SUSNANOFAB

Grant Agreement No. 882506

Initial report on training sessions

Document Details

Deliverable Number:	D4.3
Due date of Deliverable:	[M25] – 31 March 2022
Lead Beneficiary:	[IPC]
Contributors:	[CEA, IDONIAL, RINA-C]
Dissemination Level:	[PU]

Project Contractual Details

Project Title:	Integrated EU Strategy, Services and International Coordination Activities for the Promotion of Competitive and Sustainable Nanofabrication Industry
Project Acronym:	SUSNANOFAB
Contract No.:	882506
Project Start Date:	01-03-2020
Duration:	36 months

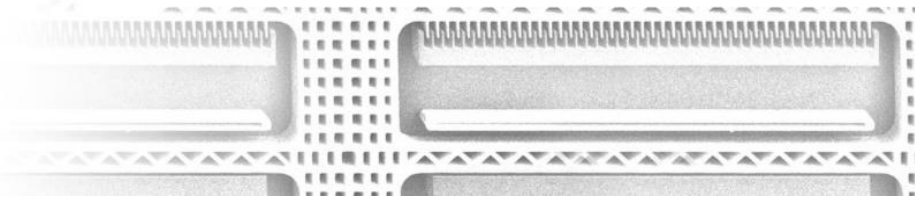
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 882506.

Document History

Version	Date	Description
V1.1	20/01/2022	First version of the deliverable
V1.2	14/03/2022	Included partners and coordinator reviews
V1.3	28/03/2022	Last version of the deliverable

Abbreviations and Acronyms

Acronym	Description
KPI	Key Performance Indicator
NM	Nano-Material
RRI	Responsible research and innovation
SPD	Severe Plastic Deformation



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Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 882506 (SUSNANOFAB). The content of publication is the sole responsibility of the author(s). The European Commission or its services cannot be held responsible for any use that may be made of the information it contains. Project website: http://susnanofab.eu/ .

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Executive Summary

This document is a deliverable of the SUSNANOFAB project – a coordination and support action to promote a competitive and sustainable nanofabrication industry – funded by the European Union's Horizon 2020 Programme, under Grant Agreement #882506.

SUSNANOFAB is a concerted sustainable action that will establish a robust network on nanofabrication to tackle the missing links between policies, infrastructure, expertise, and industry requirements. The SUSNANOFAB project proposes an integrated strategy at a European level that articulates throughout the whole value-chain, aiming at the promotion of a competitive and sustainable nanofabrication industry.

At a strategic level, the project is committed at delivering an EU-wide Strategic Roadmap on Nanofabrication. This roadmap among others will cover nanofabrication aspects from design to manufacturing upscaling, environmental sustainability, health & ethics matters, as well as future skills & capabilities. At an operational and end-user level, the project will develop an Open Access Digital Platform that interoperates with current platforms, projects, and other initiatives at the European level.

Specifically, the deliverable D4.3 describes the work realized to create the trainings that were identified as missing by previous SUSNANOFAB project studies (online survey and workshops). Most training activities were designed to answer those needs and were based on relevant industrial technologies requirements.

Four trainings sessions were organized with a minimum of 10 attendees per sessions. They were all organised online to ensure a more diversified audience (country, industry, research centre, students…).

Some training sessions were iteratively improved based on the feedback from the previous sessions where others were converted in different format to continue the content dissemination.

Most of the trainings created in the frame of the SUSNANOFAB project are public. Hence, a webpage in the SUSNANOFAB project website was created to host the training materials. The webpage is accessible with the link: https://susnanofab.eu/trainings/.

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1 Introduction

In the frame of the SUSNANOFAB project and within task 4.3 called "Planning and deployment of training activities" a series of trainings were created and disseminated. In the next section, the following steps will be explained and detailed:

- Main outputs of T4.1" Collection of training needs" (D4.1) used to create novel trainings.
- List of trainings describing the title, topics, number of attendees and link to the replay.
- List of additional materials to complete and continue the training dissemination.

2 Trainings creation based on identified needs

The previous project task, Task 4.1, focused on the identification of training gaps in the domain of nanofabrication. From the work realized in *D4.1 - Report on prioritised training gaps and shortages for the nanofabrication industry*, the project identified major missing trainings and competencies through the deployment of an online survey and several workshops (see Figure 1). Trainings developed in Task 4.3 activities were defined based on the requirements of precise industrially relevant technologies.

