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

SUSNANOFAB

Grant Agreement No. 882506

Second report on the CG sessions

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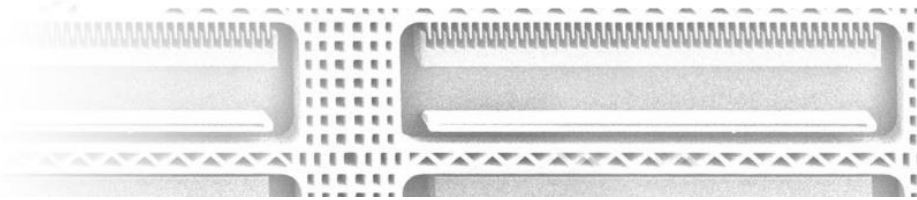
Abbreviations and Acronyms

Acronym	Description
CSA	Coordination and support actions
EC	European Commission
EHS	Environmental, health and safety
IA	Innovation action
LCA	Life Cycle Analysis
PPP	Public private partnership
RIA	Research and Innovation action
SSbD	Structured safe and sustainable-by-design



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Executive Summary

This document is the deliverable D3.4 of the SUSNANOFAB project – a coordination and support action to promote a competitive and sustainable nanofabrication industry - funded by the 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 the whole value-chain, aiming at the promotion of a competitive and sustainable nanofabrication industry.

At a strategic level, the project is committed to delivering an EU-wide Strategic Roadmap on Nanofabrication. This roadmap among other will cover nanofabrication aspects from design to manufacturing upscaling, environmental sustainability, health & ethics matters, as well as future skills & capabilities.

The aim of this report is to report the activities done with regards the establishment of the three SUSNANOFAB Experts coordination groups (CG) and their contributions to the roadmap development.

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1 Introduction

The present document constitutes Deliverable D3.4 in the framework of the SUSNANOFAB project "a coordination and support action to promote a competitive and sustainable nanofabrication industry" funded by the Horizon 2020 Programme, under Grant Agreement nº 882506.

This report is the result of activities performed within the framework of Work Package 3 "*Roadmapping and international cooperation*", and more specifically on Task 3.1 "*Organisation and activation of Coordination Groups of EU and international experts*" led by IDONIAL. Task 3.1 (M04-M34) is focused on formation and activation of the Experts' Groups, willing to collaborate in SUSNANOFAB roadmapping activities. Several entities and experts have been contacted and asked to express their interest to join the coordination groups and cooperate on project activities.

In continuation of the actions to roadmapping development in collaboration with experts, the consortium has organised, during this period, two interactive sessions inviting relevant stakeholders that are members in the three Coordination Groups (CGs). The 3rd meeting has been held on-line on March 2022 and the 4th meeting as a hybrid meeting in July 2022.

The aim of the meetings was to validate the roadmap and assess the impact of the proposed actions related to nanofabrication landscape. This report summarises the results of these meetings.

2 SUSNANOFAB Roadmapping path

The road-mapping activity aims at the development of a strategic plan for the field of nanofabrication and its path for industrial implementation

The stakeholders of SUSNANOFAB are a broad community with expertise in the nanofabrication sector that can hold a high interest towards the project. The SUSNANOFAB Coordination Groups (CGs) are organised by integrating nanoscale building blocks to favour proactive analysis and discussion on the nanofabrication industry and validate the roadmap contents and actions.

During the project the following CGs were created by inviting experts both from EU and USA and the chairs and co-chairs nominated, being the 1st one from Europe and the 2nd from USA. Nanofabrication was considered by three different perspectives, which are represented in the three SUSNANOFAB Coordination Groups (CGs):

Coordination Group 1 (CG1) deals with **Nanofabrication aspects** from material design to manufacturing upscaling. The group is chaired by IDONIAL and co-chaired by BROWN: Its main objectives are.

- Research and innovation agenda focusing on innovative nanofabrication technologies for SUSNANOFAB target products covering all relevant steps of the value chain.

- Identification of actions that require an international dimension to address existing gaps in the development and uptake of common approaches in design, modelling, characterisation and testing focusing on nanofabrication.
- Recommendations for new standards on nanofabrication technologies.

Coordination Group 2 (CG2) focuses on **Environmental and Sustainability issues**, Health and Ethics in a Life Cycle Perspective. The group is chaired by CEA and co-chaired by BAYLOR: Its main objectives are:

- Identification of EU research and innovation actions on the economic and environmental health-related sustainability efforts of SUSNANOFUB products.
- Identification of activities that require an international dimension to address existing gaps in nano-EHS research, inclusive of environmental, social and economic life cycle analyses, and knowledge dissemination by the stakeholders.
- Identification of actions where nanofabricated products and processes address current ethical issues and promote inclusiveness within EU and international countries.
- Recommendations for new standards in the CG (i.e. EHS) area.

Coordination Group 3 (CG3) focuses on **Future skills and capabilities,** chaired by INL and co-chaired by GTRC: Its main objectives are:

- Identification of EU research and coordination actions targeting different levels of education, from masters, PhDs, as well as workforce training courses, focusing on the identified nanofabrication educational needs.
- Identification of actions that require an international dimension to address the existing gaps in nanofabrication skills and education. Such actions may take the form of novel student and workforce exchange programmes, common nanofabrication curricula for masters, PhD and workforce training courses.

The groups have been enlarged to reach at least a minimum of 20 experts per CG. A good diversity of backgrounds (e.g. large companies, SMEs, RTOs, pilot's owners, policy makers, and associations) is also pursued. Moreover, members of the sister project "Nanofabnet[1]" are included for better coordination among both actions.

Participations of Experts is expected in different key points on the roadmap path development (Fig.1). Specifically, the following CGs meetings have been organised with different purposes:

- Initial CG meeting: Brainstorm session on the roadmap vision, and high level challenges and drivers
- 2nd CG meeting: To check on the challenges defined and needed actions to overcome them
- 3rd CG meeting: Roadmap validation and impact assessment -held on-line on March 2022
- 4th CG meeting: Co-creation session -hybrid type on July 2022

[1] NanoFabNet –"International hub for sustainable industrial-scale nanofabrication" https://www.nanofabnet.net/

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A 5th physical session for roadmap final presentation is expected to be held in Austria (Vienna) in February 2023.

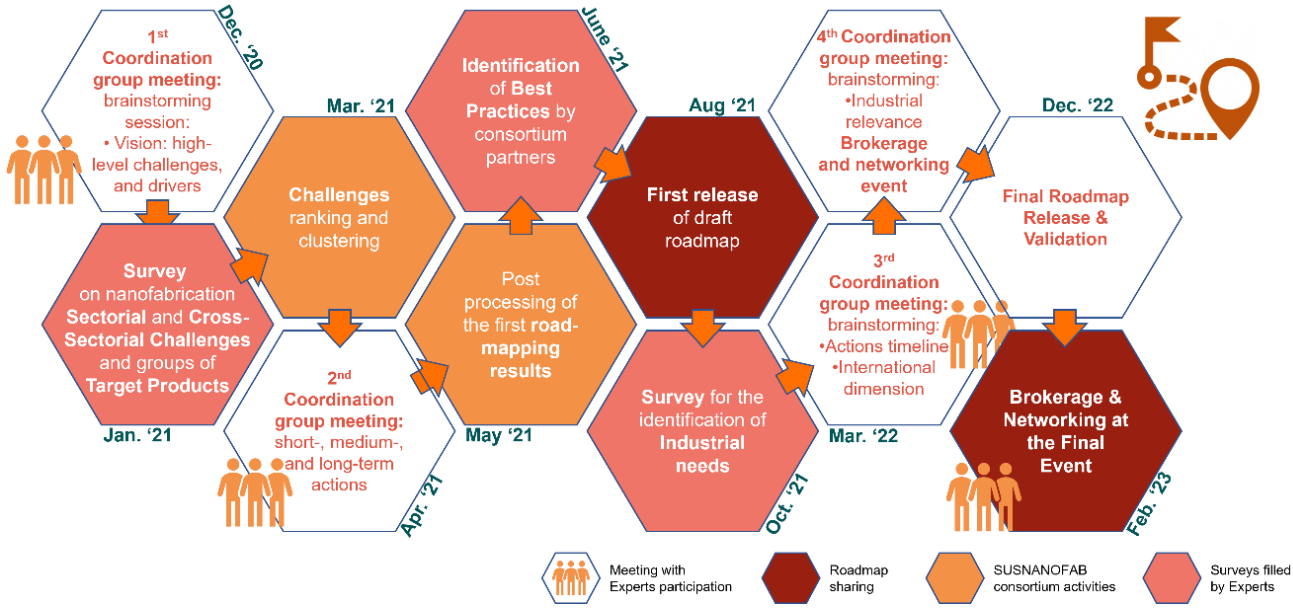

Fig.1 *Roadmapping path and expert's involvement*

The roadmap focus is on nanofabrication technologies and related non-technical issues to produce nanofabricated products. No focus on nanomaterial/nanoparticles synthesis but rather on the integration nanotechnology on micro/macro products.

