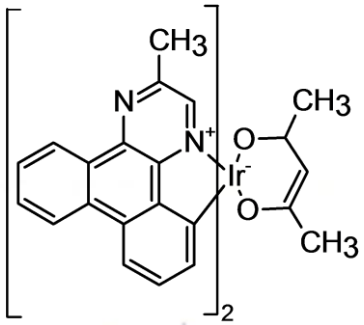
Warum ist organische, gedruckte oder flexible Elektronik grün?

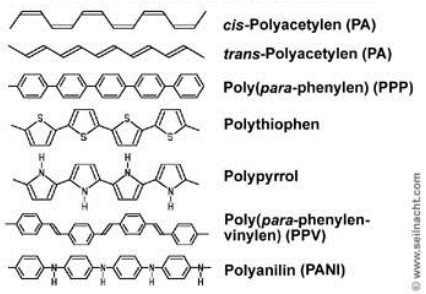
Präsentation von Dominik Gronarz, OES zum Energy Talk

Was ist organische, flexible, gedruckte Elektronik?

Materialien

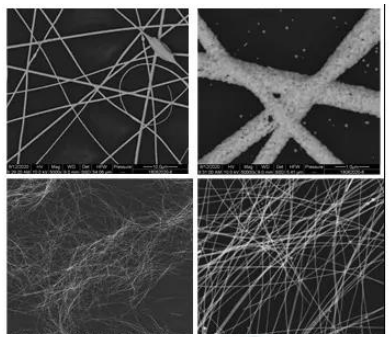


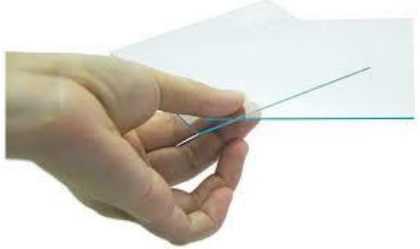
(halb)leitende Kohlenwasserstoff - verbindungen (small molecules)



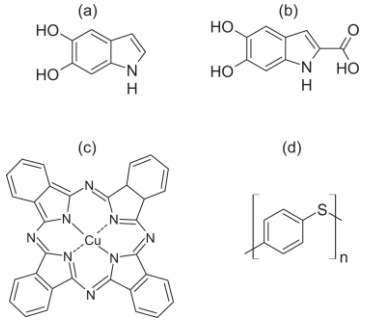
(halb)leitende Kohlenwasserstoff - verbindungen (Polymere)

leitfähige Tinten und Pasten mit “gelösten” Metallen (Au, Cu, Ag, Pt, …)





leitfähige dünne Schichten aus Metall oder anderen Materialien (z.B. ITO)

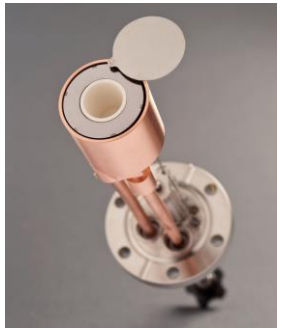


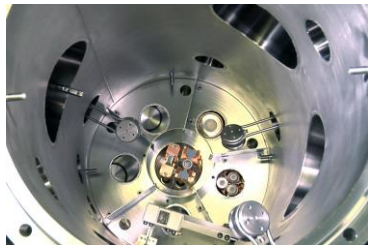
bio-kompatible / bio-degradierbare / bio-inspirierte leitfähige Materialien

Was ist organische, flexible, gedruckte Elektronik?

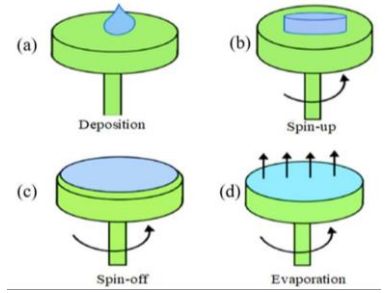
Prozesse

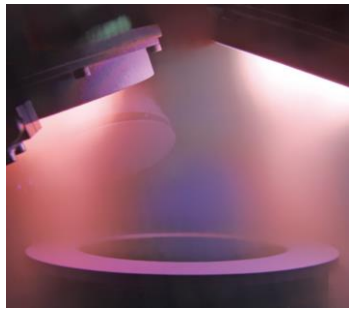
Drucken
Tintenstrahl /
Siebdruck, etc.



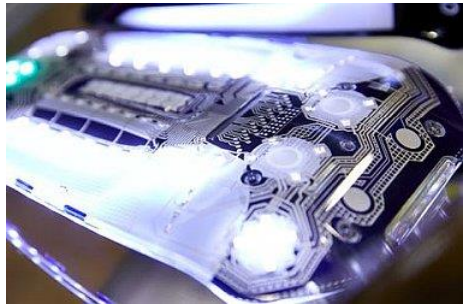


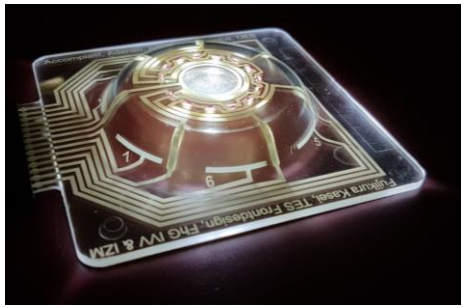
Vakuum-
verdampfung



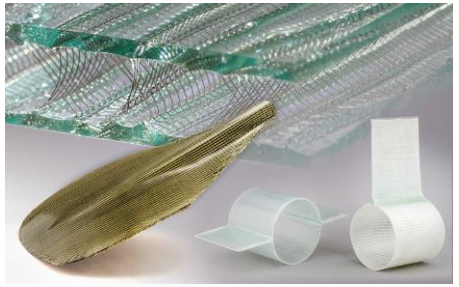


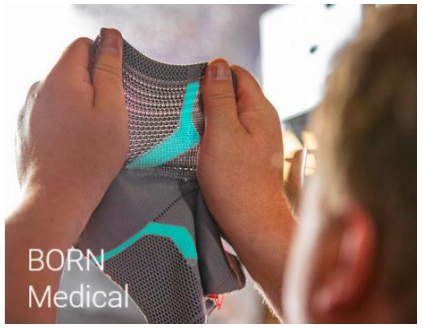
Spin-Coating,
Sputtern





3D-Elektronik
Verformung



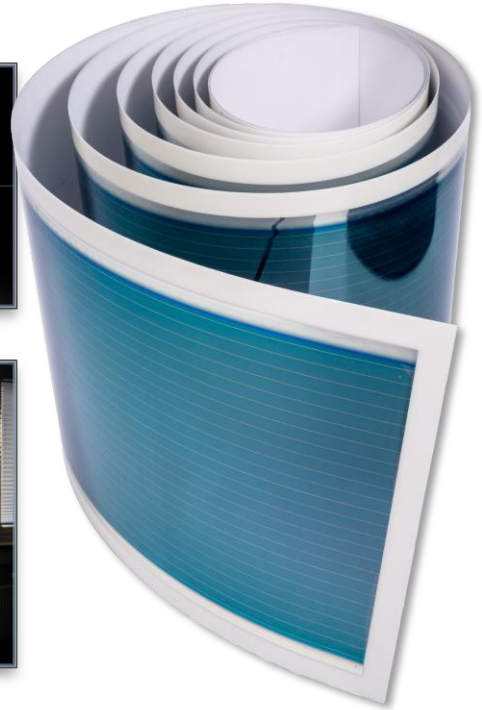


Textile Elektronik

Was ist organische, flexible, gedruckte Elektronik?