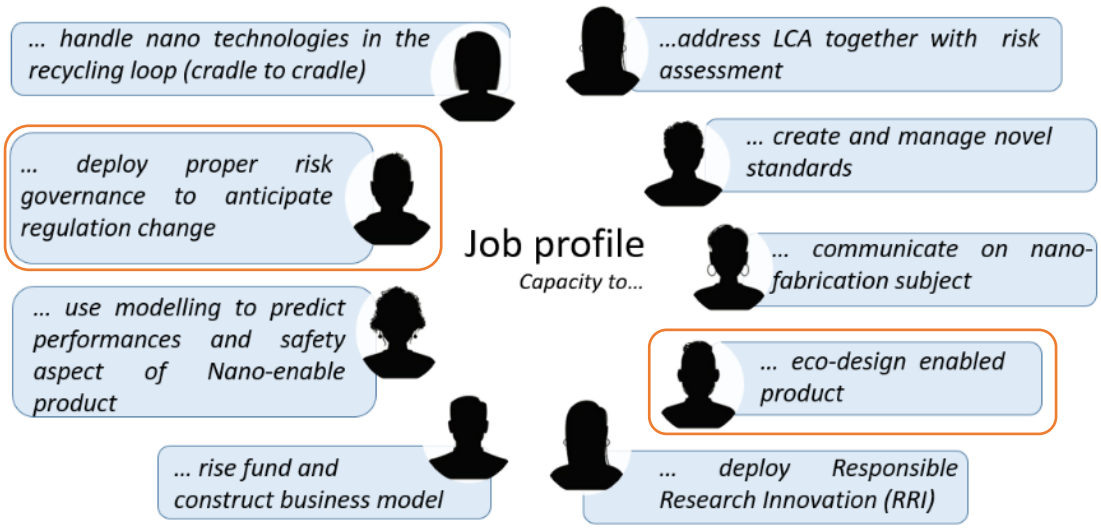

Figure 1: list of potential missing skills or job profiles to create and the ones addressed by the project novel trainings

Out of the three trainings created so far, two are addressing directly the needs identified by the project (described in orange in the Figure 1). The idea was to answer the industrial needs in accordance with one of the partner's expertise, as followed:

- **Eco-design enabled product**: IPC proposed a training on the eco-design of plastic product enhanced by nano-texturing technologies
- **Deploy proper health risk governance**: CEA proposed a training on nanosafety introducing different European regulations and Safe-by-design approaches for risk management.

To complete the objective of this task, at least one additional training will be proposed. The four sessions already realized will be updated and rescheduled at least on time during the final event (end of 2022).

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3 Description of the trainings

Most of the trainings created in the frame of the SUSNANOFAB project are public. Hence, a webpage in the SUSNANOFAB project website was created to host the training material. The webpage is accessible with the link: https://susnanofab.eu/trainings/.

The trainings proposed are described in the following section.

3.1 Nano fabrication techniques to create added value properties to plastic and metal parts

3.1.1 Description of the training session

Based on the **identified training need related to the eco-design enabled products**, a first training session was realized focusing on the nano-fabrication techniques that create added value properties in the plastic and metal industries. During this session, two techniques of nano-texturing were introduced:

- Surface nano-structuring techniques for injected plastic parts (based on HIMALAIA platform), by IPC
- Nano-structuring techniques for bulky metal, based on severe plastic deformation (SPD) techniques, by RINA

Title	Part 1: Nano fabrication technics to create added value properties to plastic parts - An initiation to micro/nano surfaces texturing and eco-design Part 2: Metals nano-structuration by Severe Plastic Deformation Techniques
Lead participant	Part 1: IPC Part 2: RINA
Language	English
Type of training	Online
Date	25/11/21
Duration	2h
Number of participants	12
Number of replay viewers	3
Link to the replay	https://attendee.gotowebinar.com/recording/7397698269403456776
Short description	**Part1:** this session introduces the eco-design of plastic part through nano-texturing technologies. To design novel plastic products that are fully recyclable, the main idea is to simplify the product design using only one material. Hence, to keep functionalities and added value at a high level with only one material, the solution is to texture the product surface with nano-pattern providing such functionalities. Antimicrobial, water proof, anti-scratch are among the properties that could be reached with this concept. The training also described the main steps to properly transfer the nano-pattern from the injection mould to the injected part using among other thing a proper heat&cool technology.

	Part2: This session introduces the approach, developments and recent achievements in metal nano-structuration by Severe Plastic Deformation (SPD) techniques that describes a group of metalworking techniques applied to impose very large strains resulting in bulk grain refinement. First, metal properties requirements, grain size and grain refinement concepts are introduced, then properties of bulk nanostructured metals are presented. Most of SPD methods are shown and classified. At the end, the practical applications of ultrafine/nanostructured materials and industrial commercialization of SPD methods are summarized.

The **training plan** was divided in two main parts:

Part1:

1. Presentation of IPC
2. Introduction
3. Nano-fabrication and high added value functions creation
4. Technologies and technological platforms
5. Eco-design and Nano-fabrication process
6. Conclusion & Q&A

Part2:

1. Introduction to nanostructures
2. Metal properties requirements
3. Metals fabrication methods and Severe plastic deformations
4. Properties of bulk nanostructured metals
5. Applications
6. Conclusions

3.1.2 Feedback or questions

A Q&A session was organized at the end of the session to allow the attendees to give feedback and ask questions. The questions collected are described below.

- *How many injection cycle can we expect before cleaning the mould insert?*
- *What is the range of the patterns size? and the maximum size of the moulded components?*
- *Can ultrasonic cleaning of nanostructured surfaces be effective?*
- *What is to say about the release of inhalable NM from the surface of these plastic parts during use?*

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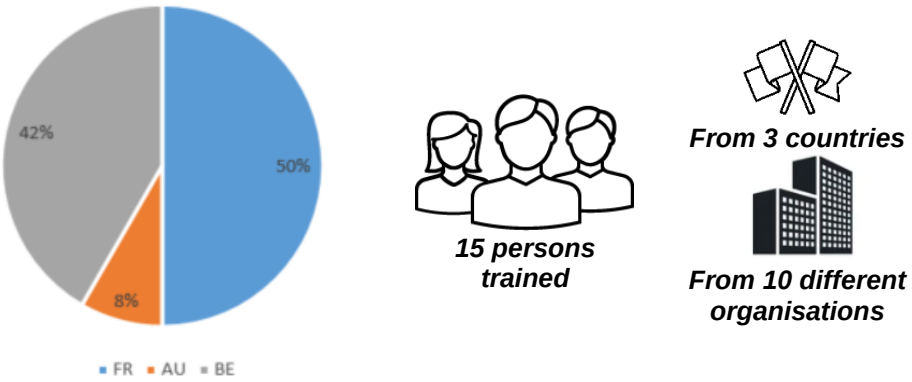

Figure 2: Statistics for the IPC/RINA workshop

3.2 Nanosafety

3.2.1 Description of the training session

Based on the **training needs related to the deployment of proper health risk governance**, CEA organised a series of workshops on nanosafety issues. Hence, SME or an industrial companies interested in nanosafety topics were invited to join this training. The workshop aims at providing an introduction to nanosafety concerns and raising awareness for all companies, especially SMEs, interested in nanofabrication.

