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SUSNANOFAB

Grant Agreement No. 882506

Training pilot based on 3 real case scenarios

Document Details

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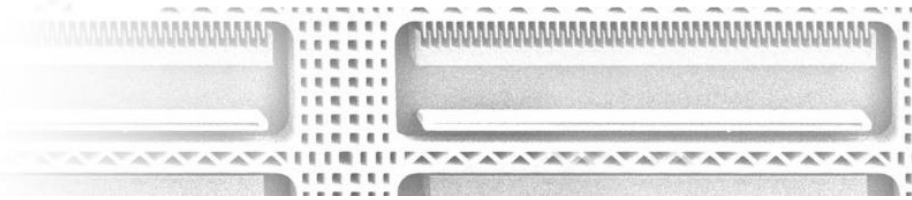
Document History

Version	Date	Description
V1.0	02/12/2022	First version of the deliverable
V2.0	27/02/2023	Completed version of the deliverable
V3.1	13/03/2023	Review and validation of the final version of the deliverable

Abbreviations and Acronyms

Acronym	Description
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
MNL	Multi-Nano-Layers
NM	Nano-Material
Q&A	Question & Answer
RRI	Responsible research and innovation
SPD	Severe Plastic Deformation
SSbD	Safe and Sustainable by Design



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Contents

Acknowledgments

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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 has established a robust network on nanofabrication to tackle the missing links between policies, infrastructure, expertise, and industry requirements. The SUSNANOFAB project has proposed 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 was committed at delivering an EU-wide Strategic Roadmap on Nanofabrication. This roadmap among others has covered 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 has developed an Open Access Digital Platform that interoperates with current platforms, projects, and other initiatives at the European level.

Specifically, the deliverable D4.6 describes the results from the project task 4.3 – *Planning and deployment of training activities*. This report describes the trainings activities, that were designed and proposed to different stakeholders. The report also includes the feedback received from the trainees during those sessions as well as description of the training content, what training tools have been used and to whom they had been delivered.

In addition to the five trainings sessions that were organized during the frame of the project, a training pilot based on 3 real case scenarios was deployed during the SUSNANOFAB final event organised in Vienna from February 23rd to 24th 2023. The final event offered the possibility to provide on-site training offering interactions with the trainees. Finally, other type of tool were developed and tested during this event such as video learning nuggets

Most of the trainings created in the frame of the SUSNANOFAB project are public. 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.
A final version of the training activities in the form of three training pilots focused on different nanofabrication processes has been developed and implemented during the project final event organized in Vienna from February 23rd to 24th, 2023.
In the next section, the following steps will be explained and detailed:

- List of the first trainings sessions describing the title, topics, number of attendees and link to the replay.
- Presentation of the SUSNANOFAB final event training actions. It will include:
  - Detailed description of the training content (What)
  - What training tools had been used (How)
  - Whom it has been delivered to (Who)
- Actions to continue the promotion of these trainings and access to training materials

2 Description of first training sessions

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.

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

2.1.1 Description of the training session

Based on the **identified training need related to the eco-design enabled products** identified in the deliverable D4.1 of the project, 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	15 participants
Number of replay viewers	9
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, waterproof, 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

2.1.2 Feedbacks and figures

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 cycles 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?*

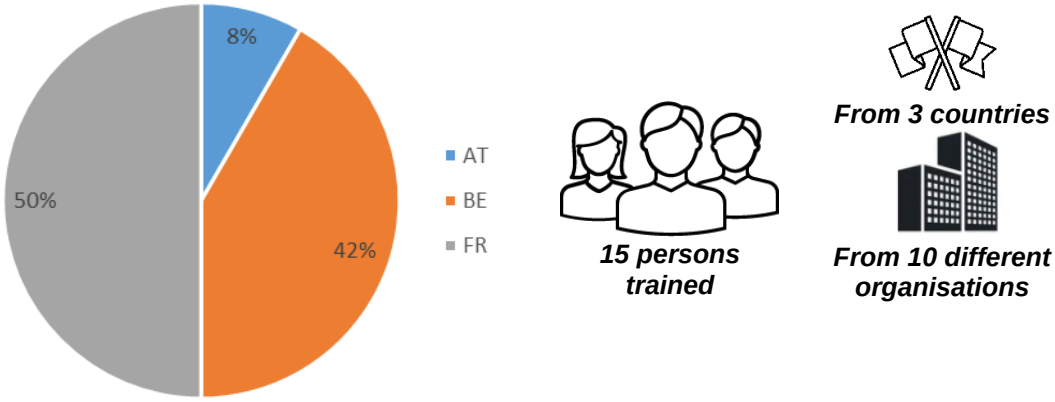

Figure 1: Statistics for the IPC/RINA workshop

2.2 Nanosafety

2.2.1 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, SMEs or 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 participants
Link to the replay	*Confidential*
Second Date	18/01/2022
Duration	3h
Number of participants	33 participants
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

