Catalogue of services for performance verification in application

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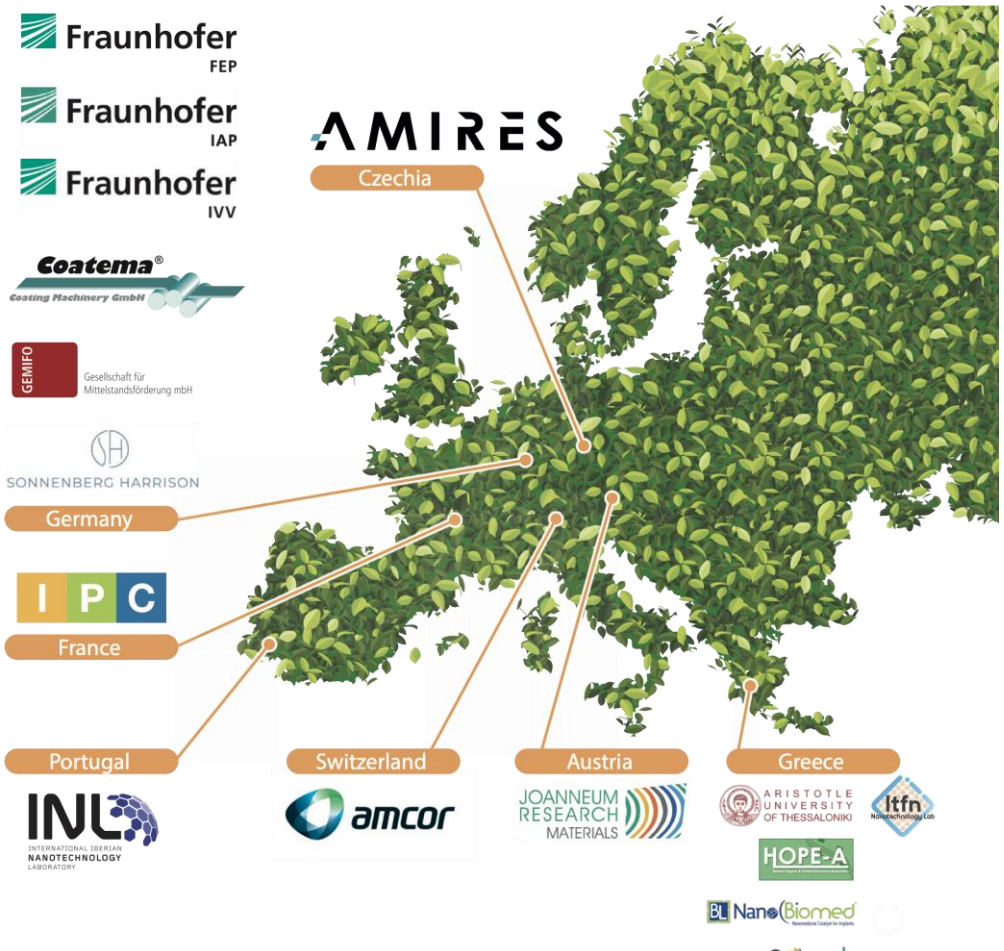
Service Providers in FlexFunction2Sustain



Use Cases of the FlexFunction2Sustain project

FlexFunction2Sustain's technical facilities and the performances of novel nano-functionalised surfaces will be demonstrated and validated by Europe's leading companies within six industrial application scenarios. Application examples for the services related to the Use Cases are labelled with a code specific for each one (UC#)

Industrial Validation in 6 Use Cases

UC1	UC2	UC3	UC4	UC5	UC6
HUECK FOLIEN	P&G	i3 Your Companion Life Science Filtration	CRF	Capri-Sun	SONAEMC
Biobased Optical Films for Labelling of Consumer Goods and Surface Design	Marine degradable shampoo sachets	Selective and switchable water filter membranes	Multifunctional scratch resistant surfaces in automotive	Recyclable mono-polymer drink pouches	Sustainable paper-based food packaging

A full description of the six Use Cases can be found in the FlexFunction2Sustain Project Handbook, available at https://flexfunction2sustain.eu

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Ageing and lifetime assessment