Title	NANOSAFETY workshop
Lead participant	CEA
Language	English
Type of training	Online
First Date	06/10/2021
Duration	3h
Number of participants	41
Link to the replay	*confidential*
Second Date	18/01/2022
Duration	3h
Number of participants	33
Link to the replay	*confidential*
Short description	This workshop aims at providing an introduction to nanosafety concerns and raising awareness for all companies with interest in nanofabrication. Definitions and European regulations are firstly presented to the attendees. An introduction of the toxicological impact is slightly developed while the exposure, release and safe-be-design part is enriched by European projects experience. Finally the attendees learn how they can reduce the exposure to mitigate the risk.

The **training plan** was the following:

1. **Discovery of the Nano world**
   Definitions, European regulations …
2. **Exposure assessment and Safe-by-design approaches**
   Methods, equipment and examples

3. **Prevent and mitigate the risk**
   Methods, tools and equipment

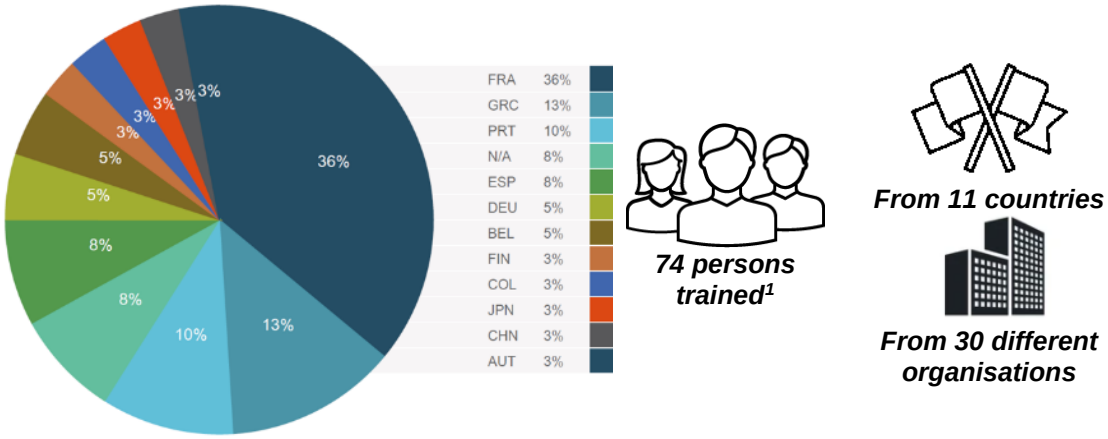

Figure 3:Statistics for the CEA nanosafety workshop

3.3 Nano-fabrication techniques to create added value properties in composite parts

3.3.1 Description of the training session

A first training session was realized focusing on the nano-fabrication techniques that create added value properties in the composites parts.

Title	Initiation to nano-enabled composites parts through the presentation of an industrial use case
Lead participant	IPC
Language	English
Type of training	Online
Date	01/03/2022
Duration	40 minutes
Number of participants	11 participants
Number of replay viewers	0
Link to the replay	https://attendee.gotowebinar.com/recording/3652387833368323587
Short description	This session introduces the capability to provide high added-value functionalities to composite parts thanks to nanotechnologies. An introduction to the use of nanotechnologies and the context of the set of services developed by OASIS project was proposed. Then nanoparticles principles and properties were described. Their uses were illustrated through an industrial use case from the OASIS project: VDL showcase. This use case shows the integration of different nanomaterial through nano-intermediates and how to process them to obtain a lightweight, mechanical resistance, thermal properties (insulation, fire-resistance) and embedded sensors in one composite part, and how this part answers to KPIs of the industrial.

[1] *Two training sessions were organized by CEA on the same topic with 41 and 33 attendees.*

The **training plan** was the following:

1. Presentation of IPC
2. Introduction
3. Nano-fabrication and high added value functions creation
4. Presentation of an industrial use case
5. Conclusion & Q&A

3.3.2 Feedback and questions

A Q&A session was organized at the end of the session to allow the attendees to give feedback and ask questions. The questions collected are described below.