Anwendungen

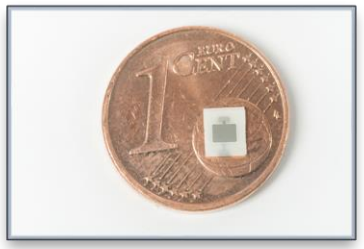
OLED



Solarzellen

Displays

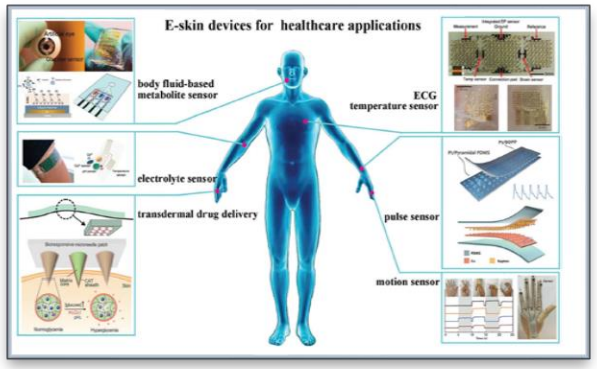
Sensoren



Batterien

Was ist organische, flexible, gedruckte Elektronik?

Zielmärkte



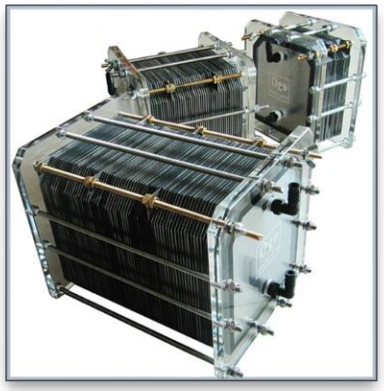
Medizin / -technik

Automobil / Verkehr

Solar und Speicher

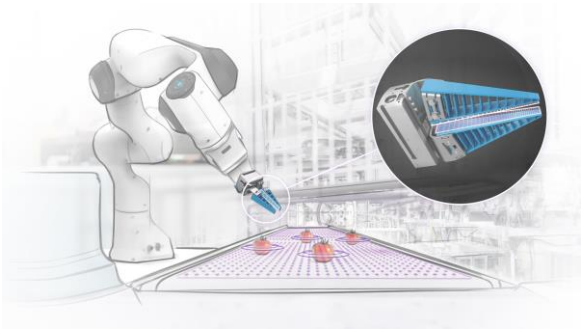
Textil

Logistic / Verpackung



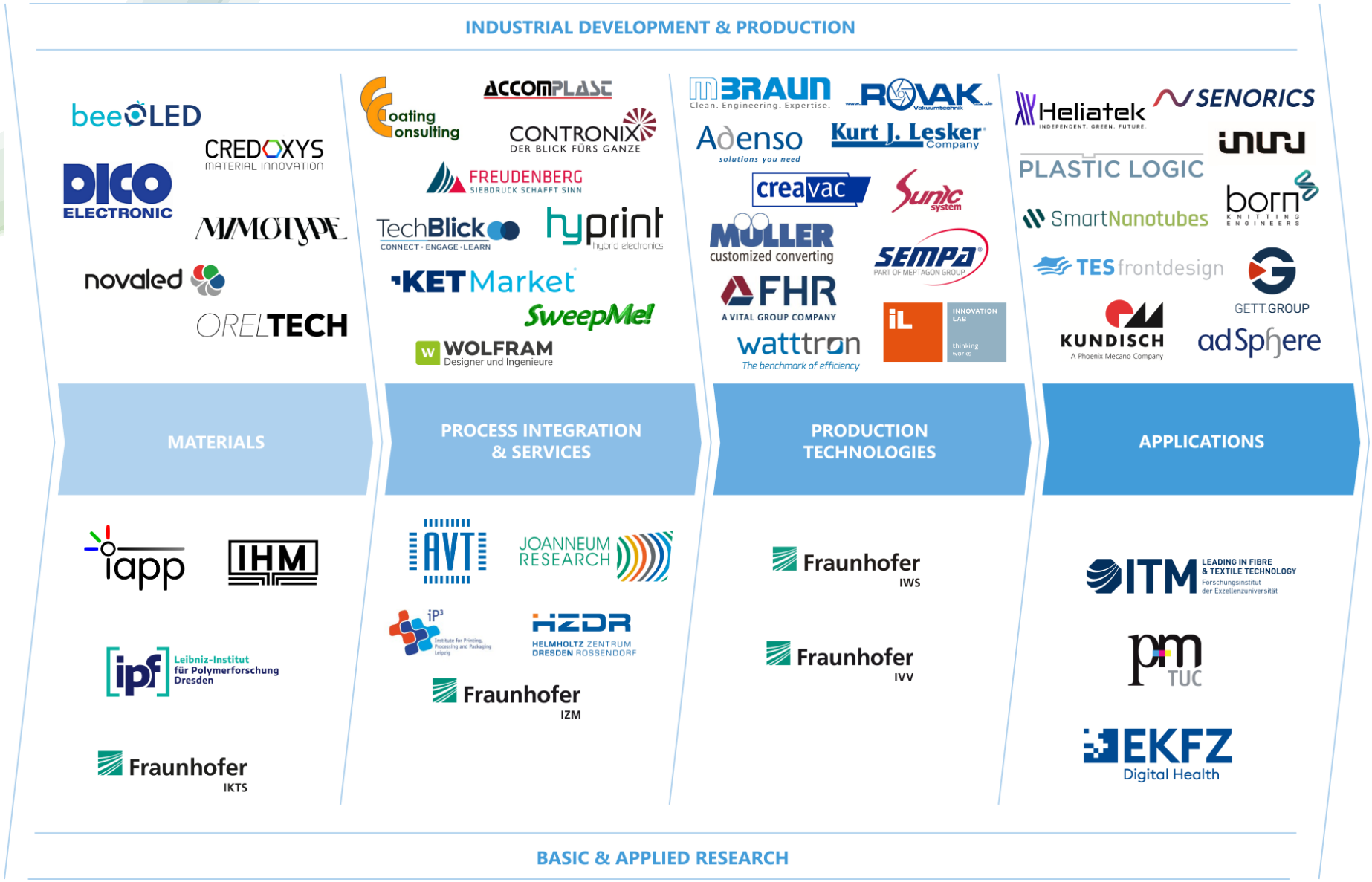
Energie / H_2

Agrar / Lebensmittel



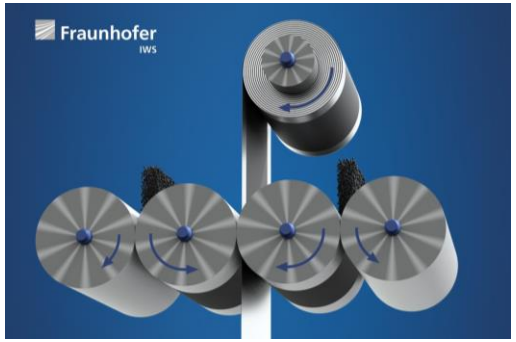
Robotik

OES - Wertschöpfungskette

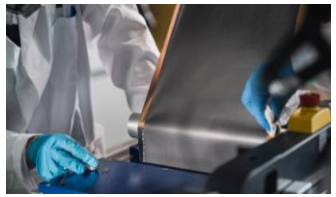


Battery Technology

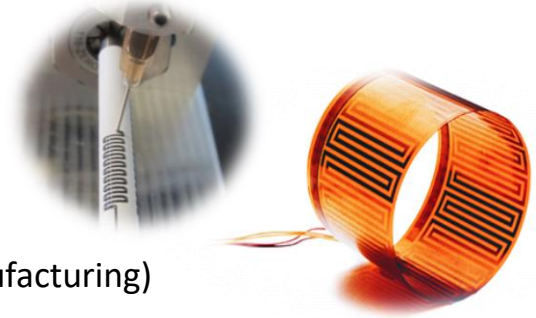
- Solvent-free DRYtraec® electrode coating process
- Reduced process costs + low equipment footprint
- Applicable to LIB and next generation batteries



ABTC
Advanced Battery Technology Center



Printing of Electronic Structures



- Design and substrate flexibility
- Dispense printed structures
- direct printing of components using novel materials and systems technology (Additive Manufacturing)