Ageing and lifetime assessment			
Functionalities	Equipment	Technical specifications	Application examples
Accelerated ageing of electro-optical devices	Climate Chamber CTS C-40/100	Flat substrates (glass, plastic, paper) Testing at ambient, tropical, and damp heat conditions Temperature: -23 °C – 180 °C RH: 0 – 100 % Samples Sizes: 50 mm × 50 mm, up to 300 mm × 400 mm	Accelerated weathering tests to ensure that electro-optical devices meet expected durability while maintaining functionality even in challenging environments. Testing devices under simulated extreme environmental conditions allows manufacturers to improve the quality and reliability of their products.
	Self-made equipment on a roof top; 45° tilt and oriented southwards	Long-time monitoring of temperature, humidity, and solar radiation. Monthly offline measurements (e.g., transmission and reflection properties) Samples Sizes: 150 mm × 150 mm	

Climate Chamber CTS C-40/100

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Ageing and lifetime assessment

Ageing and lifetime assessment			
Functionalities	Equipment	Technical specifications	Application examples
OLED lifetime assessment	McScience M6000 PLUS	Suitable for polymers and glass substrates Measurements: Current (mA), Voltage (V), Luminance (cd/ m2), Current density (mA/cm2), Photocurrent (µA), Relative Luminance (%), Temperature (°C), Elapsed time (h) Voltage: -20.04 V – 20.04 V Current: -0.2 A – 0.2 A Samples Sizes: Glass, 20 mm × 15 mm; films, 30 mm × 24 mm, 30 mm × 110 mm	Verifying that OLED materials and devices are able to withstand the continuous electrical powering or working on certain environmental conditions, ensuring their long-term performance and quality. These tests allow manufacturers to improve the quality and reliability of their OLED products.

Testing OLED materials against continuous electrical source or environmental changes

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Ageing and lifetime assessment

Ageing and lifetime assessment			
Functionalities	Equipment	Technical specifications	Application examples
Accelerated ageing tests for lifetime assessment of plastic-based materials	ATLAS CI4000	Possible to test according to D27 1911 D27 1389 Sample dimensions up to 68 mm x 145 mm x 3 mm Xenon lamp (3500 W) with borosilicate S filters (spectrum similar to natural light) Power: 0.55 W/m² at 340 nm Power: 62 W/m² over the range 300 nm – 400 nm Permanent illumination Cycle: 102 min dry - 18 min spray Setpoint temperature on the black panel: 70°C Dry bulb setpoint temperature: 50°C % RH (excluding spraying period): 50%	Ageing of plastic parts exposed to the outdoors (UC4)

Ci4000 Weather-Ometer at IPC

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Ageing and lifetime assessment

Ageing and lifetime assessment			
Functionalities	Equipment	Technical specifications	Application examples
Lifetime assessment under mechanical challenge	Bending / rolling self-made equipment	Only for flexible substrates Possibility of inline electrical measurements Samples Sizes: 400 × 200 mm	Reliability assessment and failure prediction of flexible electronics

Bending / rolling testing system at FHG-FEP

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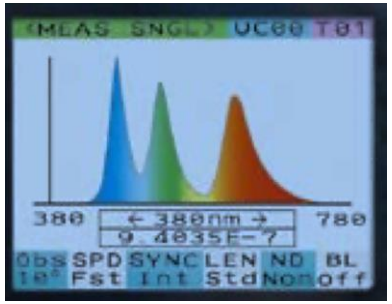
Electro-optical properties

Electro-optical properties			
Functionalities	Equipment	Technical specifications	Application examples
Spectroradiometry	Minolta Camera CS-2000	Suitable for glass, plastic, paper variable sizes up to 150 mm x 150 mm voltage range: 0 - 30 V, current range up to 100 mA, luminance range: 0.003 - 500000 cd/m²	Electro-optical properties of devices of OLED devices
Suntest at AM 1.5	Botest and home made set-up for large area	50 mm x 50 mm, 150 mm x 150 mm Illumination 100mW - 1000 mW/m²	Electro-optical properties of devices of OPV devices



Measurement of an organic EL illumination panel

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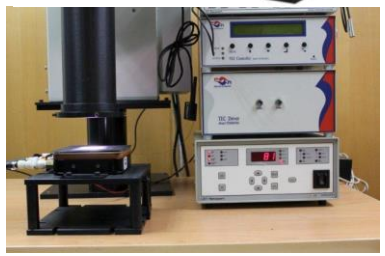
Electro-optical properties