- *What is overall thickness?*
- *Can nano technology increase biodegradability of polymer?*
- *What about the sustainability aspect of the final product? I mean how the used fabrication techniques perform regarding the energy use and circularity?*
- *Will you organize another workshop once you have considered these sustainability aspects?*
- *Will you also consider the life cycle perspective of these advanced products? For instance, the release of the NMs along the life cycle.*

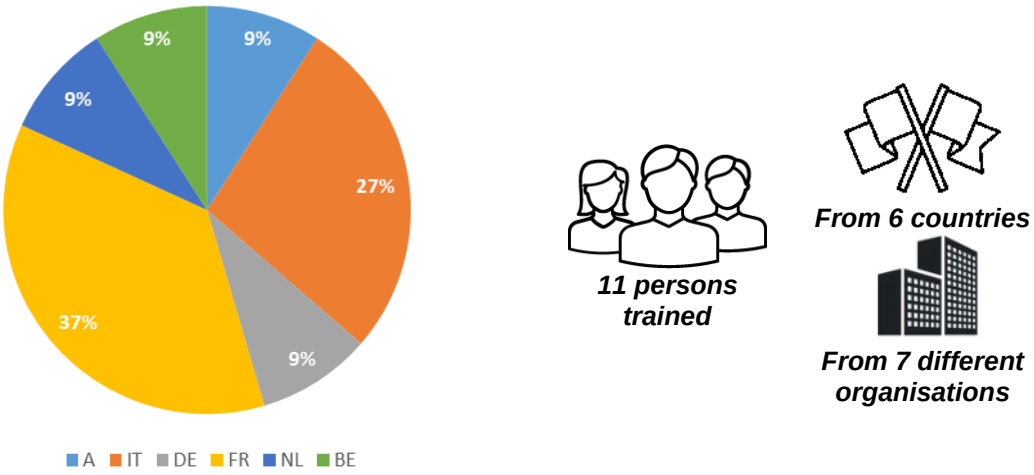

Figure 4:Statistics for the IPC nano-enabled composites parts workshop

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4 Other means of training

To accelerate the uptake of the nanofabrication techniques and nano-enabled products, different means to reach audiences were proposed. Indeed, to be able to present novel technologies to industrial stakeholders, the idea was to design short pitch decks used as sales pitch. Those pitch decks will be used **to train and create awareness** within the partner's industrial network.

The pitch decks are accessible with the link: https://susnanofab.eu/trainings/.

4.1 Pitch on surface nano-structuring techniques for injected plastic parts

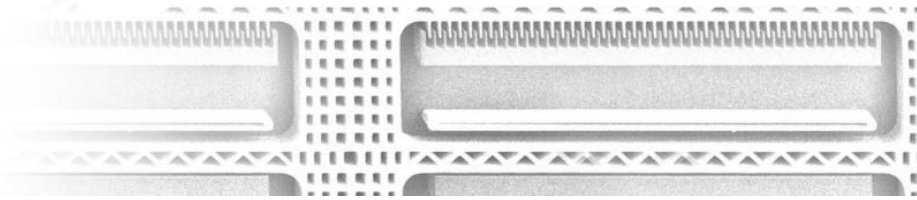
As described in the annex, a sale pitch deck was prepared for the nano-structuring techniques for injected plastic parts. The pitch will be disseminated throughout 2022 through social networks to maintain a higher visibility of the training and prepare for the final event.

To tackle the growing demand for plastic parts with functionalized surfaces, partner's sales force need to be equipped with simple and straightforward materials. Hence, the sales pitch deck will be **used to train sales agents that in their turn will disseminate the content and train future clients on at the least the basic principles of the technology**. Indeed, many industrial customers are looking for hydrophobic and self-cleaning, antibacterial, aesthetic or anti-squeak properties to enhance their products. In addition, a need to reduce coatings and/or surface treatments with negative environmental impact lead to this important interest in mono-material products with functionalized surfaces for improved durability and recyclability.

4.2 Pitch on nano-fabrication techniques to create added value properties in composite parts

As for the previous training and also described in the annex, a sale pitch deck was developed to introduce nano-fabrication techniques applied to composite parts.

This pitch deck will be also used by sale agents to promote and answer to industrial needs on multifunctional composite parts. It is a clear demand from the industrial customers to integrate even more functionalities in composite parts, especially smart functionalities, keeping lightweight and reinforced initial properties of the materials. It is also important to show the set of service available with all partners associated to OASIS network to provide a complete solution including nano-material production, integration in nano-intermediates and implementation in nano-enabled products.



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5 Conclusion

The deliverable D4.3 describes the work realized between M14 and M25 in Task 4.3 of the project. Based on the previous project task outputs and focusing on skill demands that were considered as missing today, the trainings created were related to relevant industrial technologies. Two novel trainings were created answering specific needs identified by the project survey, such as:

- Need of novel eco-design enabled product: IPC proposed a training on the eco-design of plastic product enhanced by nano-texturing technologies.
- Need to be able to deploy proper health risk governance: CEA proposed a training on nanosafety introducing different European regulations and Safe-by-design approaches for health risk management.

An additional training topic was created by IPC to introduce high added-value functionalities in composite parts thanks to nanotechnologies

Hence, four trainings sessions were organized with a minimum of 10 attendees per sessions. They were all organised online to ensure a more diversified audience (country, industry, research centre, students…). Some training sessions were iteratively improved based on the feedback from the previous session where others were converted in other format to continue the dissemination of the content.

Most of the trainings created in the frame of the SUSNANOFAB project are public. Hence, a webpage in the SUSNANOFAB project website was created to host the training replay and dissemination materials. The webpage is accessible with the link: https://susnanofab.eu/trainings/.