Reactive Multilayers and Carbon Coatings

- Extremely wear resistent and low friction Diamor® ta-C carbon coatings
- Low-stress, fast and material-friendly direct joining of metals, polymers, semiconductors using reactive multilayer systems (RMS)

Laser Precision Processing

- Direct Laser Interference Pattering of large surface areas
- Surface texturing of polymers, metals, ceramics
- Laser-based cleaning and coating removal

Optical Metrology

- Optical inspection technology (HSI, OCT, laser diode spectroscopy)
- Application Center for Optical Metrology and Surface Technologies (AZOM) in collaboration with WHZ Zwickau

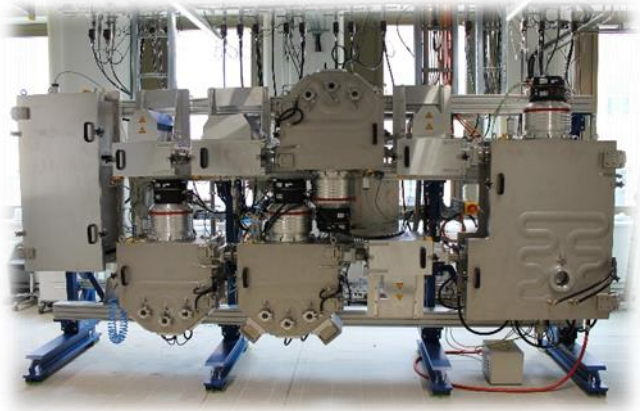
www.iws.fraunhofer.de

Flash lamp annealing systems for R&D and production

R2R - atmospheric pressure

vacuum integration

R2R - vacuum



Process integration

- Small footprint
- High throughput
- High flexibility

Advantages

- Short process time
- <u>No cooling needed</u>
- <u>Low energy consumption</u>

- Non equilibrium processing
- Temperature sensitive substrates

www.rovak.de

Adolf Müller GmbH &Co KG

- Sondermaschinenbau von Rollenschneid- und Wickelmaschinen.
- Nutzung von Rückgespeister Bremsenergie und Antriebe mit hohem Wirkungsgrad.
- Minimierung von Materialausschuss.
- Einsatz von biologisch abbaubaren Folien in der Folienveredlung.
- Konfektionierung und Lamination von empfindlichen und selbstklebenden Folien.

www.mueller-machines.com

Funktionalisierung von vormals passiven Bauteilen in Leitungssystemen oder Verbindungsstellen innerhalb von Anlagen

- Erfassung von Alterungs- und Betriebszuständen (Druck, Temperatur, Feuchte, Leckage)
- Sensorische Zugänge für Onlinemonitoring
- Multisensorsysteme zur Entkopplung von Prozess, Material und Temperaturvariationen

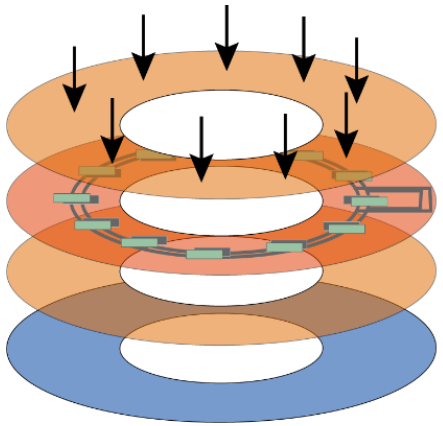
Industrielle drucktechnische Ansätze erlauben kostengünstigen Zugang zu Prozessgrößen

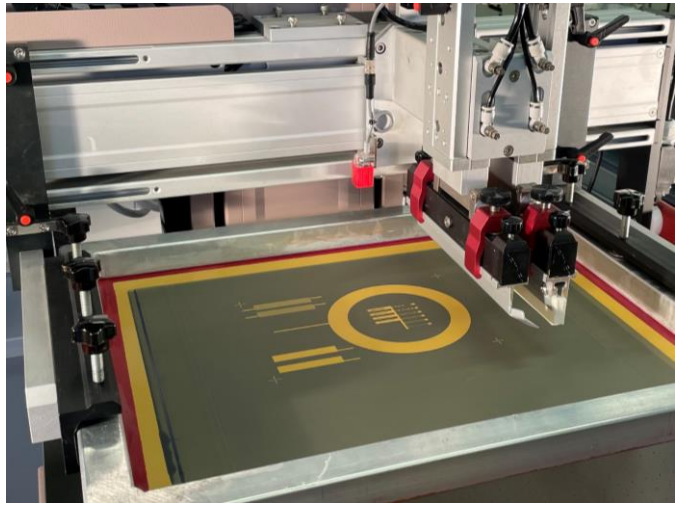
→ Digitalisierung von Anlagen ohne Umbau (zusätzliche Sensorschicht << 1 mm)

→ Preventive Maintenance (reduzierte downtime)

→ Realistische Wartungsszenarien → Kosten- und Resourcenreduktion

Beispielkonzept für funktionalisierte Dichtungen





ip3.htwk-leipzig.de

iP³ Leipzig
Institute for Printing, Processing and Packaging Leipzig

SEMPA SYSTEMS GmbH – Barrieremessung mit HiBarSens 3.0®

HERAUSFORDERUNG

Die Barrieremessung von Verkapselungsmaterialien hat eine besondere Bedeutung im Bereich der Organischen Leuchtdioden (OLEDs), da diese sehr sensibel auf Umwelteinflüsse reagieren. Insbesondere der Kontakt mit Feuchtigkeit und Sauerstoff führt zur Degradation. Für die Funktionsfähigkeit und Langlebigkeit der Produkte ist die genaue Beurteilung des Verkapselungsmaterials essentiell.

LÖSUNG

SEMPA entwickelte auf Basis eines Patents des Fraunhofer-Instituts für Werkstoff- und Strahltechnik das **Permeationsmessgerät HiBarSens 3.0®**:

- Bestimmung von WVTR und OTR einer Probe in nur einem Arbeitsgang
- Höchste Genauigkeit bei der Bestimmung der Nachweisgrenze WVTR $< 10^{-6}$ g[H_2O] m^{-2} d^{-1}
- Kürzere Messzeiten, niedrigere Investitionskosten, geringerer Platzbedarf, minimaler Handlingsaufwand und somit eine Minderung der Betriebskosten

ANWENDUNG

HiBarSens 3.0® dient der Qualitätssicherung insbesondere in den Bereichen Solar, Beleuchtung und Sensorik.

Ansprechpartner: Johannes Grübler|gruebler@sempa.de

sempa.de

GETT Gerätetechnik GmbH

Kompetenz

25 Jahre Expertise in Entwicklung, Sourcing und Fertigung von HMI - komponenten und –systemen

Technologien

CNC-Bearbeitung

Laser-/Gravur-Technik

Opt. Bonden (Reinraum)

Sieb- und Digitaldruck

Montage und Qualitätskontrolle

Nachhaltigkeit

Fokus auf Entwicklung und Produktion langlebiger und reparierbarer Produkte

Breites Portfolio von Retrofitlösungen für das Energiemanagement und den optimierten Einsatz von Ressourcen

GETT.GERMANY
Treuen • Deutschland
Headquarter & Fertigung

GETT.ASIA
Hongkong • Hongkong
Management, Sales & Marketing

Shenzhen • China
Fertigung

GETT.AMERICA
Houston • USA
Management & Sales

Über 900 zufriedene Kunden - mit >10.000 abgeschlossenen Projekten – in mehr als 38 Ländern

GETT.DE | GETT-GROUP.COM

ORELTECH

OTADVANTAGES

Metallization challenges

Precious metals wasted in subtractive processes

Impure metal layers from residues (e.g. polymers)

Restricted substrate choice due to **high** processing **temperatures**

High **energy cost** from vacuum and heat-based processes

Clogging of print heads

Harsh and **toxic chemicals**

High capex e.g. for PVD

and several more …

OrelTech advantages

Particle-free
Superior printability
Energy-saving to produce

Low temperature curing
Unlimited choice of substrates
Save 95% of curing energy[1]