Electro-optical properties			
Functionalities	Equipment	Technical specifications	Application examples
Solar Simulator	Newport Model 91191-1000 Light Source 10 SUNS Newport Solar Oriel Model 94123A solar sim Light Source 1 SUN	Suitable for glass, plastic up to 10X10 cm ±21 V @ ±1.05 A ±210 V @ ±105 mA* ±1.05A @ ±21 V ±105 mA @ ±210 V8	Power Conversion Efficiency of Photovoltaics



Newport Solar Oriel Model 94123A (above) and Model 91191-1000 (below)

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Electrical characterisation

Electro-optical properties			
Functionalities	Equipment	Technical specifications	Application examples
Electrical Characterization Synchronizing current-voltage (I-V), capacitance-voltage (C-V) and ultra-fast pulsed I-V measurements.	4 Probe System - Keithley 4200 semiconductor measuring system	Suitable for glass, plastic, paper, silicon wafers Dark and Ambient conditions Measuring resistances >1012Ω, Line voltade operation 100-240V at 50-60Hz, Current measurement ranges from 105nA/1pA to 105mA/1μA (Full scal/Nominal resolution) Voltage measurement ranges from 210mV/1μV to 210V/1mV (Full scal/Nominal resolution)	Performance and failure analysis studies of semiconductor materials and devices

Keithley 4200 at AUTH

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Spectroscopic characterisation

Spectroscopic characterisation			
Functionalities	Equipment	Technical specifications	Application examples
PLQY (photoluminescence quantum yield)	Hamamatsu Photonic Multichannel analyser, Ulbricht sphere	Suitable for glass, plastic, paper substrates Up to 1 inch² 300 -950 nm for absorption and emission	Evaluation of OLED device performance, characterization of photovoltaic materials, and the detection of failures in optical devices. The measurement of PLQY allows device manufacturers to evaluate the quality and efficiency of their products and improve their performance.
	Hamamatsu Photonic Multichannel analyser, Integrated Sphere	Suitable for glass, plastic, paper substrates Up to 1 inch² 300 -950 nm for absorption and emission	
Photoelectron spectroscopy (low energy electron counter in air)	AC-2 Riken KeiKi	50 mm x 50 mm Suitable for glass, plastic substrates	Measurements of the ionization energy of materials, analysis of the surface of materials, study of material degradation, and evaluation of the performance of electro-optical devices.

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Packaging testing

Packaging testing			
Functionalities	Equipment	Technical specifications	Application examples
Packaging Seal strength		Suitable for all type of packaging materials. Strength measurements on heat sealing seams - Quasistatic method. Different sealing jaws are available	Determination of optimal heat-sealing conditions for packaging materials (UC2, UC5, and UC6)
Package leakage test	SensorData H2000	Suitable for pouches and packages Packaging tightness based on the He gas method	Ensure closure integrity to assess sterility and penetration of oxygen or moisture into the primary packaging (UC2, UC5, and UC6)

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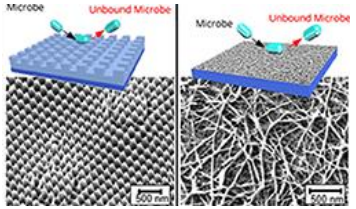
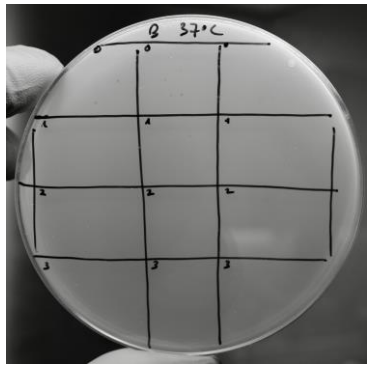
Antimicrobial coating testing

Packaging testing			
Functionalities	Equipment	Technical specifications	Application examples
Antibacterial activity testing for coatings and functional surfaces and textiles	Biosafety Level 2 microbiology laboratories	Antibacterial activity of plastics and other non-porous surfaces according to ISO 22196 and JIS Z 2801 Antibacterial activity of textiles according to ISO 20743 Testing against *Staphylococcus aureus* ATCC 6538P and *Escherichia coli* ATCC 8739; other bacterial strains may be available upon request	Performance assessment of antibacterial packaging (UC6) or automotive interior surfaces and textiles (UC4)
Antiviral activity testing for coatings and functional surfaces and textiles	Biosafety Level 2 microbiology laboratories	Adaptation of ISO 21702 (plastics and non porous surfaces) or ISO 18184 (textiles or porous materials) for testing antiviral activity with Bacteriophage MS2 (Emesvirus zinderi) as a surrogate of human viruses.	Performance assessment of antiviral automotive interior surfaces and textiles (UC4)