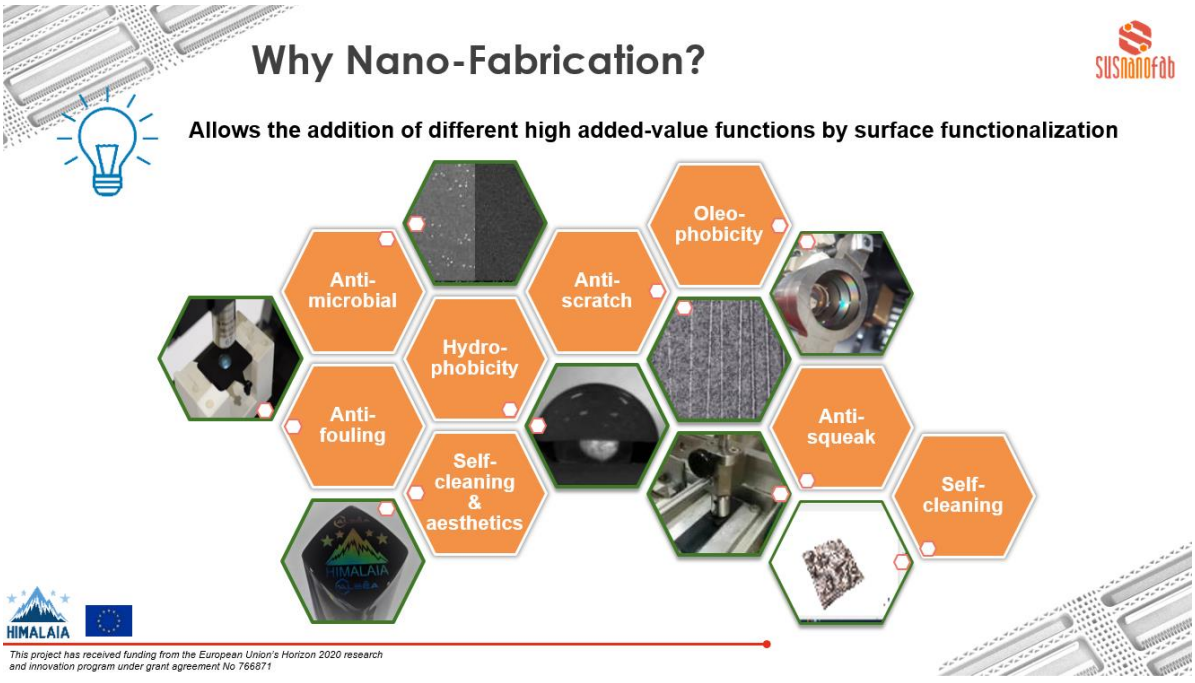
To complete the objective of this task, at least one additional training will be proposed. The four sessions already realized will be updated and reschedule at least on time during the final event (end of 2022). Actions were undertake to continue the dissemination of the training replay and pitch but were not fully deployed at this stage. These actions will be increased in the next period.

Figure 5: Global KPI of the project task 4.3

6 Annexes

The pitch decks used to promote novel nanofabrication technologies are based on a collaboration with several EU projects (HIMALAIA ID: 766871 and OASIS ID: 814581). Hence, the technologies development was funded by other EU projects while the creation of the pitch material and its dissemination were realized within SUSNANOFAB.

6.1 Pitch on surface nano-structuring techniques for injected plastic parts



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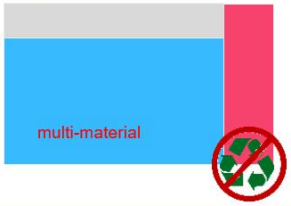
Why Nano-Fabrication?

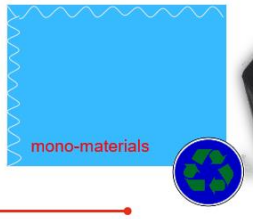
- Growing demand **for plastic parts with functionalized surfaces**:
  - Hydrophobic and self-cleaning,
  - Antibacterial,
  - Aesthetic,
  - Anti-squeak, etc.

- Need to **reduce coatings and/or surface treatments** with negative environmental impact.
- Interest in **mono-material products** with functionalized surfaces for **improved durability and recyclability.**

Functionalization by coating and bi-injection



Nano-texturing for aesthetic effect and optical properties



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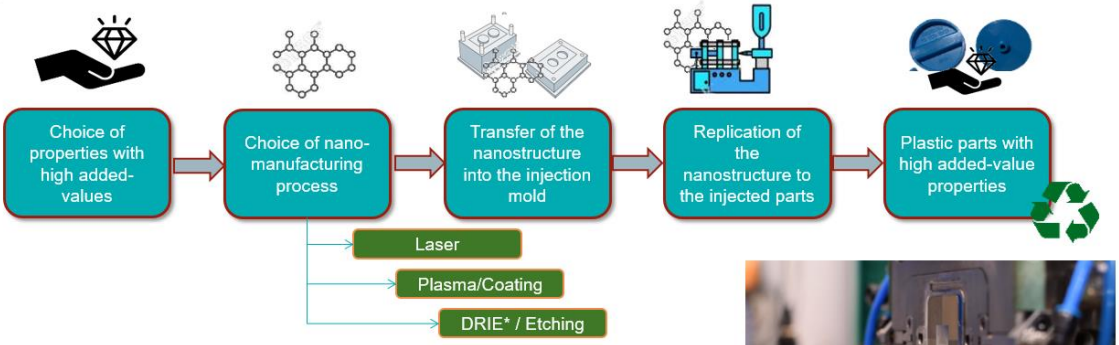
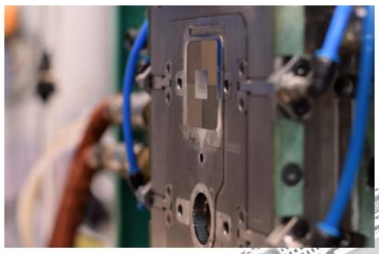
Functionalization process