Pure metal layers
No organic traces
Flexible and conductive

Process economy
Low investment
Low running cost

Green product
Non-toxic chemicals
Energy efficient
Waste free

Versatile
Many ways to apply the liquids
Bespoke layers are OrelTech's standard

1) OTech Jet silver ink cured in argon plasma compared to common heat-cured silver inks.

orelteck.com

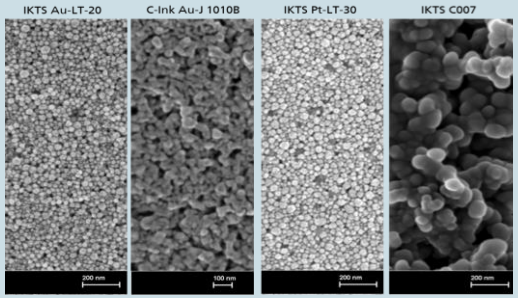
beeOLED GmbH

- We want to solve the last big problem of **OLED-Displays**: an **efficient and stable blue emitter**.
- We invented a new approach: organic shell **stabilized inter-metallic emitters.**
- **Business Model**: selling this specialty chemicals to display makers.
- Energetically it's worth it: **TV consumes about 1,5%** of electricity generated world-wide.
- Founded and managed by **OLED veterans** (Carsten Rothe, Volodymyr Senkovskyy, Jan Blochwitz-Nimoth)
- **Venture Capital** financed
- About 25 people (end 2023): chemist, physicist, engineers
- On the long run also want to look into non-OLED applications: infrared emission, battery materials, life science materials.
- **www.beeOLED.com**

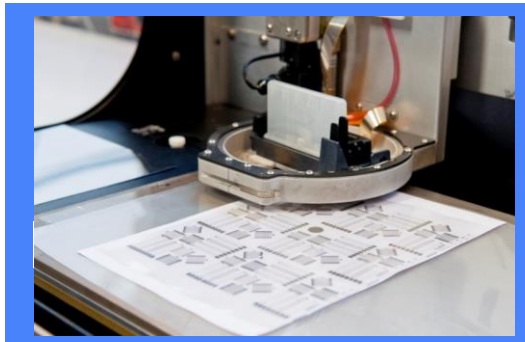
Fraunhofer IKTS

Fraunhofer Institute for Ceramic Technologies and Systems IKTS

From inks to components @ IKTS

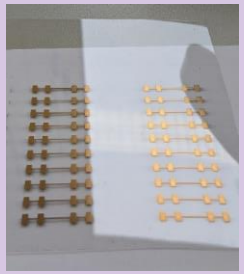


Particle synthesis & ink manufacturing

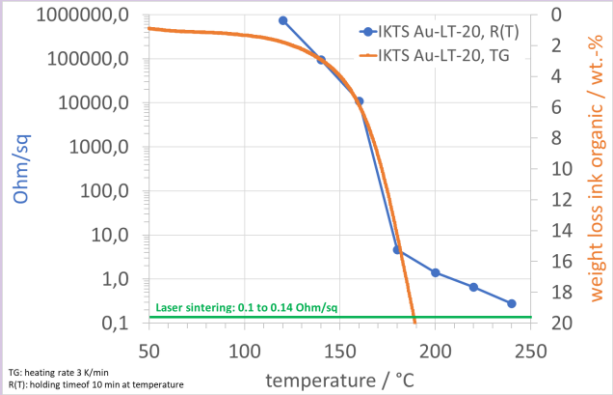


Multi Layout Printing using inkjet

Laser-sintering of inkjet layers



High quality components



Customized material development by synthesis of nano particles or commercial powders

Ink recycling

Low ink/material consumption by using inkjet printing

Direct printing of individual layouts

High speed sintering even on polymer substrates using laser (milliseconds): fast and cost efficient

Material and time saving developments with low material and energy consumption

Materials, inks and components for medical devices, sensors, biomedical platforms, electronics, fuel cells and electrolysis, batteries,…

www.ikts.fraunhofer.de

Early Warning System Li-ion Battery Fires:
SmartNanotubes' Smell Technology Detects Outgassing Events

SMART MOBILITY

Li-Ion Battery safety

- **Charging appliances**
- E-mobility: EV, e-bikes
- Cargo ships / containers

SmartNanotubes SMELL Sensors*

New proprietary material

Scalable inkjet printing

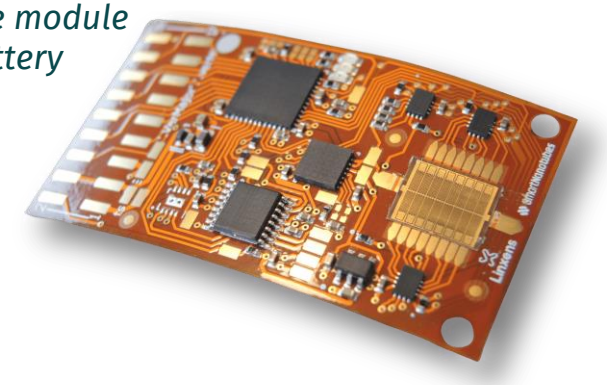
AI based software

- ✓ **highly sensitive**
- ✓ **energy-efficient**
- ✓ **compact and lightweight**
- ✓ **low cost**

**featured in IDTechEx report on gas sensors in 2022*

smell.Flex

Prototype module Li-Ion battery safety



- ✓ **Carbon nanotube sensor array** transmits smell signal pattern
- ✓ **Smell recognition** via **on board AI** software
- ✓ **embedded module** for **integration** in various devices and platforms
- ✓ **IoT** compatible
- ✓ **Flexible electronics**, further miniaturization ongoing for use in battery blocks
- ✓ **Scalable production** of nanotubes and sensors

smart-nanotubes.com

SENORICS' SENSOR: A SUSTAINABLE CHOICE

Senorics' novel sensor solution for Material Sensing is based on near-infrared (NIR) spectroscopy and uses organic electronics.

About state-of-the-art NIR sensors:

- Standard NIR sensor technology is expensive and mostly limited to laboratories and scientific studies
- Used materials like indium, gallium, arsenide or lead are toxic and carcinogenic and not compatible with consumer-centered mass markets

Senorics addresses consumer mass markets and benefits from green USPs of organic electronics technology:

- energy-efficient production
- used organic electronic materials are non-toxic, occur in abundance and are procured from ethical sources
- 90% of the used materials are sourced from German producers which ensures short procurement routes and avoids unnecessary imports

More information: www.senorics.com and blog.senorics.com

Eco-sustainable printed magnetic field sensors

Biodegradable & Biocompatible magnetoelectronics

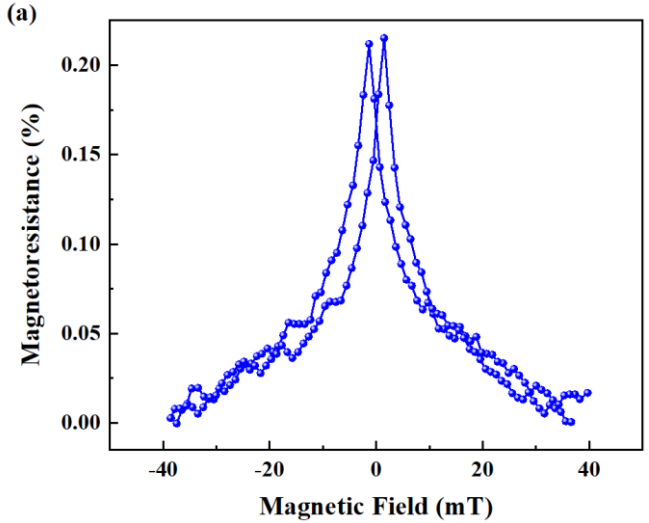
Starch

www.owlting.com

Printed sensor

Iron particles

blog.coolhealth.com



www.storm.mg

Conventional magnetoelectronics is based on Co- and Ni-containing materials, which are toxic