SUSNANOFAB Roadmap has been developed and expanded by a combination of the expert workgroups and desk research, which integrated the results of key initiatives developed within the SUSNANOFAB network.

2.1 The SUSNANOFAB Action Plan

The SUSNANOFAB Action Plan is a key component of SUSNANOFAB Roadmap, aimed at identifying key research and innovation actions where public and private stakeholders may invest in the near future for unleashing the full potential of nanofabrication. The objectives of the action plan activity are:

- to collaboratively consolidate the work carried out in the development of the reported actions and to further refine its contents.
- to leverage a larger number of experts, in order to enlarge the perspective of the action plan, to add more actions, either cross-cutting or sectorial, considering key sectors not duly represented at the moment (i.e., energy & smart mobility, construction, etc.);
- to determine the priority/timeline of the action and the international relevance

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This action plan has been derived from a re-clustering process of the inputs given on the challenges identified throughout our former meeting. In this process, eleven recurring clusters of concepts were identified:

1. Reduction of production costs, efficient cost-production
2. Scaling of volume production, testing, packaging, and deployment; high costs for the scale-up of nano-enabled technology
3. Lack of efficient mass production techniques, methods, and manufacturing capacities causes properties inconsistency in scale-up and impairs process cost-efficiency. Unreliable results are deadlock for translation in several sectors, amongst which the automotive industry
4. Metrology for quality control; Production of 3D structures
5. Lack of investments in nanotechnology, especially for energy production
6. NEMs and MEMs meeting the requirements for mobility sector, nano-sensors for water, soil, and air monitoring; sustainable power sources for wearable devices; Energy efficiency of nanoelectronics
7. Smart delivery systems require full regulatory approval; extensive clinical safety testing is required for nanoparticle-based drug formulations; safety issues of nano fabricated materials; safe-by-design approaches; Lack of information on exposure to nanomaterials; nano health-risks of fertilizers or food-additives; nanoparticles harmful perception in personal healthcare
8. Lack of information improve public perception; public perception of 'harmful' nanoparticles in personal healthcare
9. disposal and recycling of new materials; end of life nanomaterials and nanoproducts
10. Standards for risk assessments and risk management; lack of standardization as training; regulatory framework too slow w/ respect to nanotechnology development; Regulation health risks of nano-fertilizers or food nano-additives
11. Lack of a unified strategy at different levels of education; retrain and continually train skilled workers; Lack of entrepreneurship and innovative management skills; researchers/workers soft skilled to operate in transdisciplinary teams; Bridging the gap on Tech Transfer

Throughout a reorganization and integration of least relevant clusters, develop the action plan reported within this document has been developed. This change was needed to switch the from an issue-oriented perspective (challenges) to an action-oriented perspective (research (RIA), innovation (IA), and coordination actions (CSA)). After both meetings, the following final eight actions have been extracted:

1.-Mass production techniques for a sustainable nanofabrication: volume scaling and product testing (IA)

2.- Digitalisation as enabler of optimized nanofabrication production practices (RIA)3.- A nano-regulation framework: streamlined EHS assessment for nanoparticle-based delivery systems, formulations, and additives (CSA)

4.- Multi-level education strategy (upskill, reskill, and novel education curricula) for bridging the technology transfer gap from transdisciplinary nanotechnology innovation to entrepreneurialism management (CSA)

5.-Metrology for reproducible and reliable product quality in high-impact nanotechnology applications (e.g., mobility, health) (RIA)

6.-Reliable NEMS and MEMS for Key Enabling Technologies: future-oriented and energy efficient nano-sensors and systems for high-impact applications (e.g., mobility, health, and environment) (IA)

7.-Establishing a structured Safe and Sustainable-by-Design (SSbD) approach for the European nanomaterial ecosystem (CSA)

8.-Living materials for multi-function devices (RIA)

3 Third Coordination Groups workshop

The meeting has been celebrated online on the 2nd of March 2022. The objective of this coordination group's meeting was to collaboratively consolidate the work carried out in the development of the action plan, to further refine its contents, and to determine timelines of action and the evaluation of action benefitting from setting up an international collaboration.

Moreover, the best practices and protocols for sustainable nanofabrication and the main industrial needs identified have been presented during the online session.

TIME	ACTIVITY
14.05	SUSNANOFAB road-mapping approach: progress and experts' role Speaker: Paula Queipo, IDONIAL
14.15	A repository of best practices and protocols for a sustainable nanofabrication Speaker: Daniela Lacopino, TYNDALL
14.30	Identification of industrial needs within nanofabrication Speakers: Sean Kelly, NIA
14.45	SUSNANOFAB action plan: evolution and next steps Speaker: Giacomo Damilano, RINA-C
14.55	Break
15.00	Coordination Group (CG) Parallel Sessions Speakers: CG chairs and co-chairs Refining of the action plan focusing on: 1. Content consolidation (14 min) 2. Timeline (22 min) 3. International dimension (8 min) 4. Inter-CG group discussion on the outcomes (18 min)
16.10	Break
16.20	Plenary wrap up session on the outcomes

	Facilitators: CG chairs and co-chairs
16.45	Plenary discussion on the international dimension of the actions Facilitators: CG chairs and co-chairs
17.10	Conclusions of the meeting

Fig. 2 *3rd CG meeting agenda*

A total of 37 participants, including experts of the three CGs, were engaged in the collaborative sessions and share their expertise and opinions on the identified actions

Table 1: *List of the organisations of the attendees to the 3rd meeting*

ENTITY	COUNTRY
RINA-C	Italy
TYNDALL	Ireland
IDONIAL	Spain
TECNALIA	Spain
INL	Portugal
NIA	Belgium
CEA	France
IPC	France
BROWN	USA
BAYLOR	USA
Georgia Tech	USA
Maastricht University	Netherlands
TUW	Austria
LNE Nanotech Institute	France
Technical University of Clausthal	Germany
Research Institutes of Sweden	Sweden
Pennsylvania State University	USA
Fraunhofer Institute for Systems and Innovation Research	Germany
IMNR	Romania

BioNanoNet	Austria
Centre for Research & Technology Hellas - Chemical Process Engineering Research Institute	Greece
ONVENGA	Sweden
Material Research and design (MATRES)	Italy
Université de Lorraine	France
Festo	Germany
Institut catholique d'arts et métiers (ICAM)	France
NTC nanotech Coatings GmbH / NANOfutures	Germany

3.1 Main outcomes

The feedbacks and suggestions received were discussed and included in the draft action plan to shape the final document based on the expertise of different actors of the value-chain and ecosystem. The main result of the 3rd CG meeting was, in this sense, the revised, updated and consolidated version of the action plan.

Other than the collaborative session, a slido pool has been placed to prioritise the actions that will benefit from an international cooperation. Results are shown in the tables below. According to experts the action that will benefit the most is the one on the establishment of a structured safe and sustainable-by-design (SSbD) approach for the European nanomaterial ecosystem. This action also constituted a priority in question of time of execution, although the 1st one in this case is to put the educational strategy in place.