2.2.2 Feedbacks and figures

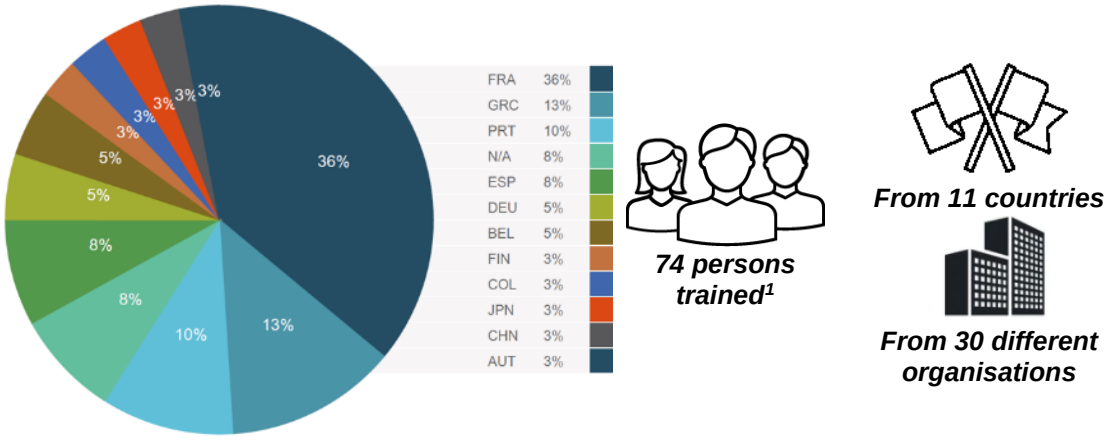

Figure 2: Statistics for the CEA nanosafety workshop

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

2.3.1 Description of the training session

A 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

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

Date	01/03/2022
Duration	40 minutes
Number of participants	11 participants
Number of replay viewers	2
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.

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

2.3.2 Feedbacks and figures

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

- *What is the 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.*

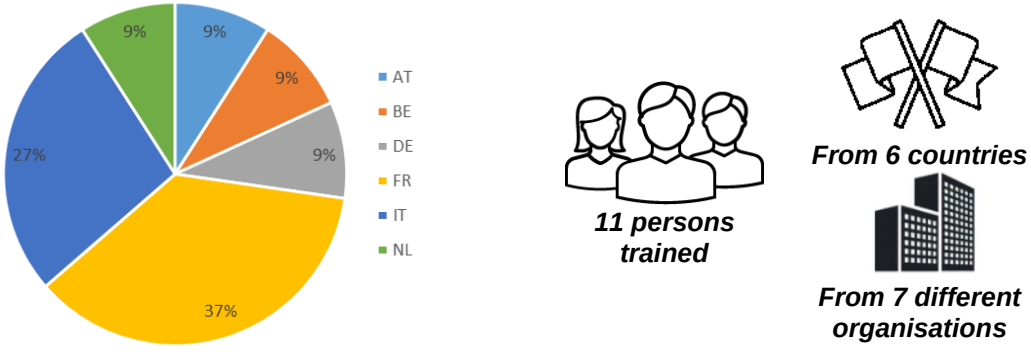

Figure 3: Statistics for the IPC nano-enabled composites parts workshop

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

2.4 Initiation to Safe-and-sustainable-by-design (SSbD): perspectives for nanomaterials

2.4.1 Description of the training session

This training was provided during the Networking event organised in INL facilities in Braga from July 5th to 7th, 2022. The objective of this training was to introduce the SSbD concept and how nano-manufacturing can use it and provide recommendations. This training was identified as a missing piece of knowledge during the training needs identification session organised in March 2021 (see D4.1).

Title	Initiation to Safe-and-sustainable-by-design (SSbD): perspectives for nanomaterials
Lead participant	IPC
Language	English
Type of training	On-site + Online
Date	05/07/2022
Duration	40 minutes
Number of participants	27 participants
Number of replay viewers	24
Link to the replay	https://www.youtube.com/watch?v=ysSPt0Gk3qg
Short description	This session introduce the concept of SSbD, with first presents the planet boundaries global issue, then the Safe topic followed by the Sustainable topic. These introductions allow to describe the SSbD concept. The second part aimed at offering practical view of this concept, reminding EU regulation, how works SSbD scoring and how in practice needed data were obtained to process it. Finally the SSbD concept was applied to nanomanufacturing, with introduction of predictive tools and modelling of Safety applied to nanotechnology. Design process and trusted environment for nano-technologies concluded this presentation.