Printing (i.e., solution processable sensors) is the key enabler of eco-sustainable magnetic field sensors based on Fe

HZDR realised the world's first eco-sustainable magnetic field sensor

PyzoFlex®

Smart Mobility

seat occupancy, hands-on detection, energy harvesting, smart sensing interior

Industry 4.0

predictive maintenance, condition monitoring, structural health analysis, acoustic event detection

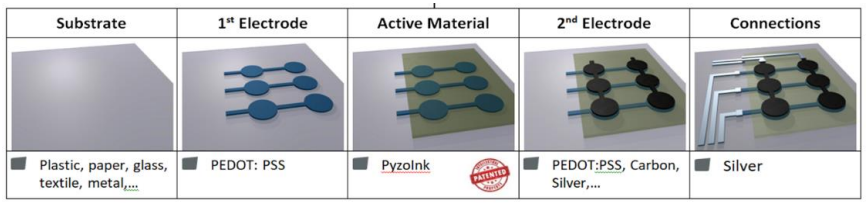
Smart City Smart Living

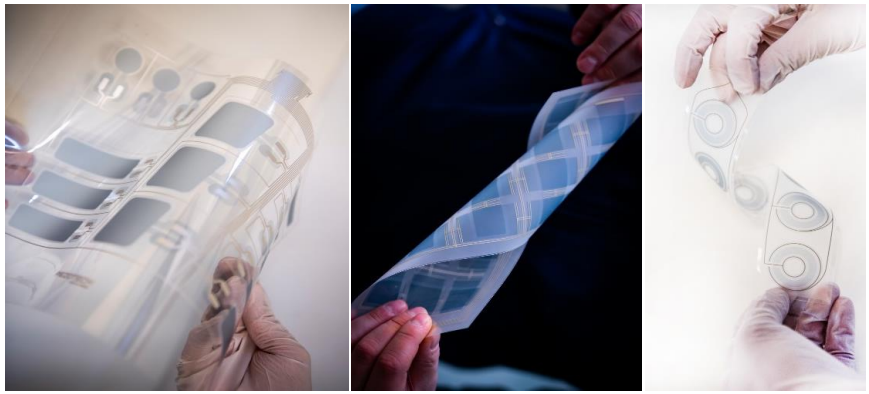
building control, energy- and security management, smart lighting for public and private spaces

JOANNEUM RESEARCH MATERIALS

www.joanneum.at
www.pyzoflex.com

- Sensors based on printed electro active polymers (eap) – for changes in pressure, temperature, vibration; **and energy harvesting** feasible
- Fuss-free production (various substrates as PET; TPU etc., and inks) & adaption to the respective use-case
- Various surfaces and constructions – can be integrated onto/into form parts, textiles, floors, wood and many others – equipping standard-components with sensory functions
- Piezoelectric energy converters can use almost omnipresent existing vibrations and deformations to generate energy (Replacement of PZT compounds by printed P(VDF-TrFE) decrease of lead waste by 100%).
- No structural elements and movable components needed
- Energy-efficient and scalable printing processes offer significant cost reductions and energy savings as compared to high-temperature processes needed in manufacture of piezoceramics (Compare low temperature printing vs. high temperature fabrication ≥ 90% decrease on energy input per mW harvesting power).

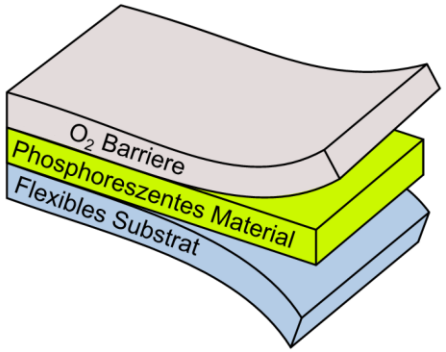


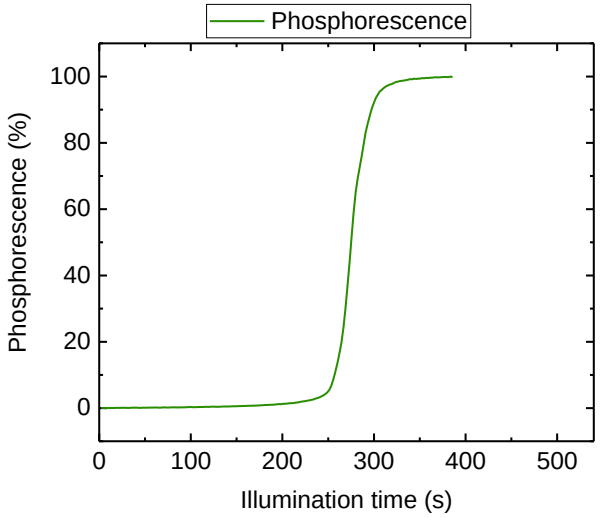


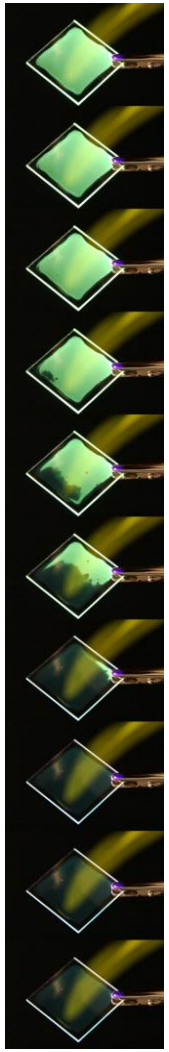
No Power Supply for Sensor required

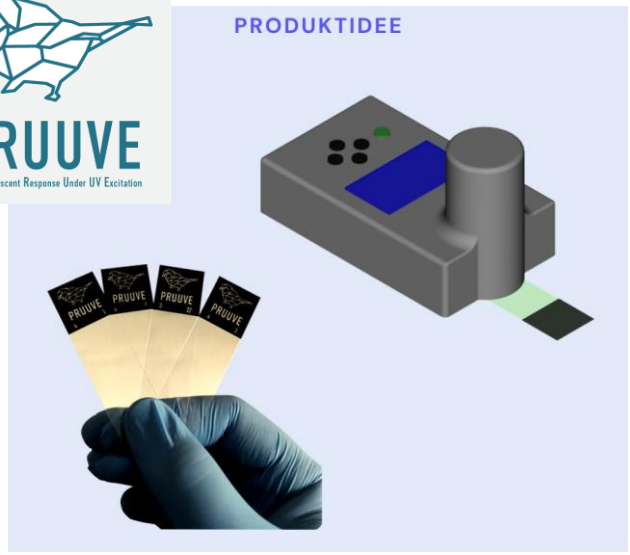
durch Strahlung aktivierbare Sensorfolien

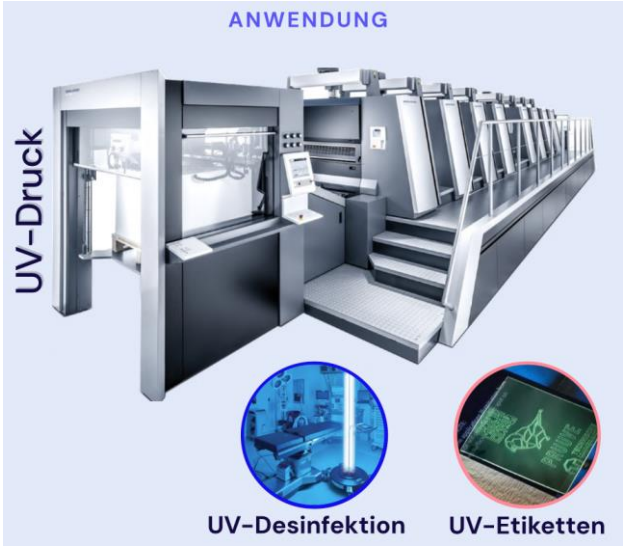
- Anwendung: Dosimetrie-Messungen
- Kontaktloses Verfahren
- Dünne, flexible Folien können beliebig in Prozesse integriert werden
- Datenauswertung passiert im Nachgang
- Spin-off Projekt PRUUVE verfolgt Kommerzialisierung
- Erstes Anwendungsfeld: Überwachung von UV Härtungsschritten im Spezialdruck
- Auch für Etikettierung nutzbar











www.pruuve.de

Innovating for a Greener Future with Bioelectronics / Bio-inspired Organic Electronics

