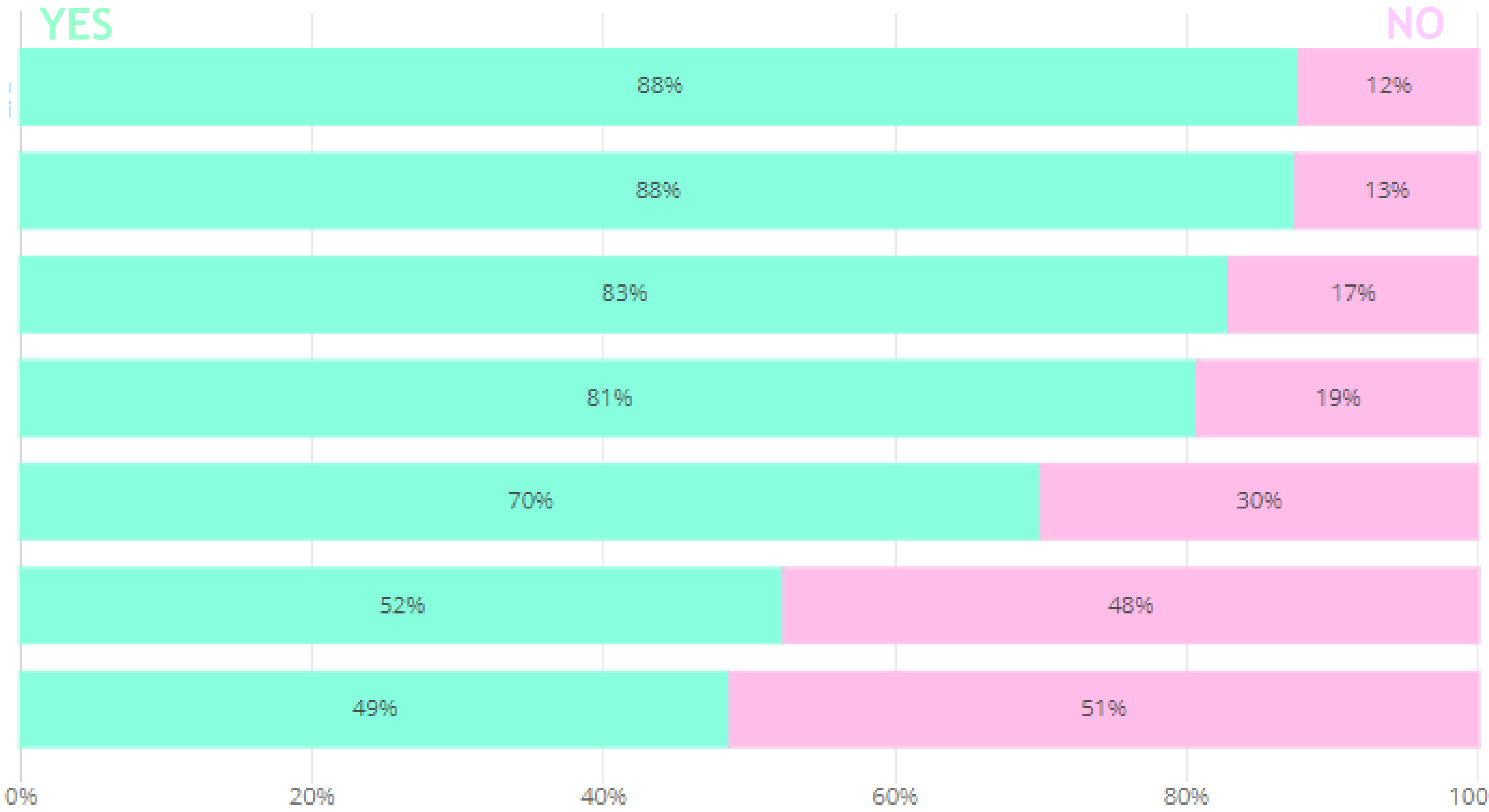
We have invested heavily in digitalisation and digital systems in 2021-30