Upgraded Microbiology Labs @AUTH and @INL for antimicrobial/antifouling surfaces – ongoing



Viral plaque counts in antiviral surface assessment

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Prototyping of components and products

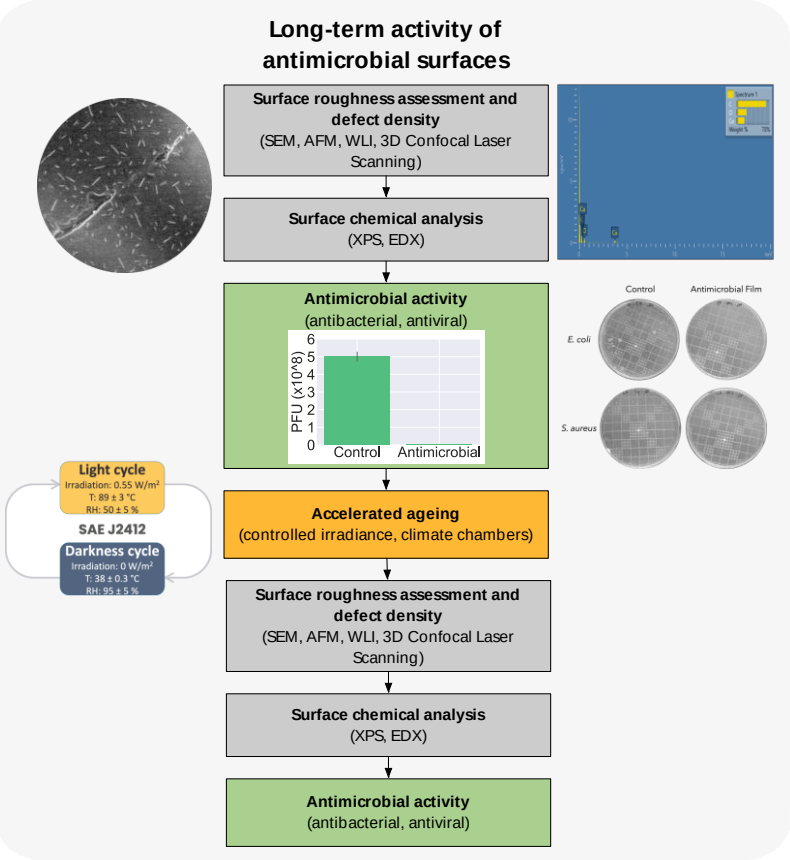
Material processability validation			
Functionalities	Equipment	Technical specifications	Application examples
Material processability validation by thermoforming	BERG M7	Suitable for plastic substrates Processing temperature up to 350°C, various forming geometries available up to 700x500x10 mm	Rapid prototyping to evaluate the shape, size, and performance of components and devices before mass production. Manufacturing of small-batch production parts (UC4)
Material processability validation by overmoulding	Engel EM440/150 Arburg 370S 700	Suitable for paper and plastic substrates (any thermoplastic material) Various plate mould dimensions available up to 950 x 950 mm in Engel EM440/150 and up to 510 x 510 mm in Arburg 370S 700	

BERG M7 thermoforming device (top) and Arburg 370S 700 overnoulding system (left) installed at IPC

Workflows for Performance Verification services based on the integration of multiple methodologies