MIMOTYPE

- Mimotype Technologies GmbH specializes in organic light research & development, focusing on eco-friendly solutions to replace conventional lighting. We investigate the environmental impact of current lighting technologies and their effects on biodiversity and global ecosystems, aiming to contribute to a sustainable future through our strategic focus on bio-inspired organic semiconducting materials
- Mimotype Technologies GmbH also delves into the fields of bioelectronics and bionanotechnology, with a specific focus on creating devices using Green Fluorescent Protein (GFP). Our approach integrates biological, protein-based components into electronic systems, opening new possibilities in biotechnology and sustainable transient electronic solutions

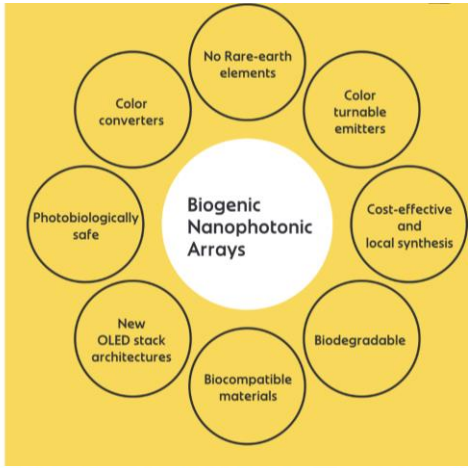
We are solving toxic light.

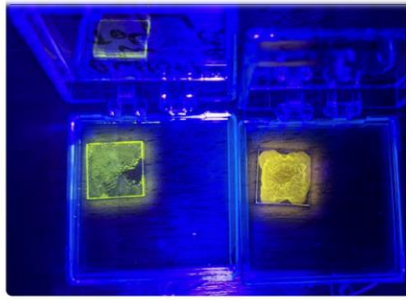
Environmental Impact
Protein-based organic light-emitting materials.

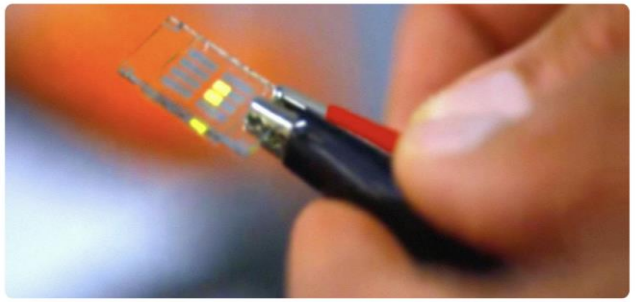
Light Quality
Color-tunable and bio-compatible emission spectrum.

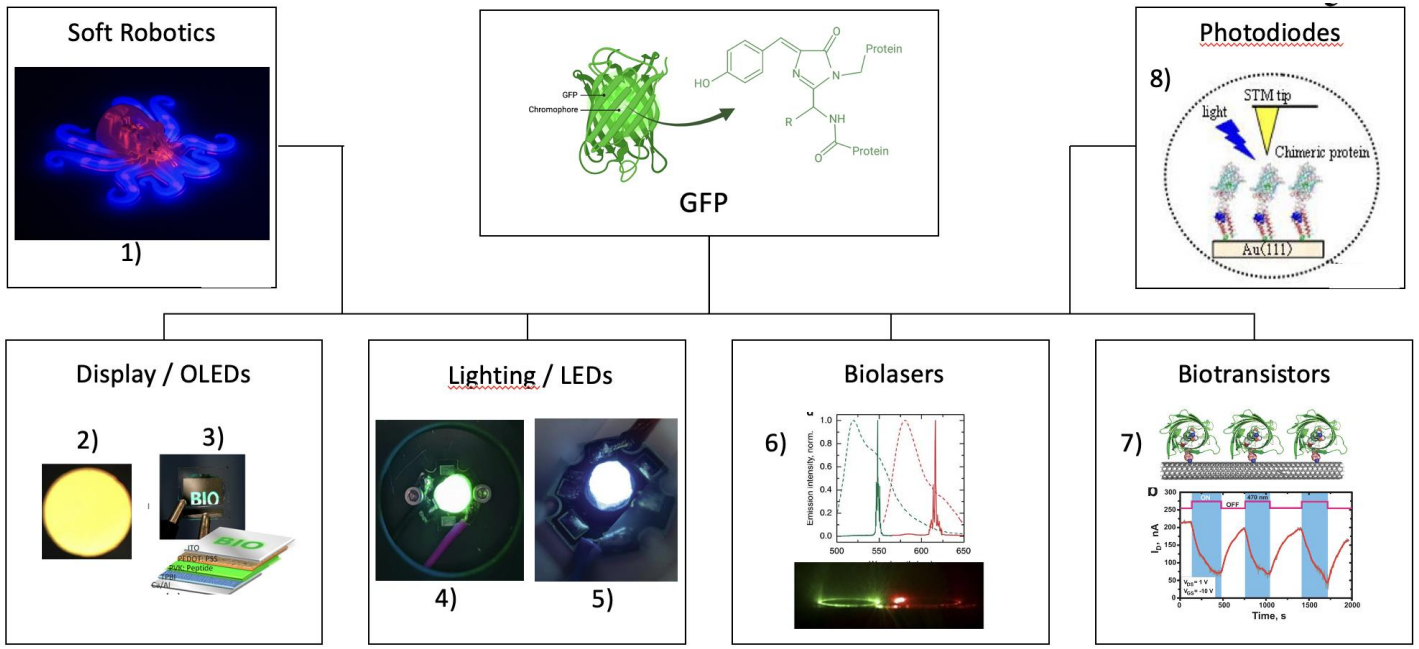
Supply chain
Facile and inexpensive local chemical synthesis.

Disposal
Biodegradable materials with structural simplicity.









Contact : claudio@mimotype.org
www.mimotype.org

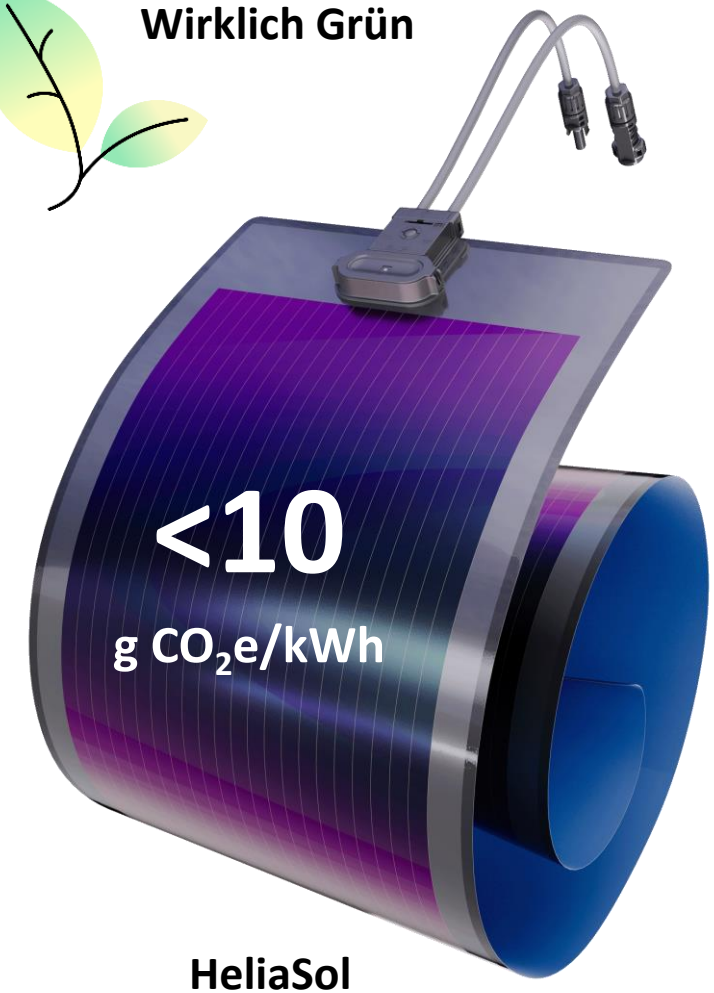
HeliaSol – Die innovative Solarfolie

OPV – Die grünste aller Solartechnologien

Heliatek
INDEPENDENT. GREEN. FUTURE.

www.heliatek.com

Wirklich Grün



HeliaSol

WAS HEISST GRÜN?