The **training plan** was the following:

1. Presentation of the concept of SSbD
2. SSbD in practice
3. SSbD for nanomaterials

2.4.2 Feedbacks and figures

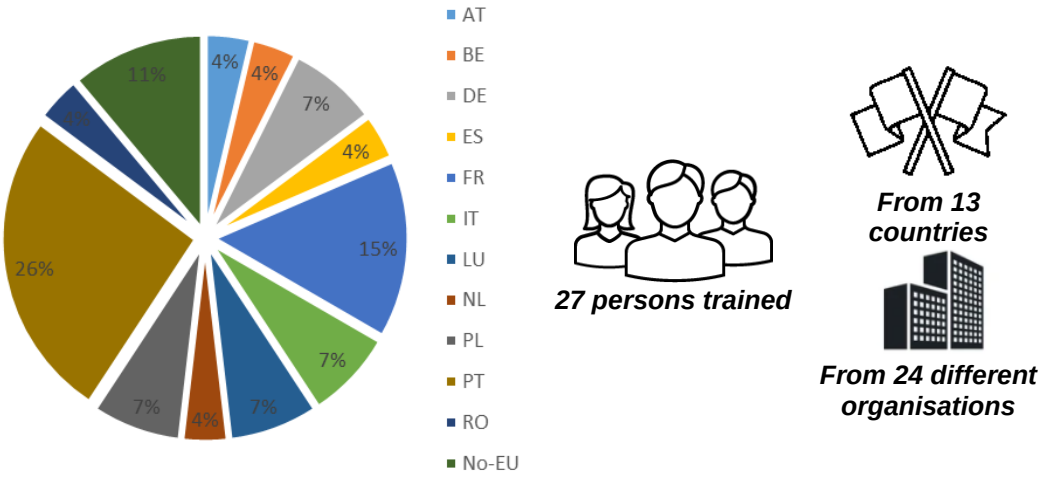

Figure 4: Statistics for the SSbD session during Braga Networking Event

2.5 Towards harmonized test methods for nanomaterials in the NanoHarmony project

2.5.1 Description of the training session

As in the previous section, this training was provided during the Braga Networking event in July 2022. The objective was to provide general information about standardisation for nano-manufacturing industry. It was a key demand expressed during the training needs session in 2021 (see deliverable D4.1).

Title	From Science to Standards and Guidance: Towards Harmonized Test Methods for Nanomaterials in the NanoHarmony Project
Lead participant	NIA
Language	English
Type of training	On-site + Online
Date	05/07/2022
Duration	55 minutes
Number of participants	27 participants
Number of replay viewers	12
Link to the replay	https://www.youtube.com/watch?v=DYp-rXz-45E
Short description	This session aims to provide information about standards and test guideline to nanomanufacturing industry. Indeed, standards and test guidelines are important tools for industry to use to help them develop new products that can reach the market in an efficient and regulatory compliant way. Standards are useful to end users in ensuring that the concerned products have been manufactured or tested using established methods that are understood and accepted to other

	industry experts. OECD Test Guidelines are also useful to industry to ensure that they are complying with regulations, such as REACH. This training session will cover using and developing standards from a CEN perspective and how OECD Test Guidelines are developed and used and how the NanoHarmony project is working to help the whole nano community by adapting nano-specific test guidelines.

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

2.5.2 Feedbacks and figures

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.

- *Do we need to have quality standards controls and how to perform them?*
- *Do you think is it possible to optimise the effort in preparing Standard Project Submission Form (SPSF) when different projects/initiatives are working on adaptation/optimization of the same techniques? If yes, how?*
- *What are the solutions for identifying the needs and priorities of EU stakeholders in term of standardisation?*
- *Resources are limited to move forward on these issues, so how can we prioritise the work to be carried out?*
- *How industry is involved in test guideline developments?*