1. Which actions does greatly benefit from an international cooperation?	
Establishing a structured safe and sustainable-by-design (SSbD) approach for the European nanomaterial ecosystem (CSA)	69%
Metrology for reproducible and reliable product quality in high-impact nanotechnology applications (e.g., mobility, health) (RIA)	46%
A nano-regulation framework: streamlined EHS assessment for nanoparticle-based delivery systems, formulations, and additives (CSA)	46%
Mass-production techniques for sustainable nanofabrication: volume scaling and product testing (IA)	38%
Multi-level education strategy (upskill, reskill, and novel education curricula) for bridging the technology transfer gap from transdisciplinary nanotechnology innovation to entrepreneurialism management (CSA)	31%
Digitalisation as enabler of optimized nanofabrication production practices (RIA)	15%
Living materials for multi-function devices (RIA)	8%
Reliable NEMS and MEMS for Key Enabling Technologies: energy efficient nano-sensors and -systems for high impact applications (e.g., mobility, health, and environment) (IA)	0%

2. Please prioritise timewise the actions listed below*	
Multi-level education strategy (upskill, reskill, and novel education curricula) for bridging the technology transfer gap from transdisciplinary nanotechnology innovation to entrepreneurialism management (CSA)	4.92
Establishing a structured safe and sustainable-by-design (SSbD) approach for the European nanomaterial ecosystem (CSA)	4.08
Mass-production techniques for sustainable nanofabrication: volume scaling and product testing (IA)	3.79
Digitalisation as enabler of optimized nanofabrication production practices (RIA)	3.79
Metrology for reproducible and reliable product quality in high-impact nanotechnology applications (e.g., mobility, health) (RIA)	3.67
Living materials for multi-function devices (RIA)	3.54
Reliable NEMS and MEMS for Key Enabling Technologies: future-oriented and energy efficient nano-sensors and systems for high-impact applications (e.g., mobility, health, and environment) (IA)	3.42
A nano-regulation framework: streamlined EHS assessment for nanoparticle-based delivery systems, formulations, and additives (CSA)	3.17

*Average rates (based on prioritisation from 1 to 8)

4 Fourth Coordination Group workshop

The 4th meeting has been held on INL facilities in Braga, on day 1 (July 5th 2022) within the joint event on sustainable fabrication organized between Susnanofab and Nanofabnet projects. The main goal of the Co-Creation Session will help to assess the impact of the proposed preliminary actions and stimulate implementation ideas within the SUSNANOFAB Roadmap. The session has held both in physical and online.

TIME	ACTIVITY
14.00	SUSNANOFAB road-mapping approach and co-creation session Speaker: Paula Queipo, IDONIAL
	NANOFABNET Roadmapping Speaker: Steffi ; Nanofabnet project coordinator
14:30-15:45	Posters co-creation session
15.45-16:00	Conclusions of the meeting

Fig.3 4th CG meeting agenda

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Fig.4 Pictures of the event showing the presentations of SUSNANOFAB and NANOFABNET roadmapping activities respectively

A total of 75 attendees have joined the event in Braga, whereas concerning the on-line participants there were 94 on day 1, 40 on day 2 and 36 on day 3. Online option was also available specially to facilitate the participation of USA partners. Organizations of the participants and countries are listed below.

Table 2: *List of the organisations of the attendees to the meeting at INL in Braga*

Entity	Country
MEDICAL	Italy
RINA Consulting SpA	Italy
TU WIEN	Austria
Onvega	Sweden
Tecnalia Research & Innovation	Spain
IDONIAL	Spain
Nanofutures/NTC nanotech Coatings GmbH	Germany
IPC	France
CT-IPC	France
ISQ	Portugal
BioNanoNet Forschungsgesellschaft mbH (BNN)	Austria
CEN TC352 Nanotechnologies	France
OCSiAl Europe Sarl	Luxembourg
Maastricht University	Netherlands
ISQ	Portugal
Karslruhe Institute of Technology	Germany
Institute of Technology	Nigeria
LNE	France
CEA	France
BASF SE	Germany

Seven Past Nine	Germany
INL - International Iberian Nanotechnology Laboratory	Portugal
Tyndall	Ireland
The Nanonet Foundation	Poland
IMDEA Materiales	Spain
Warrant Hub S.p.A. (ASINA project)	Italy
PV Nano Cell Ltd	Israel
Karlsruhe Institute of Technology (KIT)	Germany
I3S	Portugal
Steinbeis Europa Zentrum	Germany
Romanian	Romania
Jerzy Haber Institute of Catalysis and Surface Chemistry PAS	Poland
LIST	Luxembourg
Icam of Lille	France
Steinbeis 2i GmbH	Germany
HoloSS	Portugal
AcumenIST	Belgium
PV Nano Cell Ltd.	Israel
NILU	Norway
EuroNanoLab	France
Nanotechnology Industries Association (NIA)	Belgium
ASCENT+	Portugal
BRGM & CEN TC352	France
Graphenest SA	Portugal
Intergalactic	Sweden
NANOTECHIA	Belgium
ISTEC - CNR	Italy
European Commission	Belgium
BHAM - AC	UK
Chemitek	Portugal
NANOGAP	Spain

Eight posters, one for each action of the SUSNANOFAB action plan, including key details on expected outcomes and scope have been designed for the session.

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Fig.5 *Sticker designed to collect comments on the outcomes and scope of the 8 actions*

Moreover, 3 additional posters on specific fields and Challenges and opportunities have been also prepared:

- Sectorial Poster: smart mobility, energy, construction, food & health.
- Cross-cutting Poster: design/safe by design, manufacturing, modelling, methods/techniques, procedures/protocols, Innovative solutions, advanced materials, testing.
- White Paper poster: collection of challenges & opportunities in specific identified issues/topics as a starting point for a whitepaper on sustainable nanofabrication to be produced in collaboration with NanoFabNet.

***Fig 6**. Stickers designed to collect comments on the actions and challenges*

In addition, each poster includes boxes for collecting information on relevant past and ongoing funded projects with reference to the action topics.

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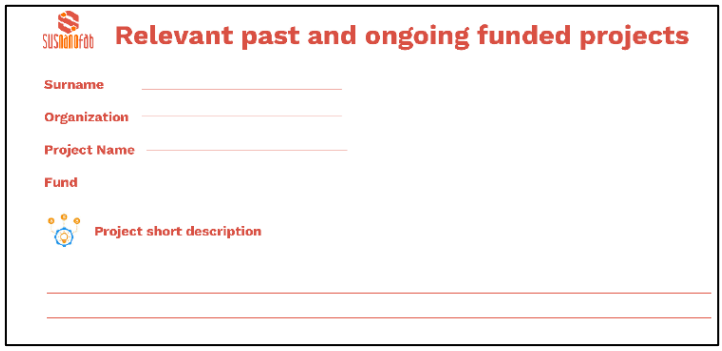

Fig.7 *Sticker designed to collect information on related regional, national, and European Projects*

Overall list of posters prepared and used in the meeting is detailed in the table below. Pictures are shown on Annex 1.

Table 3: *List of the posters and its corresponding facilitator for the co-creation session*

Poster short name	Title	Corresponding CG	Facilitator
Action 1	Mass-production techniques for sustainable nanofabrication: volume scaling and product testing (IA)	CG1 & CG2	Sean Kelly, NIA
Action 2	Digitalisation as enabler of optimized nanofabrication production practices (RIA)	CG1	Paula Queipo, IDO
Action 3	A nano-regulation framework: streamlined EHS assessment for nanoparticle-based delivery systems, formulations, and additives (CSA)	CG2	Mathieu Lion, IPC
Action 4	Multi-level education strategy (upskill, reskill, and novel education curricula) for bridging the technology transfer gap from transdisciplinary nanotechnology innovation to entrepreneurialism management (CSA)	CG3	Monike Rocha, INL
Action 5	Metrology for reproducible and reliable product quality in high impact nanotechnology applications (e.g., mobility, health) (RIA)	CG1 & CG2	Chiara Venturini, NIA
Action 6	Reliable NEMS and MEMS for Key Enabling Technologies: future oriented and energy efficient nano sensors and -systems for high impact applications (e.g., mobility, health, and environment) (IA)	CG1	Dmitri Petrovykh, INL

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Action 7	Establishing a structured safe- and sustainable-by-design (SSbD) approach for the European nanomaterial ecosystem (CSA)	CG2	Simon Clavaguera, CEA
Action 8	Living materials for multi-function devices (RIA)	CG1	Laura Waslmayr, TUW
Sectorial Poster	Sectorial Action	NA	Lorenzo Dall'Oro, RINA
Cross-cutting Poster	Multi-sectorial Actions	NA	Nadja Adamovic, TUW
White Paper	Joint whitepaper in cooperation with NanoFabNet	ALL	Margherita Cioffi - RINA

Each poster was supervised by a poster chair (table 3) to trigger a poster discussion and facilitate the work of attendants to put their stickers on it. Additional contributions by other expert stakeholders on the 11 posters are obtained in parallel also online by using the Slido polling tool as a final activity the 8 preliminary actions have been ranked in terms of impact and priority.

Fig.8 *Pictures of the roadmap co-creation section*

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4.1 Main outcomes

The most relevant comments collected during the co-creation session are reported below. Moreover, the projects suggested by experts related to the topic and that can provide knowledge and solutions to narrow the action's gap are also listed.