- Carbon Footprint (CO_2 Fußabdruck) von weniger als 10 g CO_2e/kWh
- Energy Payback Time (EPBT) von weniger als 6 Monaten
- Carbon Payback Time (CPBT) von weniger als 3 Monaten
- 2,5-mal weniger Materialverbrauch pro Wp als bei herkömmlichen Solarmodulen
- Keine giftigen Schwermetalle wie Blei oder Cadmium, keine seltenen Erden, keine begrenzten Rohstoffe
- Einfache & umweltfreundliche Entsorgung durch Verbrennung (zusätzliche Energie)

WIE GRÜN?

WASSER	OPV	c-Si PV	GAS	NETZ	KOHLE
3	<10	49	409	484	1,004
g CO_2e/kWh	g CO_2e/kWh	g CO_2e/kWh	g CO_2e/kWh	g CO_2e/kWh	g CO_2e/kWh

WARUM GRÜN?

- Geringer Materialeinsatz von synthetisch herstellbaren oder reichlich vorhandenen Materialien
- Materialauswahl und Vermeidung von toxischen Schwermetallen & seltenen Erden
- Effizienter Rolle-zu-Rolle-Produktionsprozess ohne extreme Temperaturen, Drücke, Gase oder Substanzen und mit relativ geringem Energiebedarf
- Kompaktes Fabrikdesign, weltweit einsetzbares Produktionsverfahren für reduzierte Transportvolumen und –gewichte

* Aufgrund fehlender industrieller Recyclingverfahren wird HeliaSol heute als nicht gefährlicher fester rückgewonnener Brennstoff (SRF) eingestuft.

pmTUC : Institute for Print & Media Technology at Chemnitz University of Technology

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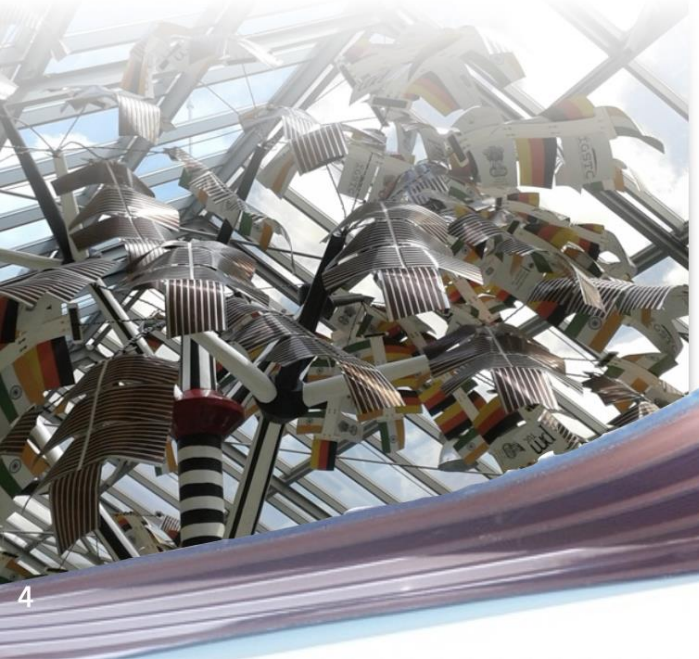
www.tu-chemnitz.de/pm

Products and Services

- Basic research in next generation PV technology: Mass-printed endless solar cells

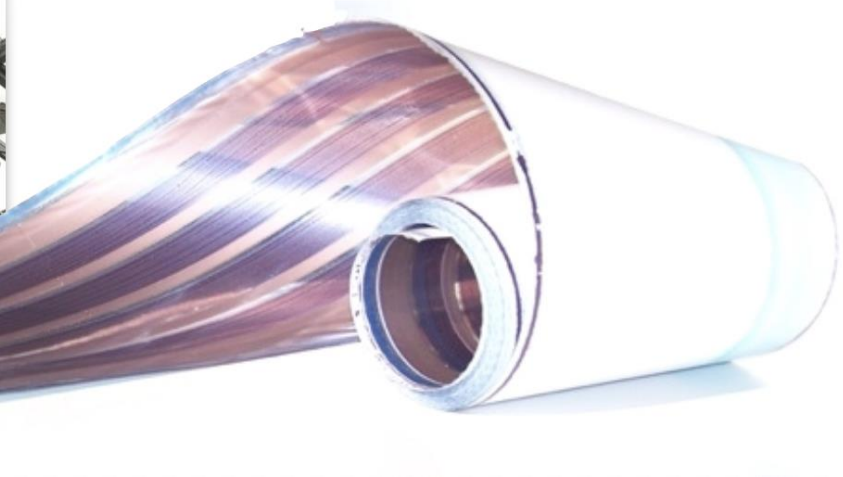
References

- P☀PULAR – »Printed & Stable Organic Photovoltaics from Non-fullerene Acceptors«
  The leading research project on printed solar cells in Germany. 7 partner universities, 8 years



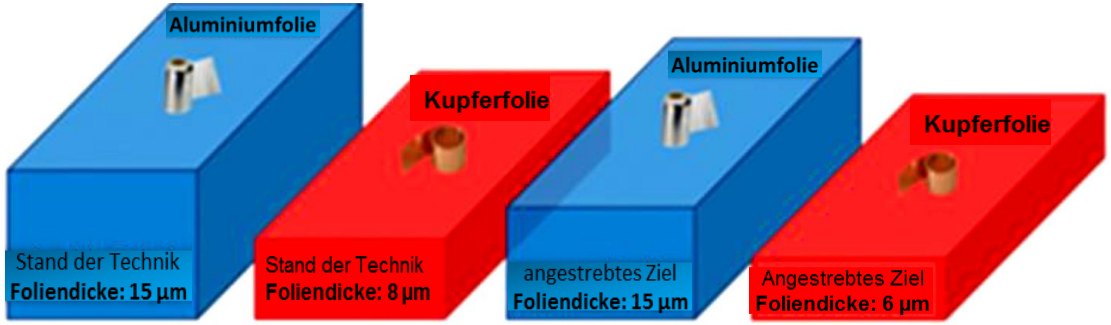
Fields of interest / Cooperation requests

- Disruptive business scenarios for mass-printed PV applications

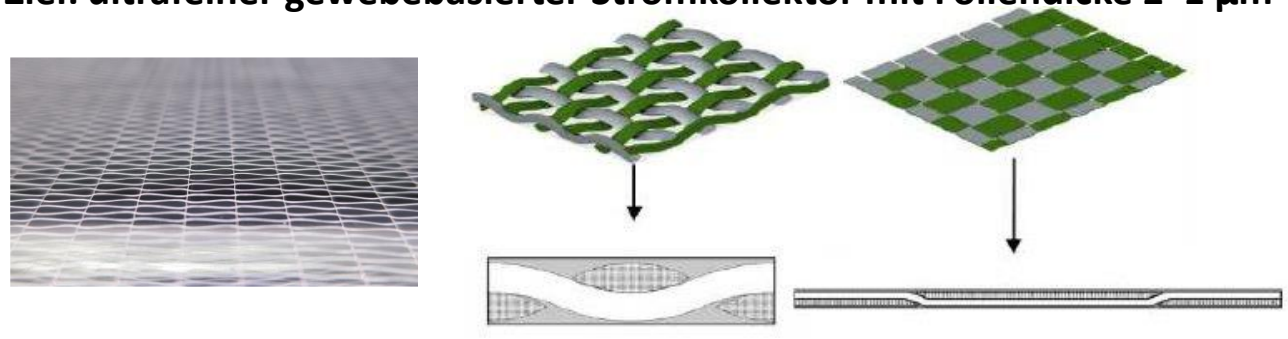


revoLect – Hocheffiziente Elektroden mit ultraleichten Stromsammlern auf Gewebebasis für Lithium-Ionen-Batterien