Case study 1: Long-term activity of antimicrobial materials

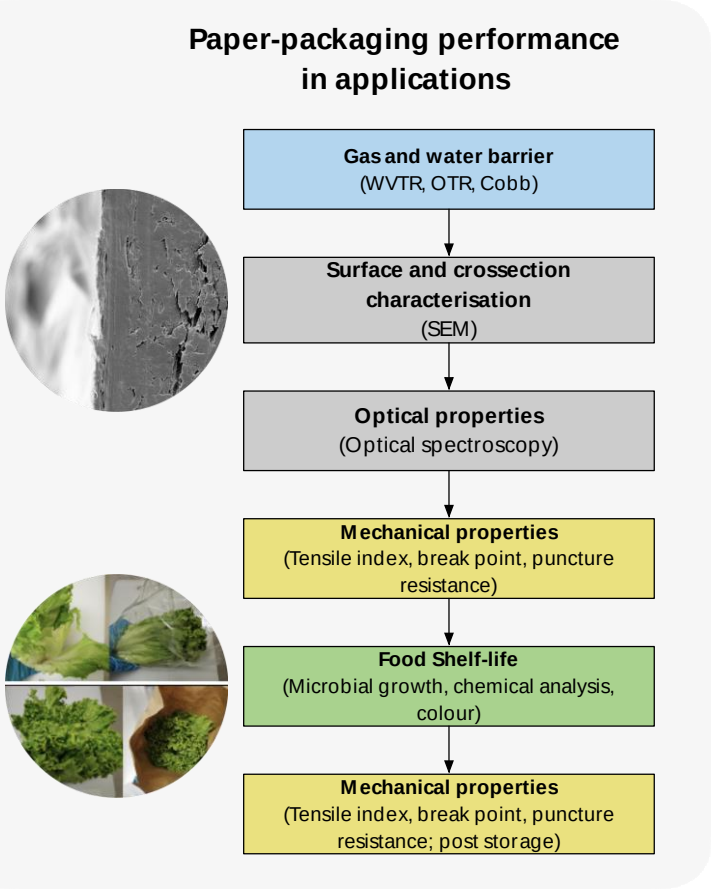
- Despite having a good immediate antimicrobial activity, a coated or nano-structured surface may not offer adequate protection if it degrades and fails before its intended life cycle.
- This is especially true for materials subjected to frequent stress and washing under harsh conditions (such as coated textiles), constant friction (such as on seating surfaces), frequent wiping with aggressive cleaning solutions (such as on furniture surfaces) or weathering due to exposition to light sources and heat. To ensure the successful development of novel functionalised surfaces, the assessment of antimicrobial performance must be combined with tests to evaluate the integrity of the coatings.
- In this workflow, a plastic material with an antimicrobial coating incorporating metallic nanoparticles is characterised for its long-term antibacterial activity. The physicochemical properties and the nanostructure of the surface are characterised at the beginning of the process using a combination of optical and electron microscopy techniques (e.g., White Light Interferometry, 3D Confocal Laser Scanning, or Scanning Electron Microscopy) and X-ray analysis (e.g., XPS or EDX), and the antimicrobial activity is analysed according to industry standards (e.g., ISO 22196). The materials are then exposed to an accelerated ageing cycle (e.g., SAE J2412). At the end of each ageing cycle, surface properties and antimicrobial activity are re-evaluated.



Workflows for Performance Verification services based on the integration of multiple methodologies

Case study 2: capability of paper-based packaging to preserve shelf-life of food products

- Food packaging must be tailored to the needs of each individual product.
- Interaction between the packaging material and the food, under unfavourable conditions, could cause changes in the composition and quality of the food or alterations to the physical properties of the packaging material itself.
- FlexFunction2Sustain offers functional verification programmes based on strict quality controls appropriate to each case to ensure the shelf life, quality, and safety of the food during transport and storage. This workflow shows one example of a characterisation to assess the impact of paper-based packaging on the shelf life of fresh vegetables packaged in it and verify their performance.
- In the first step, the barrier and mechanical properties of the material are evaluated according to the specific requirements of the product to be packaged and its marketing form. The impact on the quality and shelf life of the food is evaluated by chemical, physical and microbiological analyses. Finally, the packaging material is again subjected to physical characterisation to determine how it has withstood the packaging and storage process.



Workflows for Performance Verification services based on the integration of multiple methodologies

Case study 3: Performance assessment of recycled polypropylene films as substrate for printed electronics

- Maintaining the final product's performance while incorporating recycled materials can be challenging, so a customised characterisation workflow for each product may be the key to success.
- FlexFunction2Sustain facilities have testing capabilities to offer performance verification programmes suited to the final applications of each recycled material, combining chemical (e.g., FTIR and RAMAN), thermal (e.g., DSC, TGA, HDT), and mechanical characterisations (e.g., Young's Modulus) and assessment of gas barrier properties (WVTR, OTR) and failure analysis (e.g., SEM, WLI).
- This workflow shows an example of the characterisation of recycled polypropylene films intended to be used as a substrate for organic photovoltaic cells (OPV) production. The designed protocol considers multiple steps to evaluate gas permeability, analysis of the presence of surface defects (which could indicate the need to add a planarization layer), and an analysis of optical and mechanical properties to ensure the film's suitability for the selected application.