ACTION 1 - "Mass-production techniques for sustainable nanofabrication: volume scaling and product testing" Fig. 10, Annex 1)

- The lack of process reliability control and reproducibility is often due to the lack of understanding of governing laws therefore it is necessary to allow the development and the establishment of mathematical models that properly describe the process.
- Recycling strategies have to be considered and investigated in this action.
- Performing Life Cycle Assessment needs interdisciplinary work and must be based on reliable data.
- Data and Knowledge sharing from EC-Funded projects and cross-project collaboration is needed

Related projects suggested by Experts:

-ASINA: process oriented SSbD inventory and solutions for nanomanufacturing -H2020, RIA Action.

-TINKER: Developing digital processed to make sensors based on nano materials-H2020

ACTION 2 - "Digitalisation as enabler of optimized nanofabrication production practices" (Fig. 10, Annex 1)

- Optimisation using artificial intelligence require access to all data sources from safety, LCA,…
- The action should define the level of detail needed and how to exchange data and knowledge.
- The action should also include activities for convincing SMEs that digitalization is essential for controlling their processes

Related projects suggested by Experts:

-NANOCOMMONS- creating a community framework and infrastructure for reproducible science, and in particular for in silico workflows for nanomaterials safety assessment and beyond-H2020

-NOMAD repository: to store computational data on materials, including nano

-PILATUS-To demonstrate 3 digitalised pilot lines for production of silicon wafers and solar cells in Europe

-Past projects from FP7 such as EUMINAFAB that probably content data not in used anymore

*ACTION 3- "*A nano-regulation framework: streamlined EHS assessment for nanoparticle-based delivery systems, formulations, and additives "(Fig. 11, Annex 1)

- The action should support and foster interlaboratory studies focused on in vitro (or alternative) models for nanotoxicity
- The action should address the issue of the lack of real exposure data to the environment.
- The EHS assessment need to be linked to the life cycle sustainability assessment (SSbD) and to the ethical impact assessment.
- To ensure a good public perception

Related projects suggested by Experts:

-PATROLS

-RIKSGONE-Promoting risk governance

-NANOHARMONY

-GOV4NANO

*ACTION 4 -"*Multi-level education strategy for bridging the technology transfer gap from transdisciplinary nanotechnology innovation to entrepreneurialism management" (Fig. 12, Annex 1)

- There should be a general guideline for education curricula that define a minimum basic level.
- The curricula should be updated frequently: one should define "basics" and then the courses should be updated along the time.
- Coordination with industry with regards their education and training needs is necessary

Related projects suggested by Experts:

-NANOTOES-Training experts in safety-FP7

*ACTION 5 - "*Metrology for reproducible and reliable product quality in high impact nanotechnology applications" (Fig. 13, Annex 1)

- Standardised and harmonised techniques and quality measures are needed
- In case the low-cost requirement could be not so achievable it is better to focus on the "easy-to-implement".
- Action should necessarily include the involvement of trusted authorities.
- Action should find new reliable techniques not requiring expensive and specialized equipment.

Related projects suggested by Experts:

-EURAMET PPP

-ELENA-to support nanoelectronics by providing a EU metrological infrastructure-EMPIR

-NANOWIRES-High-Trough put metrology for nanowires energy harvesting devices-EMPIR

-ISO-C-Scope-Standardised graphene characterization-EMPIR

ACTION 6 - *"*Reliable NEMS and MEMS for Key Enabling Technologies: future oriented and energy efficient nano sensors and -systems for high impact applications" (Fig. 14, Annex 1)

- Overcoming current barriers in the implementation of NEMS and MEMS is strategic for the Europe because, unlike chip manufacturing, there are still EU industrial manufacturers.
- Action should detail application-oriented aspects with the purpose of targeting markets where Europe can play a strong role.

Related projects suggested by Experts:

-NANOWIRES-High-Trough put metrology for nanowires energy harvesting devices-EMPIR

ACTION 7 - *"*Establishing a structured safe- and sustainable-by-design (SSbD) approach for the European nanomaterial ecosystem "(Fig. 15, Annex 1)

- The action should include activities dedicated to fostering the inclusion of SSbD into the scope of the main scientific journals
- Safe and Sustainable by Design could be enriched by Ethical by Design.
- Long-term funding should be made available.

Related projects suggested by Experts:

-ASINA: process oriented SSbD inventory and solutions for nanomanufacturing -H2020, RIA Action.

-IRISS-SSbD roadmap -H2020, CSA

-Sabyna-SSBD-H2020

ACTION 8 - "Reliable living materials for multi-function devices" (Fig. 16, Annex 1)

- The action should address the energy harvesting of complex systems with living materials (e.g., algae) connected to electrical circuits.

Related projects suggested by Experts:

-RegMEdXB-Regenerative medicine initiative -National Dutch funding

SECTORIAL POSTER (Fig. 17, Annex 1)

- Nanotechnology/nanofabrication for energy storage applied to smart mobility have to be more exploited.
- There is a need for the promotion of cost-assessment methodologies as they represent a key barrier to food and health products.

Cross-CUTTING POSTER (Fig. 18, Annex 1)

- There is a lack of models for the whole product life cycle in the field of the safe by design
- There is a need for exploiting new solutions to supply chain issues and resilience towards disruptions (e.g. pandemia) in the manufacturing application field.
- An action should be dedicated to joint working activities together with SMEs on specific optimisation cases of innovative solutions.
- There is a need of facilitating the organisation of interlaboratory studies to validate characterization methods
- Access to Open Innovation Test Bed and infrastructures via tailored projects and brokerage services

JOINT WHITEPAPER POSTER (Fig. 19, Annex 1)

- Objective measurement criteria of product life-cycle improvements have to be established.
- Regional flagships infrastructures competition has to be overcome.
- It is necessary to gather existing training on nanofabrication in a shared database.
- Research communities need to be sensibilized to the different needs of each other (*e.g.,* sustainability vs engineering).
- Existing nanomaterial productions can not be improved as there are IP issues (patents and so on).
- Ethical impact assessment of nanotechnology/nanofabrication has to be investigated.
- -To gain public acceptance of nanotechnology

In general, there are some **recurrent comments** which are valid for all the posters:

- There is a need for a bilateral collaborations and cooperative development between research and industry.
- The integration of the industrial environment with user/customer needs is necessary.
- It is necessary to overcome the unwillingness to accept newly established standardization & harmonization channels/bodies.
- There is a lack of data exchange between different domains mainly for interoperability issues.
- There is a need for sharing knowledge and, in particular:
    - Cross-project collaboration as well as data/results/knowledge sharing shall be made mandatory for each EC-funded project

    - For action that should promote investments you must be wondering who will have the benefits and who will have a good return on money
- The nano-landscape changes quickly, therefore regular updates have to be considered.

5 Summary and next steps

The roadmapping development and validation has benefited greatly from the contribution of the experts belonging to the Coordination Groups.

During the 3rd Coordination Group meeting the roadmap was discussed in depth and the impact the proposed actions were ranked by the experts. Moreover, the co-creation session of the 4th CG meeting allowed an open and collaborative work which has led to the validation of each action belonging to the action plan. In addition, the experts agreed on the importance of some key points which will be considered for the Joint Whitepaper to be developed in cooperation with NanoFabNet. The Whitepaper will address challenges and opportunities in sustainable nanofabrication, including R&D priorities, standardisation, necessary requirements and constraints on infrastructures, knowledge and skills, provisions for inclusive communication, and the engagement of initiatives to foster international collaborations.

The next step will regard the roadmap presentation which will be done during the final SUSNANOFAB event which is expected to be held next February in Wien. In this version, main feedbacks gathered in the co-creation session ill be incorporated in the action plan.