We have reduced our CO2 footprint

Sustainability offers us a lot of business opportunities

Circularity is an essential part of our business

We use artificial intelligence tech's broadly



Collaboration needed

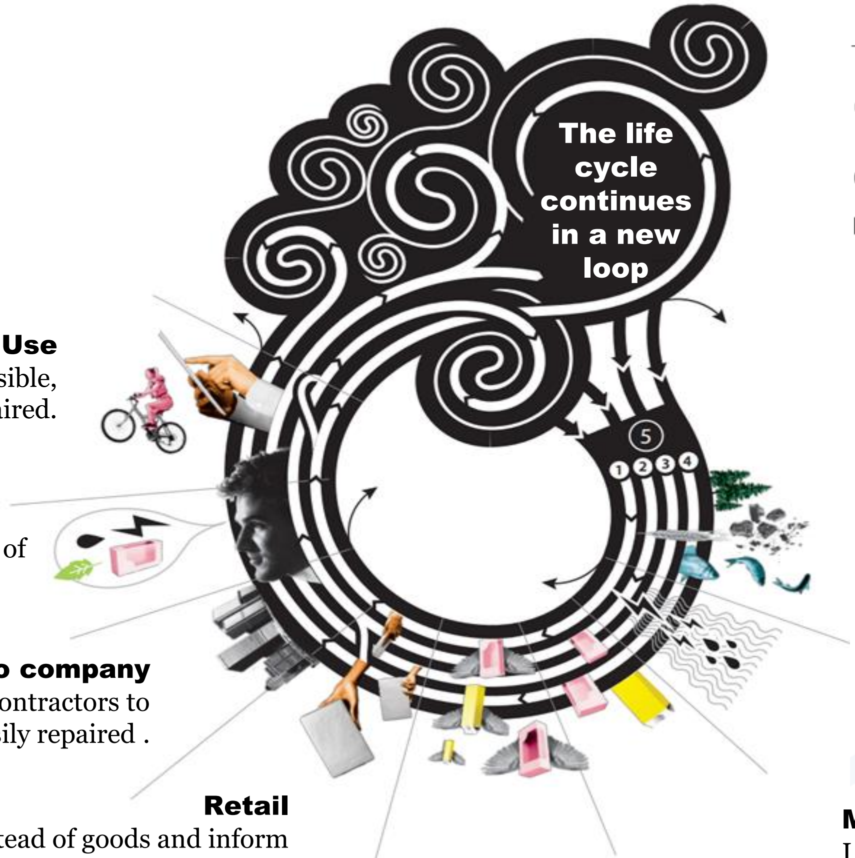
gaia-x

Hub Finland

THIS IS HOW WE CREATE A

Circular economy

IN FINLAND



Use
as long as possible,
must be serviced & repaired.

Consumer
demand creates a supply of sustainable solutions

From company to company
Companies require subcontractors to provide parts that can be easily repaired .

Retail
sells services instead of goods and inform environmental impacts, materials and further use in the final phase of LC.

Distribution
co-ordinated between sectors, renewable fuels and jointly owned transport equipment in use

Primary sector
Raw materials are capital for primary sector. Sustainable solutions based on wise use of raw materials.

Material processing
planning reduces energy needed to refine raw materials.
The use of side streams.

Manufacturing industry
Long-term products that can be repaired and maintained.
Materials separated at the end of LC.

https://www.sitra.fi/en/events/gaia-x-finland-domain-working-groups/
paivi.kivikyto-reponen@vtt.fi

Summary

- Green manufacturing relies on data sharing in value chains
- Innovative examples inspire
- Business opportunity
- Manufacturing for big handprint
- Collaboration needed

Thank you!
@VirkkunenRiikka

Advanced Digital Manufacturing: Summary

- **Industry 4.0** is an important enabler and thus **"the right framework"** to achieve Europe's 2030 goals as set e.g. in the New Green Deal
- **Great savings** potential **through digitization** - especially in energy consumption
- **Digital business models** are influenced by changing value proposition
- Sustainable digital business means cooperating and operating in **circular economic systems**.
- **Laser** is a technology offering great advantages for Industry 4.0
- There is a need for
    - **sustainable, flexible and zero-defect processes**
    - **intelligent machines** that are connected, autonomous, reconfigurable and flexible
    - **smart products** that are more interactive, make intelligent decisions, cooperate with humans, machines, sensors, etc
- **Green manufacturing** and holistic sustainability development **need data sharing**
- Positive **sustainability indicators** to communicate and plan
- **Innovative examples**, such as those in **Horizon 2020** projects, inspire
- **Circular Economy** is a new business opportunity.


High-Performance Manufacturing Systems
High Productivity
High Quality
High Efficiency
High Flexibility
High Resilience
Distributed knowledge based intelligence
in real time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