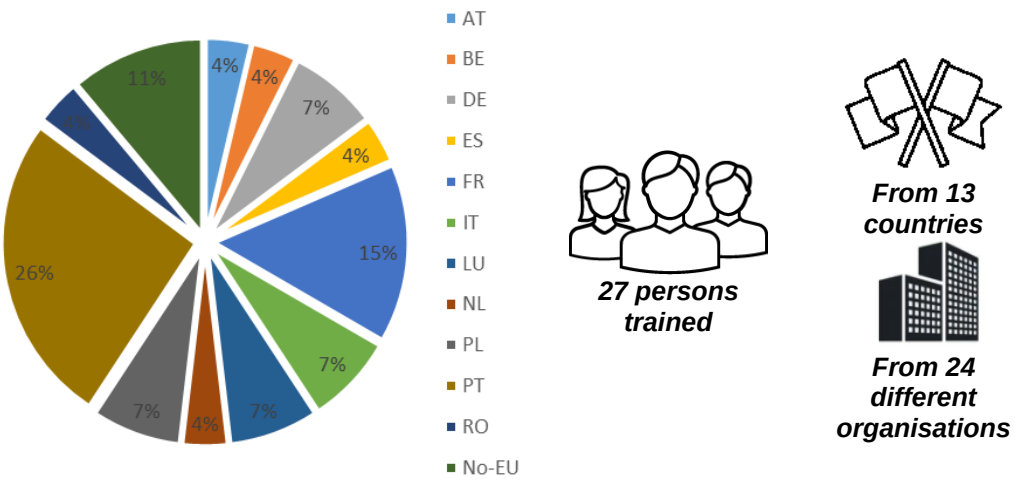

Figure 5: Statistics for the Standardisation session during Braga Networking

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3 Training pilots based on 3 real case scenarios

3.1 Context

In the previous project task, Task 4.1, training gaps had been identified for the nanofabrication domain. 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*Figure 6). Trainings developed in Task 4.3 activities were defined based on the requirements of precise industrially relevant technologies.

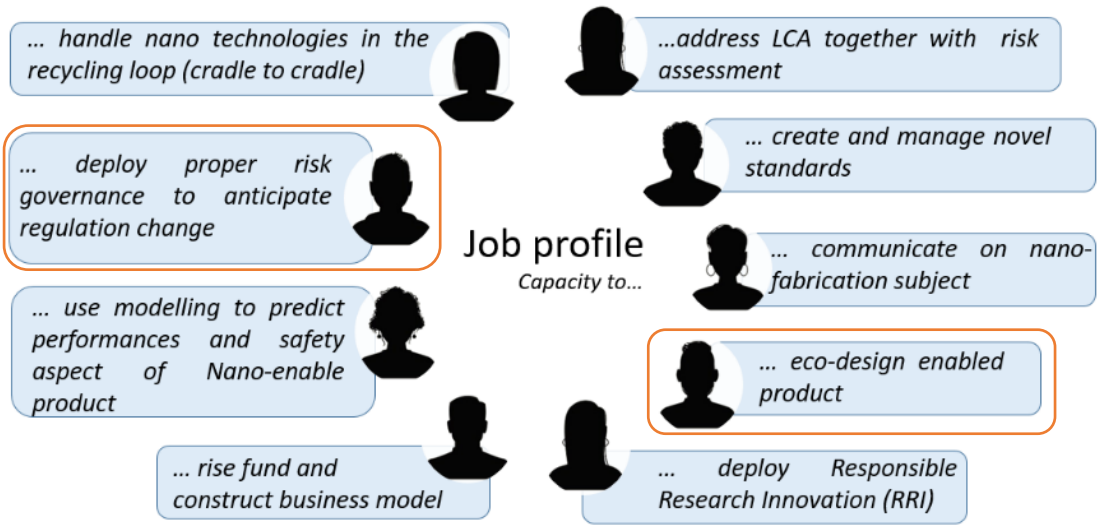

Figure 6: list of potential missing skills or job profiles to create and the ones addressed by the 3 real case scenario

During the final event of the project organised in Vienna, from February 23rd to 24th, 2023, 3 training pilots was organised. These three pilots were addressing directly the needs identified by the project (described in orange in the Figure 6), due to the importance of these topics identify during training needs phase. The idea was to answer the industrial needs in accordance with partners' expertise, as followed:

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

These trainings were initiation on these topics, based on oral presentation. This format also offered interactions possibilities with the trainees, thanks to the onsite organisation.