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

6 Annex 1 Poster pictures

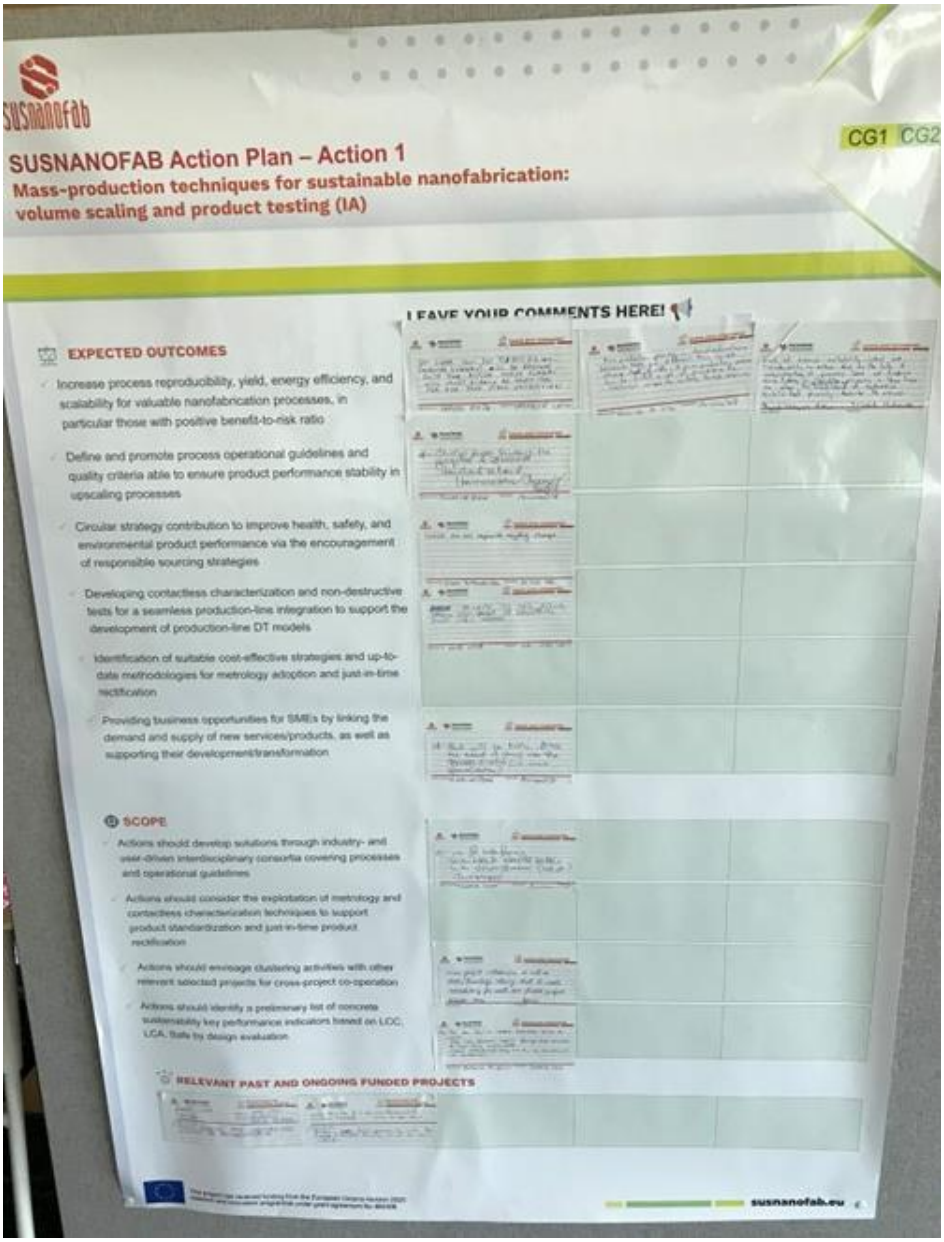

Fig.9 *Poster on Action 1*

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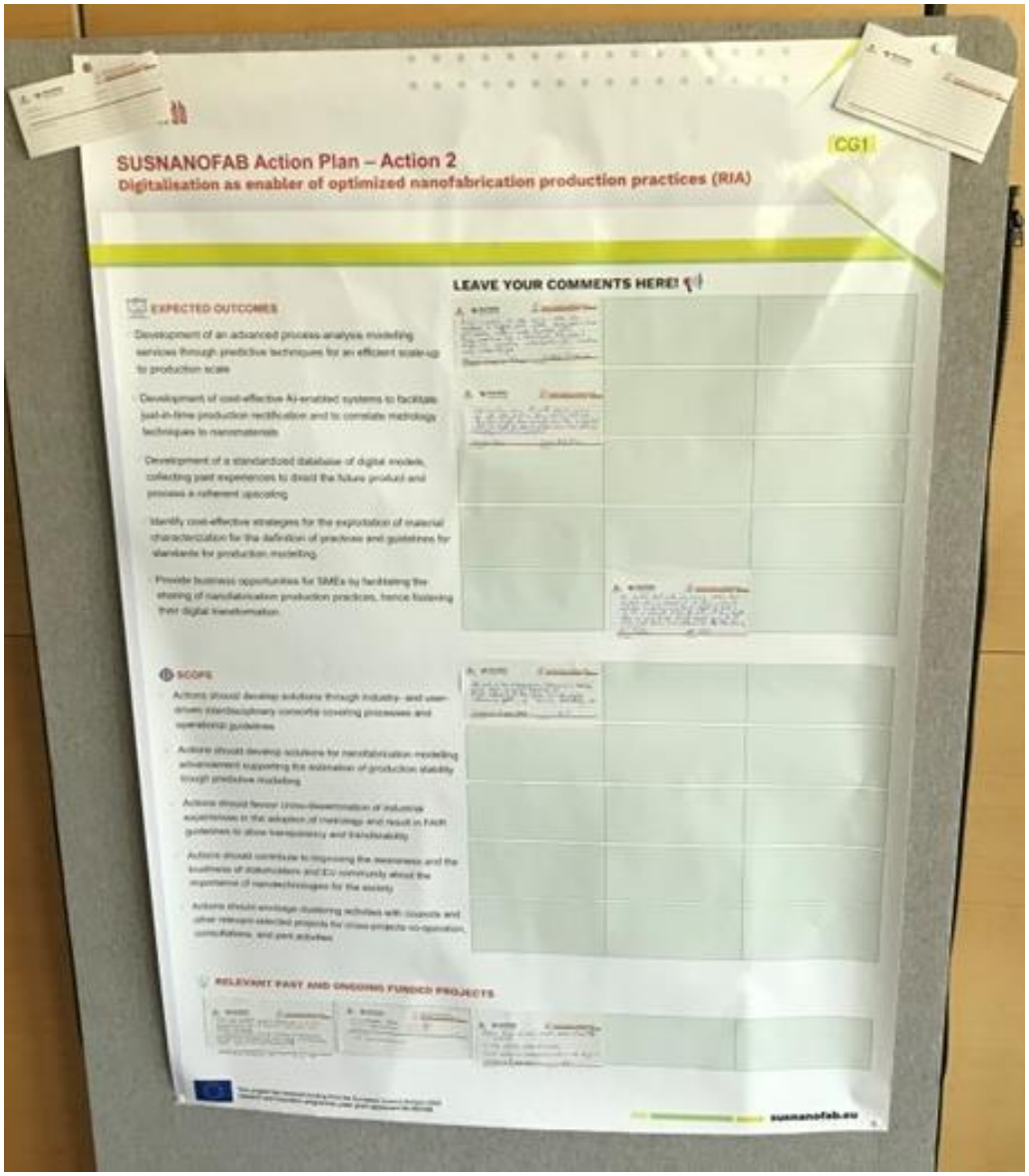