Stand der Technik - Folienstromkollektoren

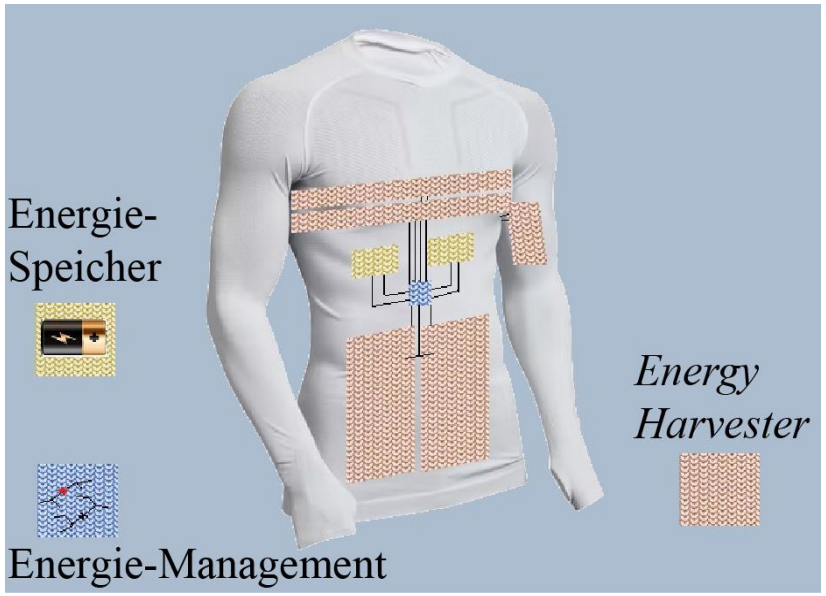


Ziel: ultrafeiner gewebebasierter Stromkollektor mit Foliendicke ≤ 1 µm



Drastische Reduktion des Metallgehalts in den Lithium-Ionen-Zellen und Maximierung der Gewichtersparung

TriGiFi– Triboelektrische textile Generatoren für multifunktionale textile Stromerzeugung und Sensorik

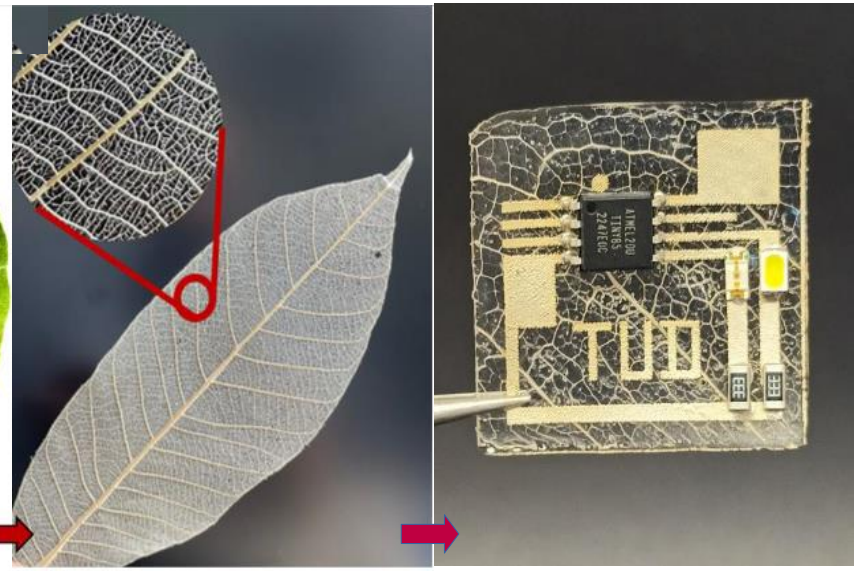


Ressourcenschonende und autarke *Textile Energy Harvesting* Systeme durch die Umwandlung Bewegungsenergie in elektrische Energie für Wearable im Sport, Fitness, Gesundheit und Verteidigung

PtJ Projektträger Jülich Forschungszentrum Jülich
AiF
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

Magnolia Leaf

Reflow Soldered Leaf PCB



Our Vision of Truly Sustainable Electronics

Towards Truly Sustainable Electronics

- Natural Leaves as general-purpose PCB
- True circular economy of electronics – reuse of SMD components, regain metals, compost substrate
- Leaf as active electronic component, e.g., batteries, sensors,...

ExFolia – Spin-off project – IAPP TU Dresden (N. Nair, A. Weißbach, H. Kleemann, K. Leo)

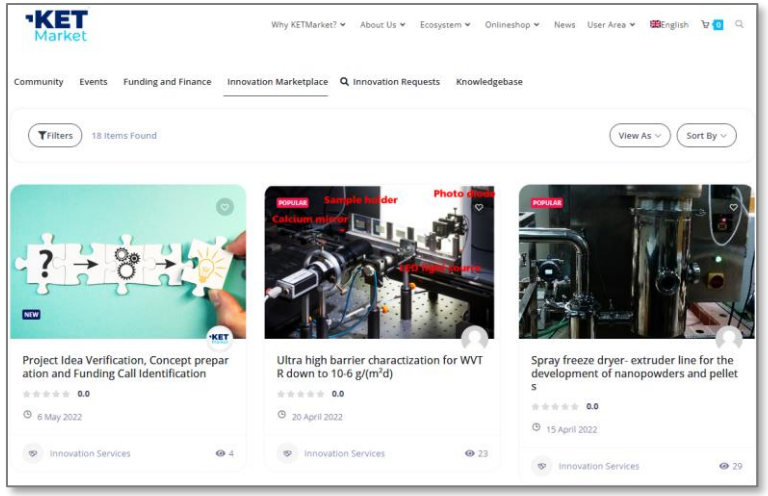
tu-dresden.de/dcpc/iapp

SweepMe!

- Modular measurement software
- Quick creation of new procedures
- Used for solar cells, LEDs, sensors, batteries, electrochemical cells, etc.
- Large set of already included instruments
- Development of new technologies

Free download: **sweep-me.net**

KET Market®



- Worldwide largest digital innovation marketplace with > 140 offers about flexible electronics (Innovation Services, News and funding opportunities)
- Deep understanding of requirements and challenges in the transition to sustainable electronics
- Sales partner for Open Innovation networks for green transition
  - **ESNA**: Services for sustainable flexible plastic and paper products (coatings, surface treatment, printed electronic device processing)
  - **Convert2Green**: R&D support for bringing circular, ecofriendly materials to smart textiles, flexible electronics, clean vehicles, and clean energy solutions.
- R&D Service for industry by including institutes, funding, project planning and technology consulting

ketmarket.eu

Why Participate?

The microprinting workshop aims to bring together leading academic scientists, researchers, research scholars and in particular industrial players. This will create an interdisciplinary stage to exchange and share knowledge and research results on diverse topics related to microprinting, including printed and flexible electronics, wearables, bioprinting and MEDTech, MEMS and bioMEMS, additive micro-manufacturing, microfluidics.

When & Where?

18 – 20 March 2024
Hotel Elbresidenz, Bad Schandau, Germany

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www.oes-net.de

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Director

Jitka Barm
Project Manager

Dr. Jonas Jung
Project Manager

Franziska Richter
Team Assistance