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3.2 Description of real case scenarios

3.2.1 Nanosafety

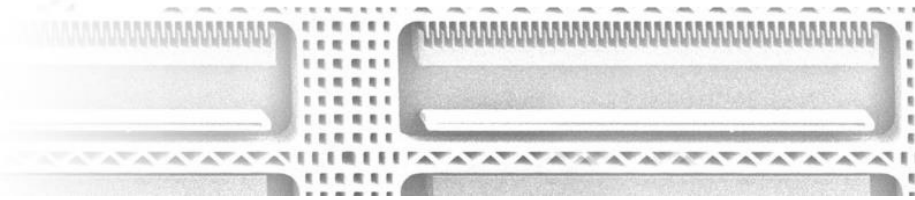
Title	NANOSAFETY training
Lead participant	CEA
Language	English
Type of training	Onsite
Date	23/02/2023
Duration	1,5h
Number of participants	23 participants
Short description	After two joint SUSNANOFAB and OASIS nanosafety workshops held in October 2021 and January 2022, a summarized version is given at the final SUSNANOFAB event in February 2023. This introductory nanosafety course is divided into three main chapters. First, an overview of the nanoworld is given to the participants with specific and general definitions, aspects of legislation and slight information on hazards. Second, the exposure mechanism is explained with simplified aerosol physics highlights. Third, once the hazard and exposure are lightly explored, the presentation goes into more depth on risk management measures with a focus on collective protective equipment and best practices

The **training plan** was the following:

1. Discovering nanosafety
2. Exposure assessment and metrology of aerosols
3. Risk mitigation

3.2.2 An initiation to micro/nano surfaces texturing and eco-design

Title	An initiation to micro/nano surfaces texturing and eco-design
Lead participant	IPC
Language	English
Type of training	Onsite
Date	24/02/2023
Duration	45 minutes
Number of participants	23 participants
Short description	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.



The **training plan** was:

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

3.2.3 Multi-nanolayering technology - Enhanced barrier properties for plastic films

Title	Multi-nanolayering technology - Enhanced barrier properties for plastic films
Lead participant	IPC
Language	English
Type of training	Onsite
Date	24/02/2023
Duration	45 minutes
Number of participants	23 participants
Short description	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, waterproof, 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.

The **training plan** was:

1. Presentation of IPC
2. Introduction
3. Confinement effect
4. Process description
5. Products
6. Conclusion

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3.3 Participations and feedbacks from participants

During this event, 23 participants took part to the training sessions, in addition to consortium members.

A Q&A session was organized at the end of each session. The questions collected are described below:

- *For Nanotexturation and MNL sessions, questions raised after both trainings:*
  - *Is there any issues with nanosafety to process these technologies?*
  - *Are industrials ready to use these technologies?*
  - *Does the simulation propose models correlated to the process?*
  - *For MNL: what are barriers performance? Do they provide same performance as commercial materials?*

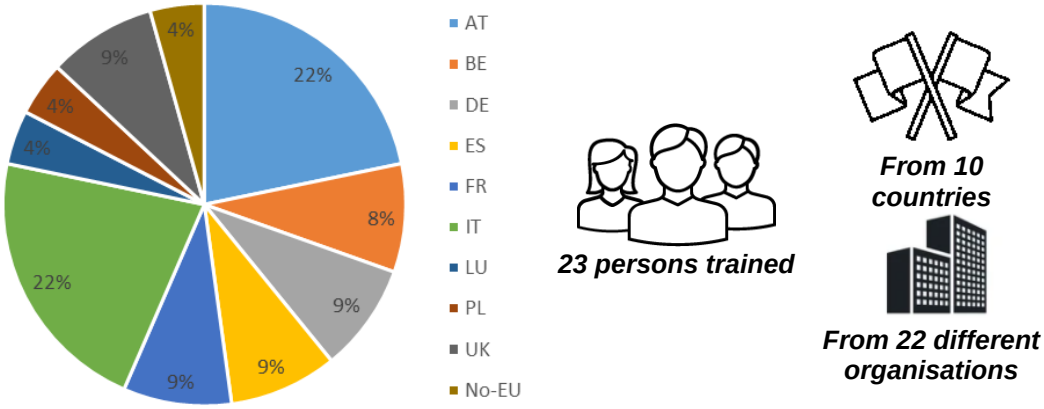


Figure 7: Statistics for the Training pilot during Final Event in Vienna

4 Other means of training

4.1 Pitch decks

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. Those pitch decks have been used **to train and create awareness** within the partner's industrial network. They are available for the following topics:

- Initiation to micro/nano surfaces texturing and eco-design
- Initiation to nano-enabled composites parts through the presentation of an industrial use case

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

4.1.1 Pitch on micro/nano surfaces texturing and eco-design

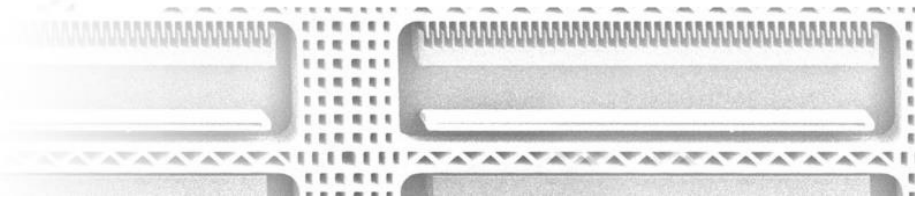
- s described in the annex, a pitch deck was prepared for the nano-structuring techniques for injected plastic parts. The pitch was disseminated throughout 2022 through social networks to maintain a higher visibility of the training and prepare for the final event.