Fig.10 *Poster on Action 2*

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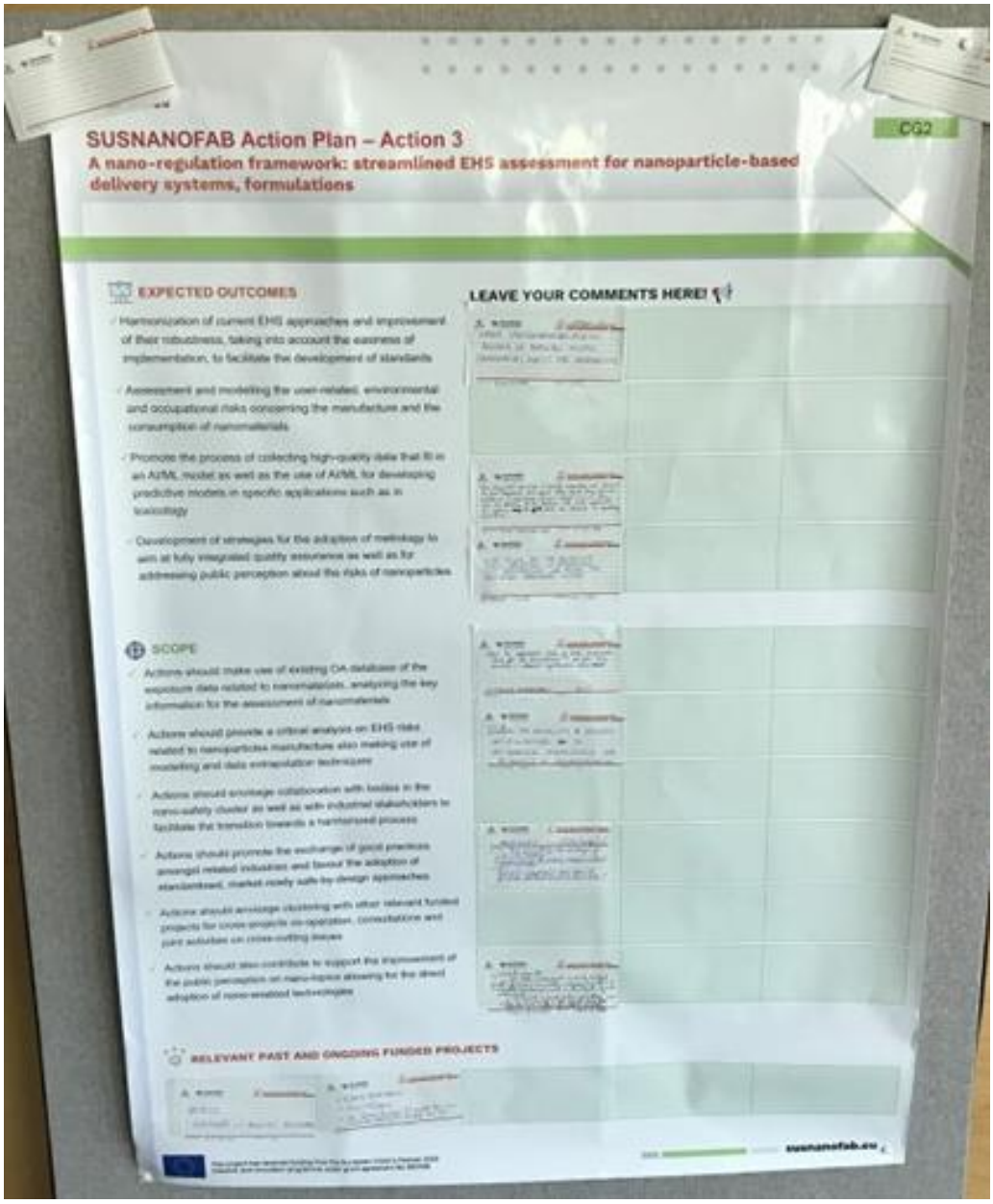

Fig.11 *Poster on Action 3*

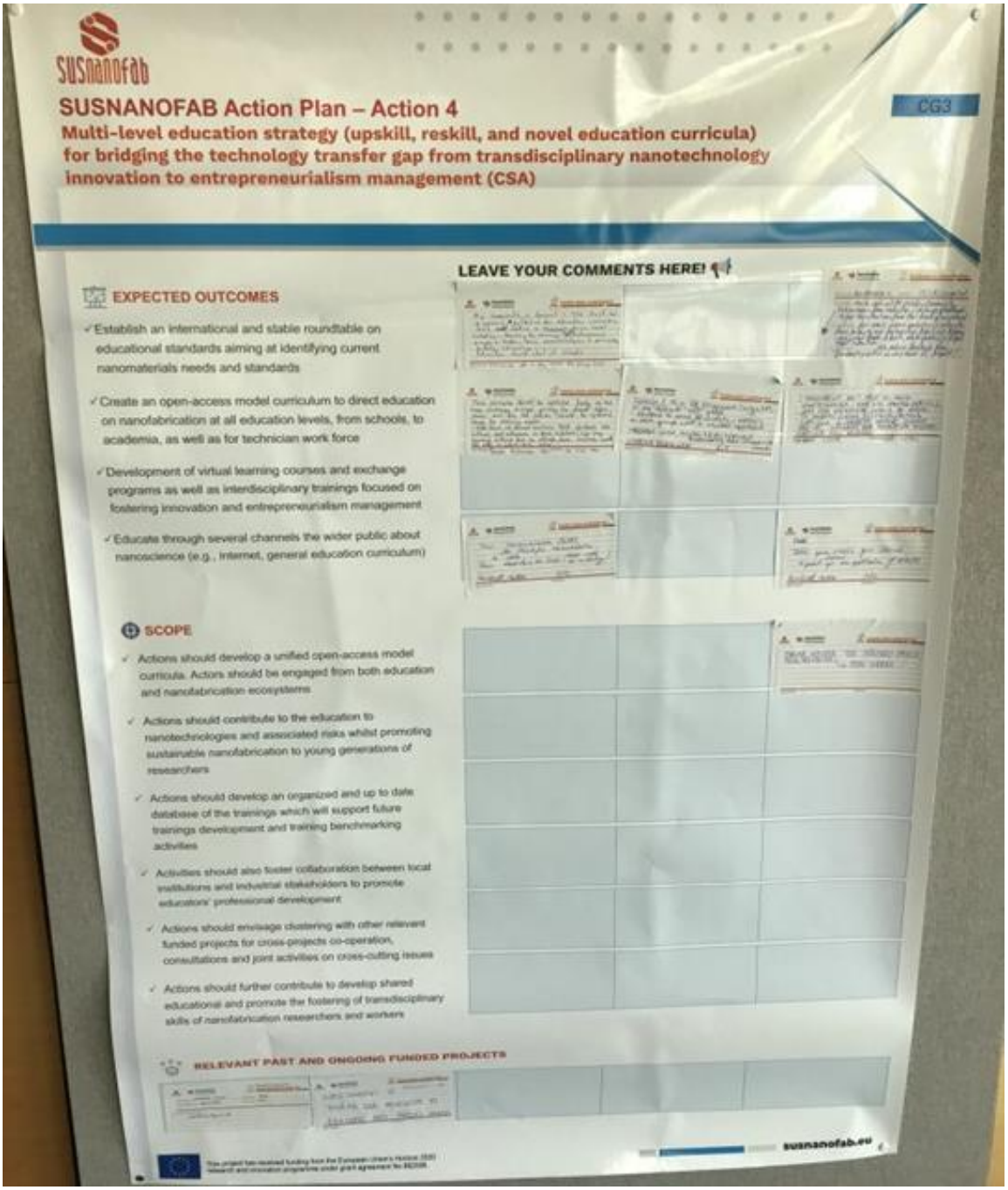

Fig.12 *Poster on Action 4*

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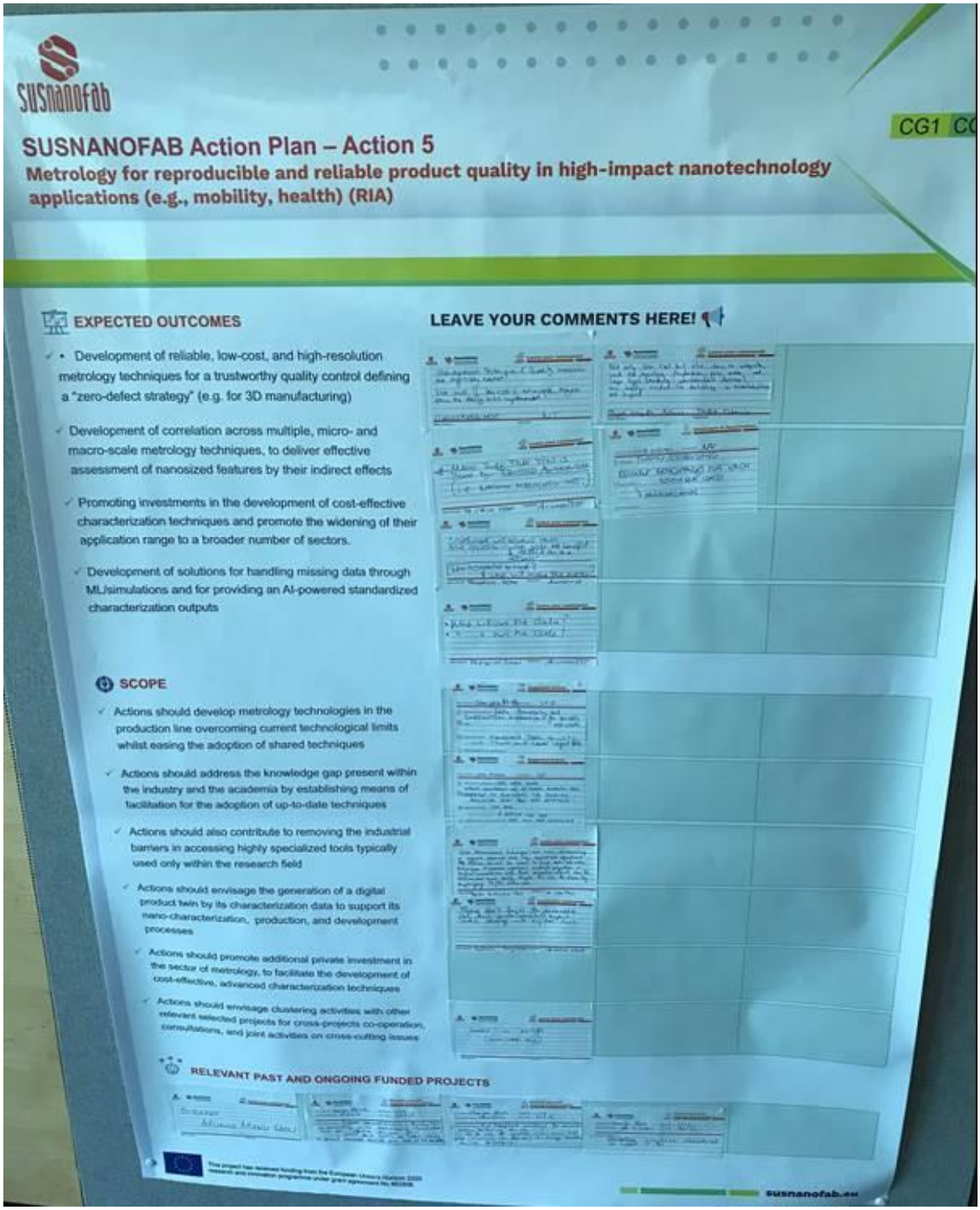