➢ **Replication of nano-structured surfaces from the injection mold to plastic parts**



Injection mold with nanostructured surface

**DRIE: Deep Reactive Ion Etching*

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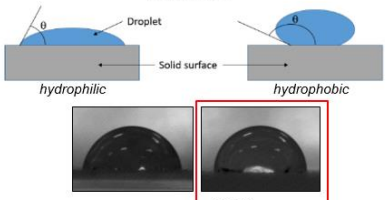
Application examples – Packaging

➢ Addition of aesthetic and anti-stain functions

- Materials evaluated: PP, PE, ABS
- Dimensions: 100mm length, 10mm diameter

ALBÉA

Anti-stain: super hydrophobic surface



Water-repellent, stain-resistant, antimicrobial, anti-fouling…

Surface with advanced optical properties

HIMALAIA

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Examples of applications – Automotive

➢ Addition of anti-friction and anti-scratch functions

- Materials evaluated: PC-ABS, PP, PA-ABS
- Cabin elements – dashboard
- Objectives:
  - Limit unwanted friction and vibration noise
  - Increase resistance to scratches and dirt
  - Add antibacterial properties

CRF

Mold insert Text. A

Mold insert Text. B

Replication of texturing on the part

HIMALAIA

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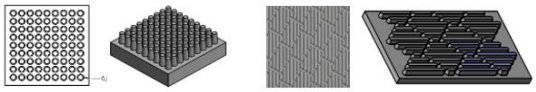
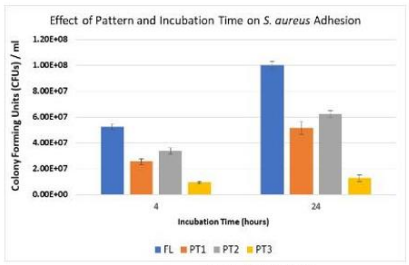
Examples of applications – Medical

➢ Addition of anti-bacterial functions

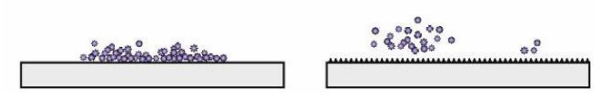
- Materials evaluated : PSU
- Orthodontic elements – complex geometry
- Objectives:
  - Reduce the appearance of bacteria





2D Samples

PT1: LIPSS IR Laser
PT2: LIPSS Green Laser
PT3: PN



Flat surface - hydrophilic material

Micro/nano structured surface - Hydrophobic material

Increased anti-bacterial properties

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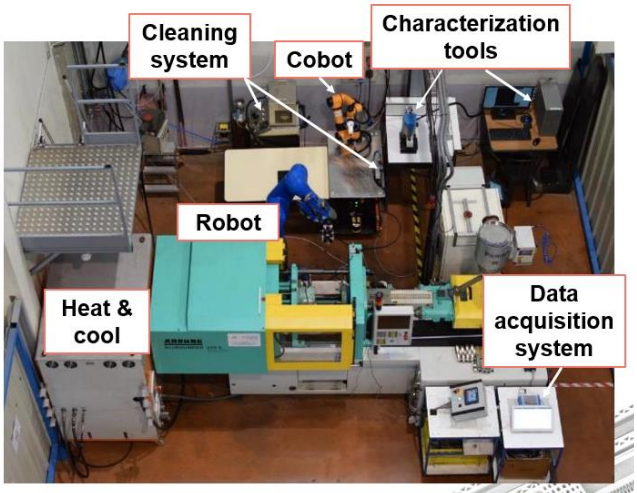
IPC – HIMALAIA Platform

➢ A set of technical means available to the industry to develop nano-textured parts

- Molds incorporating technologies such as:
  - Conformal cooling
  - Additive manufacturing
- Injection with Heat & Cool technology for better tool temperature control
- Mould cleaning by supercritical CO_2
- Online parts control



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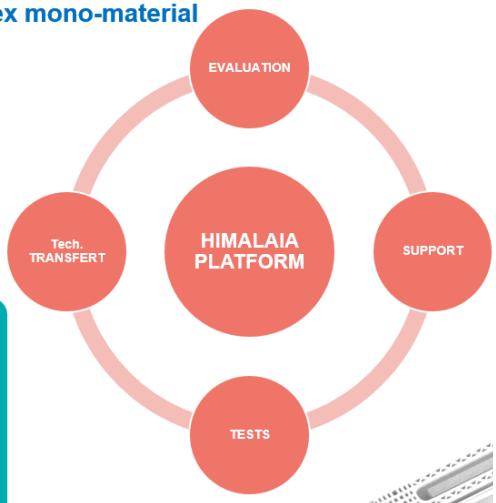
IPC offer – Technical support

➢ **A set of services for the development of complex mono-material plastic parts with functionalized 3D surfaces**

- Technological platform at your disposal for:
  - R&D activities: testing new functionalities, micro/nanostructures, new materials, etc.
  - Development of POC (Proof-of-concepts)
  - Deployment support and technology transfer
- Complementary skills and experts who support you throughout the process



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6.2 Pitch on nano-fabrication techniques to create added value properties in composite parts