To tackle the growing demand for plastic parts with functionalized surfaces while answering the circular economy challenges, the pitch deck will be **used to disseminate the content and train future technology adopters on 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 leads to this important interest in mono-material products with functionalized surfaces for improved durability and recyclability.

4.1.2 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 pitch deck was developed to introduce nano-fabrication techniques applied to composite parts.

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



4.2 Learning nugget videos

One objective of SUSNANOFAB is to disseminate complex concept to a large audience and provide more accessible information about technical nanomanufacturing processes. In order to answer this objective, learning nuggets, in the form of short videos, were developed for three trainings:

- Initiation to micro/nano surfaces texturing and eco-design
- Multi-nanolayering technology - Enhanced barrier properties for plastic films
- Initiation to Safe-and-sustainable-by-design (SSbD): perspectives for nanomaterials

They were displayed during the SUSNANOFAB final event.

These learning nuggets were developed as animated videos to widely share knowledge. They are not only addressing technical expertsbut also the general public which is not easy to reach.

These videos have been spred among the SUSNANOFAB YouTube channel, and also shared with interested projects and initiatives.

In order to facilitate the lecture of this deliverable, in addition to the video, each of them will be displayed in a global fresco. It shows all sequences of a video in one image.

4.2.1 Video on initiation to micro/nano surfaces texturing and eco-design

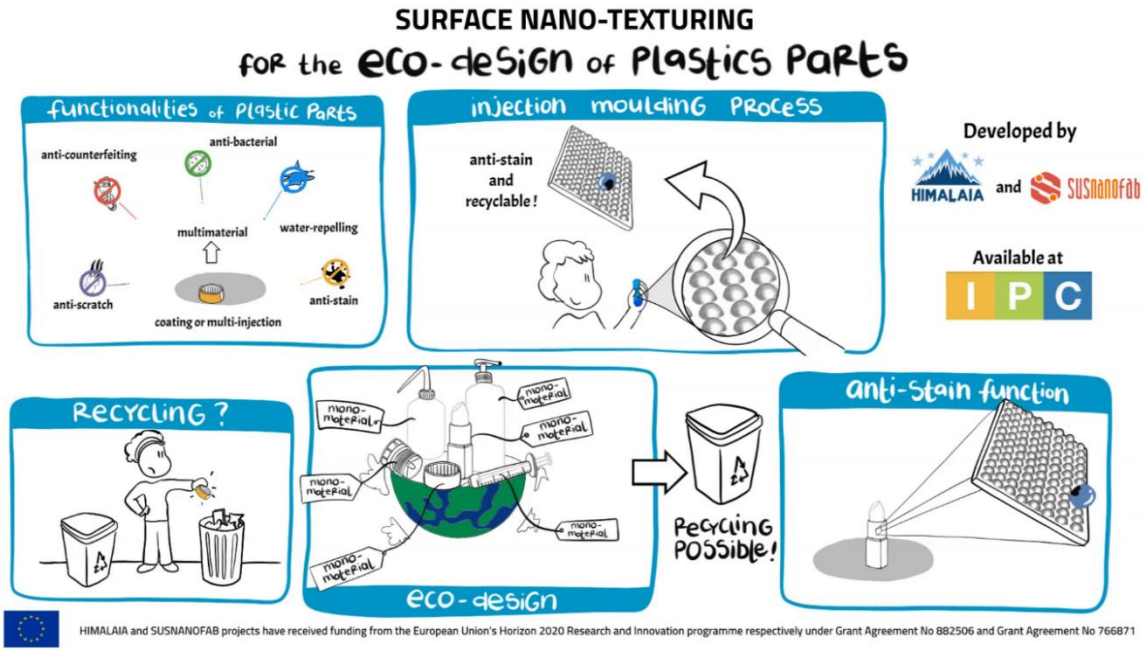


Figure 8: Storyboard of surface nano-texturing video

Available on the following link: https://www.youtube.com/watch?v=x9QewrnR25Q

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4.2.2 Video on initiation to multi-nanolayering technologies