Fig.13 *Poster on Action 5*

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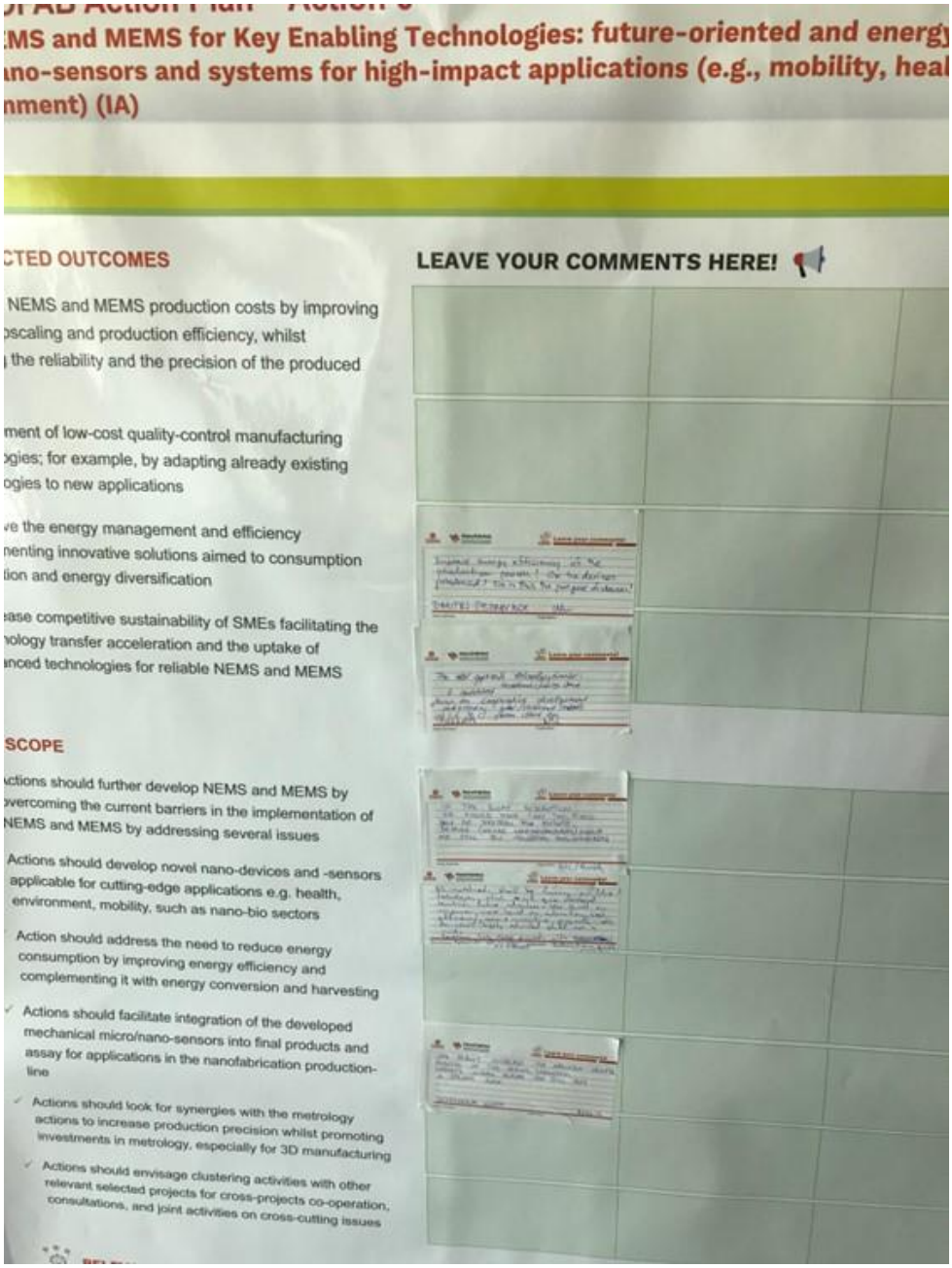

Fig.14 *Poster on Action 6*

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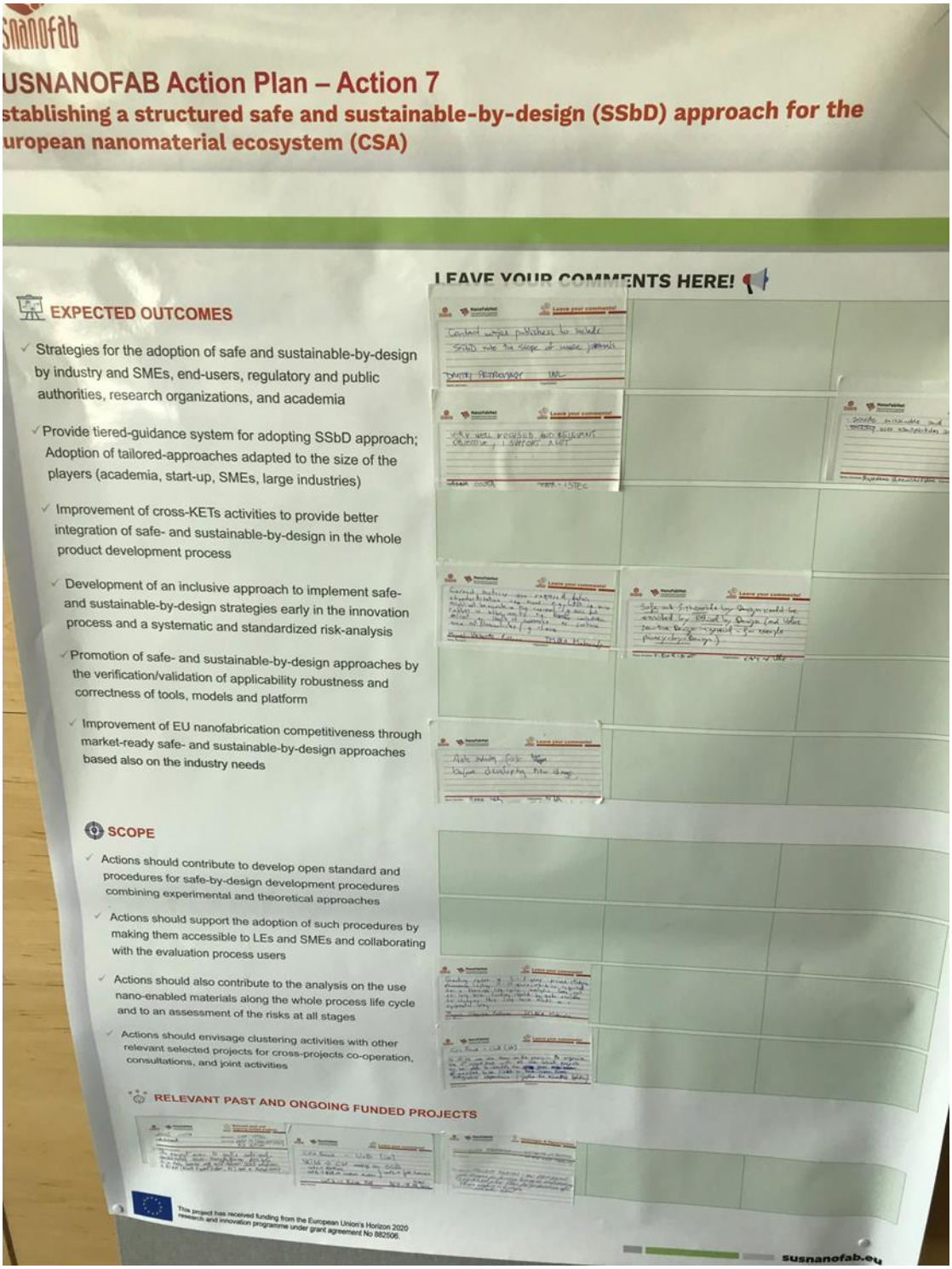