Nano-fabrication techniques to create added value properties in composite parts

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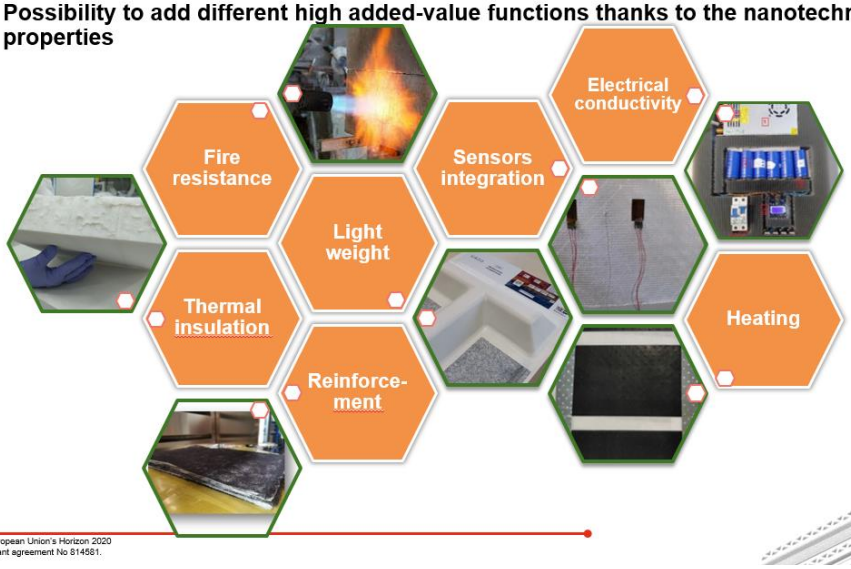
Why nano-fabrication?

Possibility to add different high added-value functions thanks to the nanotechnology properties



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Why nano-fabrication?

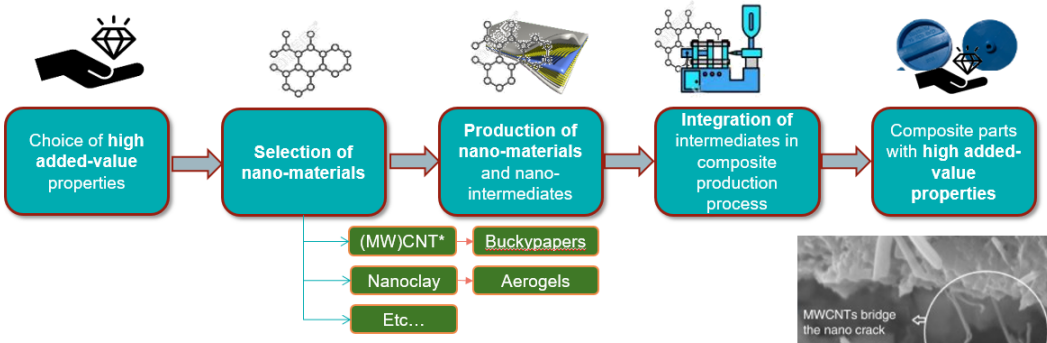
- Increasing demand for **composite parts with enhanced functions** :
  - light-weight,
  - reinforced,
  - Embedded sensors,
  - Thermal insulation, etc.
- Need for **new type of tailored solutions with several of those properties** to enhance the composites capabilities.
- Addition of **nanotechnology and advanced manufacturing** providing additional properties and **added value without increasing weight and cost.**

Automotive demonstrator including lightweight and reinforced function thanks to carbon nanotubes, and thermal properties (insulation, fire resistance and induction heating) thanks to aerogels and buckypapers, and embedded sensors produced with nano-ink

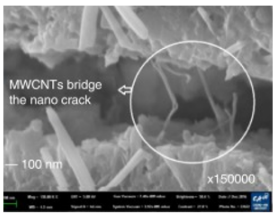
Sensors embedded in battery casing lid thanks to nano-ink printed electronics and overmould process of thermoplastic composite for lightweight property

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814581.

Functionalization process



➢ **Implementation of the high added-value function in composite parts production process**



Bridging effect provided by carbon nanotubes that enhanced crack resistance

Ali Naqi et al. Journal of Materials Research and Technology Volume 8, Issue 1, January–March 2019, Pages 1203-1211

**MWCNT: Multi Walled Carbon NanoTube*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814581.

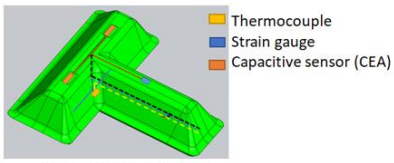
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 882506.

Application examples – Automotive

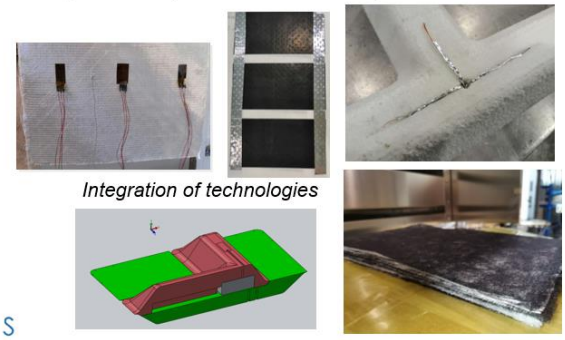
➢ Heating functionality thanks to buckypapers

Development of a demonstrator panel for automotive application:

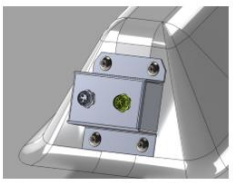
- Incorporation of buckypaper heating elements.
- Complete infusion of the final product without compromising the homogeneity of the heating capacity.
- Maintain the current surface quality with sensors integration.
- Increase of strength after impact thanks to CNT doped veils.