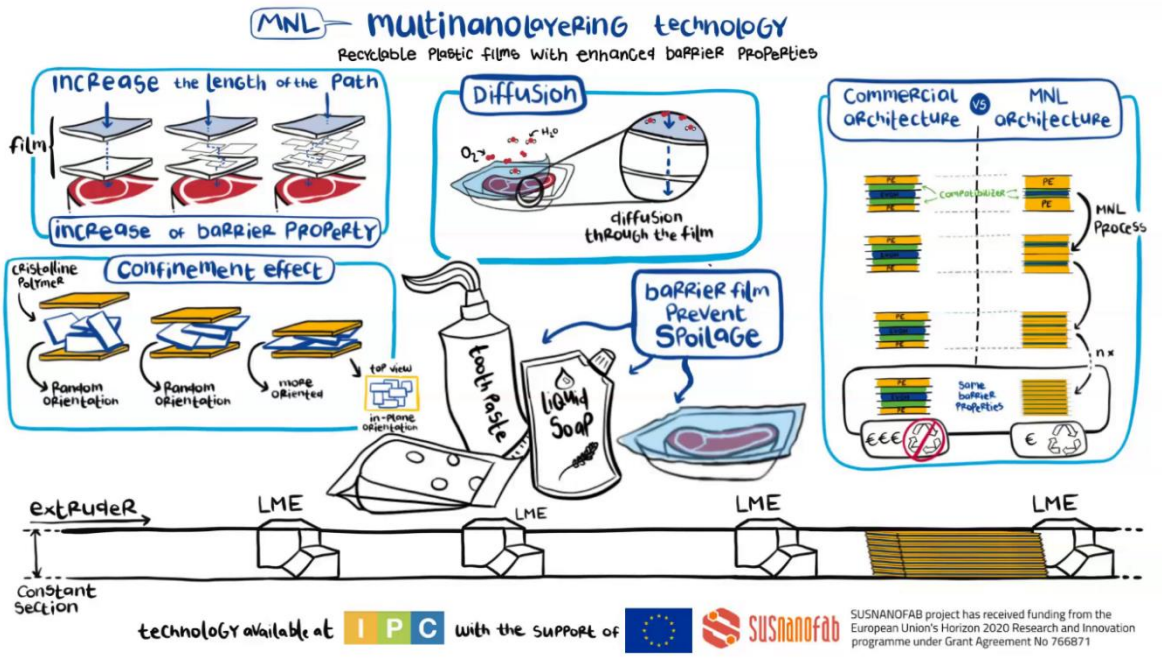

Figure 9: Storyboard of the MNL video

Available on the following link: https://www.youtube.com/watch?v=H3-e0CxsGc0

4.2.3 Video on initiation to Safe and Sustainable by Design concept

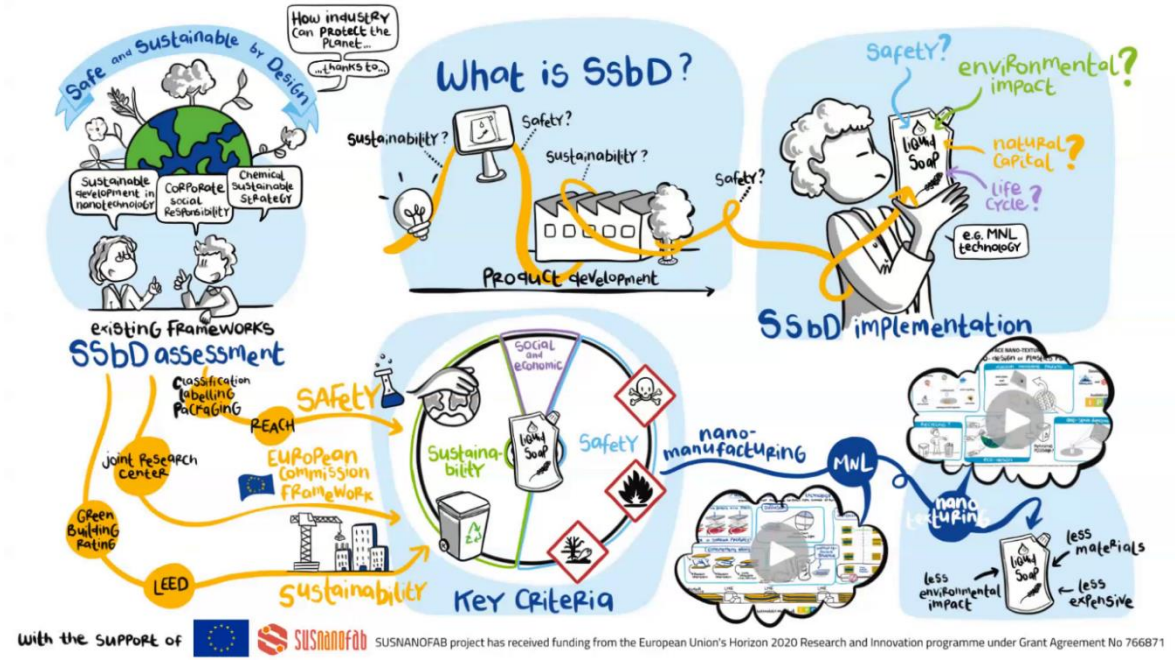

Figure 10: Storyboard of the SSbD video

Available on the following link: https://www.youtube.com/watch?v=xB2AHVdsRmU

5 Conclusion

The deliverable D4.6 provides a general view of all activities performed in the frame of the trainings implementation. In addition, to summarize the work carried out between M14 and M25 of the project and already described in D4.3, this deliverable presents additional trainings that were performed.

The three real case scenarios are also described, as well as additional training materials (pitches and learning nuggets).

Hence, novel trainings were created based on the task T4.1 outputs. Figure 11 shows that nearly 70% of the expressed needs were covered by SUSNANOFAB trainings.

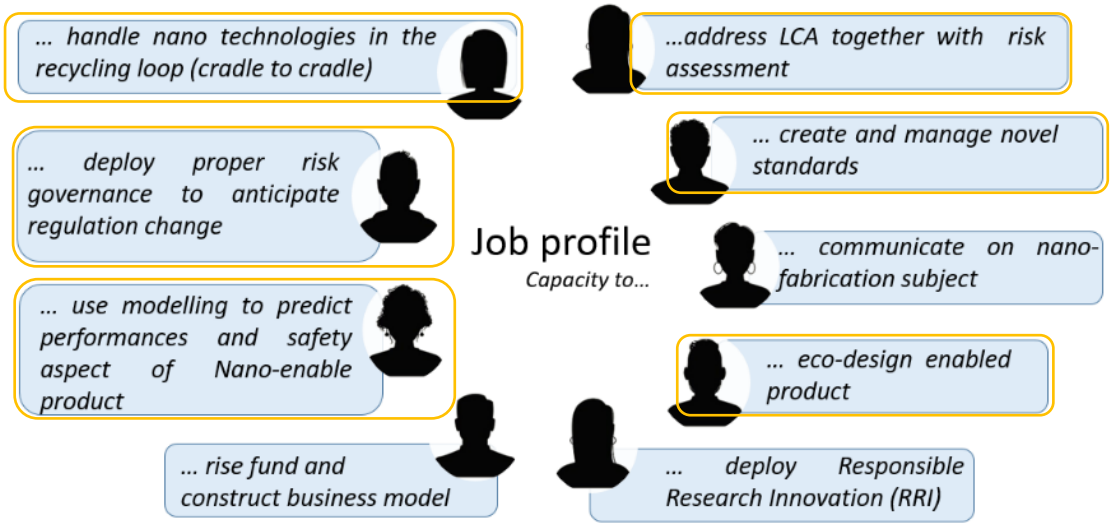

Figure 11 - list of potential missing skills or job profiles to create and the ones addressed during the whole duration of the task T4.3

Indeed, following needs were address with specific trainings, such as:

- To handle nano technologies in the recycling loop (cradle to cradle): Nano-texturing, multi-nanolayering and SSbD trainings
- To deploy proper risk governance to anticipate regulation change: Nanosafety and standardisation trainings
- To use modelling to predict performances and safety aspect of Nano-enable product: Nanosafety training
- To address LCA together with risk assessment: SSbD training
- To create and manage novel standards: Standardisation training
- To develop eco-design enabled product: Nano-texturing and Multi-nanolayering trainings

Most of the trainings created in the frame of the SUSNANOFAB project are public. The webpage in the SUSNANOFAB project website dedicated to trainings hosts replays and dissemination materials. The webpage is accessible with the link: https://susnanofab.eu/trainings/.

In order to perform this work different tools were developed. On-site presentations, online webinars, replay videos for whom not able to participate. In addition to the type of training based on presentations, tools were also developed to enhance the spreading of these trainings. Pitches are available for two trainings in order to easily communicate during face to face meetings. Learning nuggets, offering short and didactic presentations, are also available and online.

These trainings allowed to reach a large panel of participants as represented in Figure 12.

Figure 12: Global KPI of the project task 4.3

As a conclusion, even after the project's end, these materials will remain available to continue to provide support to the nanomanufacturing industry. Partners will be encouraged to spread these materials and also to share them with other initiatives interested in this topic.