Demonstrator



Integration of technologies



Connection to vehicle

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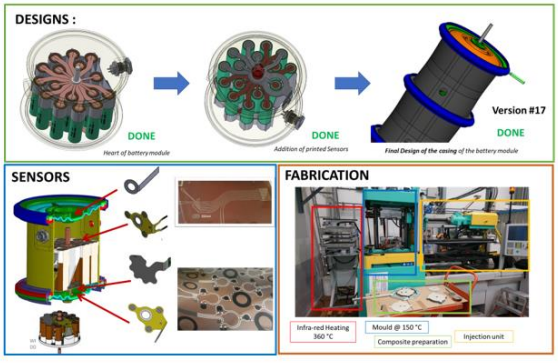
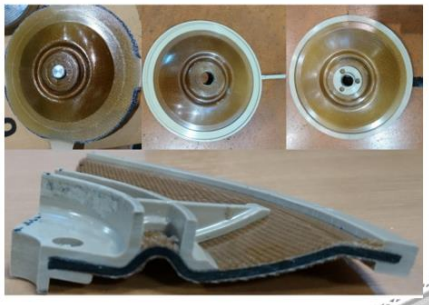
Application examples – Aerospace

➢ Smart functions and lightweight properties

Development of battery casing for aerospace applications

- Choice of adequate material for each part of the casing
- Real improvement on the flame propagation of the composite thanks to fire retardant nanoparticles
- Integration of printed thermocouple and printed piezo acoustic sensor
- Weight reduction of 17% compare to current solution





Different stages of part production

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Application examples – Building

➢ Electrical functionalities

Prefabricated sound absorbing panels with integrated energy storage devices:

- Reinforcement of lightweight composite materials
- Integration of flame retardant nanomaterials

Demonstrator panel with integration of Pleione's supercapacitor module to the final supercapacitor Power Bank

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IPC – OASIS pilot lines

➢ Set of 12 pilot lines offering services from nanomaterials production to nano-enabled parts

- **Nanomaterials production**:
  - FUNCTIONALIZED NP: SiO_2 nano reinforced aerogels. functionalized nanoparticles
  - NANOWET: wet chemical nanoparticles and nanomaterial synthesis
  - NANOCOMPOSITES: magnetic and flame-retardant nanoparticles and nanocomposites
- **Nano-intermediates:**
  - BUCKYPAPER: self-supporting continuous sheets of entangled MWCNTs "buckypapers"
  - CNT DOPED VEILS: lightweight and thermoplastic nonwovens doped with CNTs
  - R2R: CNT treated prepregs
  - PICTIC: sheet to sheet printed devices
  - SIMPNANO: nano-reinforced metallic alloy lingots
- **Nano-enabled products:**
  - METcast: nano-enabled lightweight injected cast parts. functionalities: mechanical and wear resistance properties
  - **RTM: nano-enabled functional polymer based composites parts (IPC)**
  - **HCIM: nano-enabled functional hybrid Al/composite/plastic parts products (IPC)**
  - NanoPUL: nano-enabled Al/composites hybrid products

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IPC – OASIS pilot lines

➢ IPC offers from OASIS technologies

- **RTM**: nano-enabled functional polymer based composites parts (IPC)
  - Develop large smart composite parts
  - Perform in-line control of the process parameters, including viscosity
  - Perform in mold control of the curing stage and pressure
  - Facilities:
    - *300T vertical press*
    - *platen size: 3,0 m x 2,5 m*
    - *bi-component injection machine*
    - *composite parts with complex shapes and surfaces up to 3 m^2 with an output of 24 parts/day*

RTM vertical press

- **HCIM**: nano-enabled functional hybrid Al/composite/plastic parts products (IPC)
  - Develop large smart composite parts.
  - Perform in-line control of 100 % of the product.
  - Apply non-destructive testing technologies.
  - Facilities:
    - *horizontal composite injection molding machine*
    - *composite parts with size up to 1,5 m*
    - *heating and forming thermoplastic prepregs, followed by injection molding*

Horizontal composite injection molding machine

OASIS

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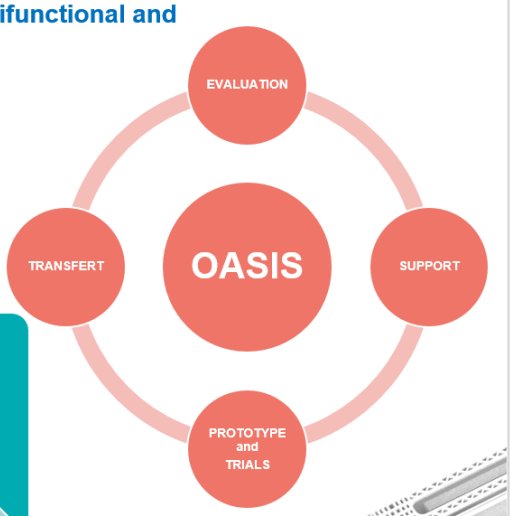
IPC offer – Technical support

➢ A full set of service to answer to your multifunctional and lightweight composite needs

- Set of pilot lines and services among Europe:
  - Support for product development: selection of materials, development, characterization, design and modelling…
  - Prototype and small batch development
  - Support for technology transfer
- In addition to pilot lines other services such as design, modelling, characterization, nanosafety, business support are available to answer to your needs



OASIS

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