Fig.15 *Poster on Action 7*

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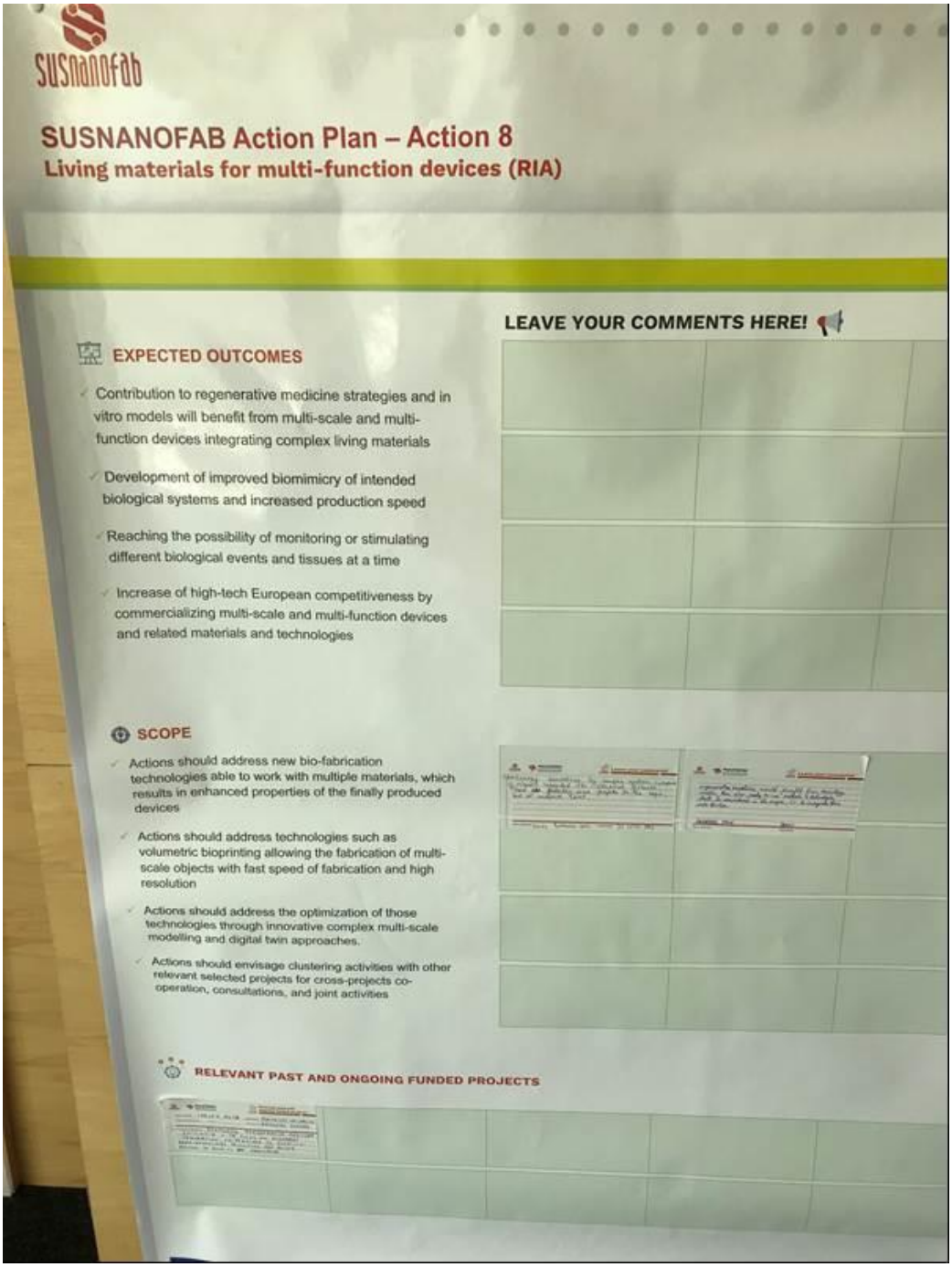

Fig.16 *Poster on Action 8*

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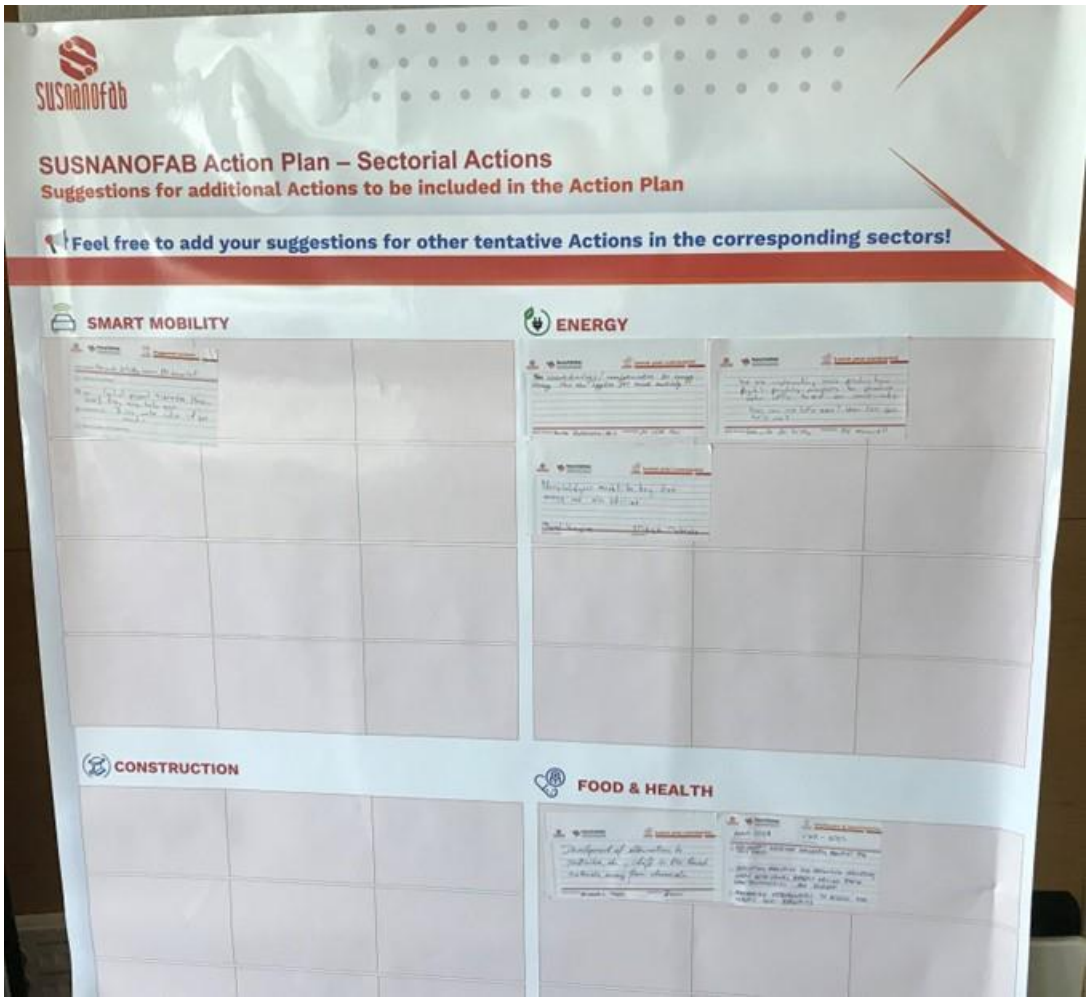

Fig.17 *Poster on sectorial actions*

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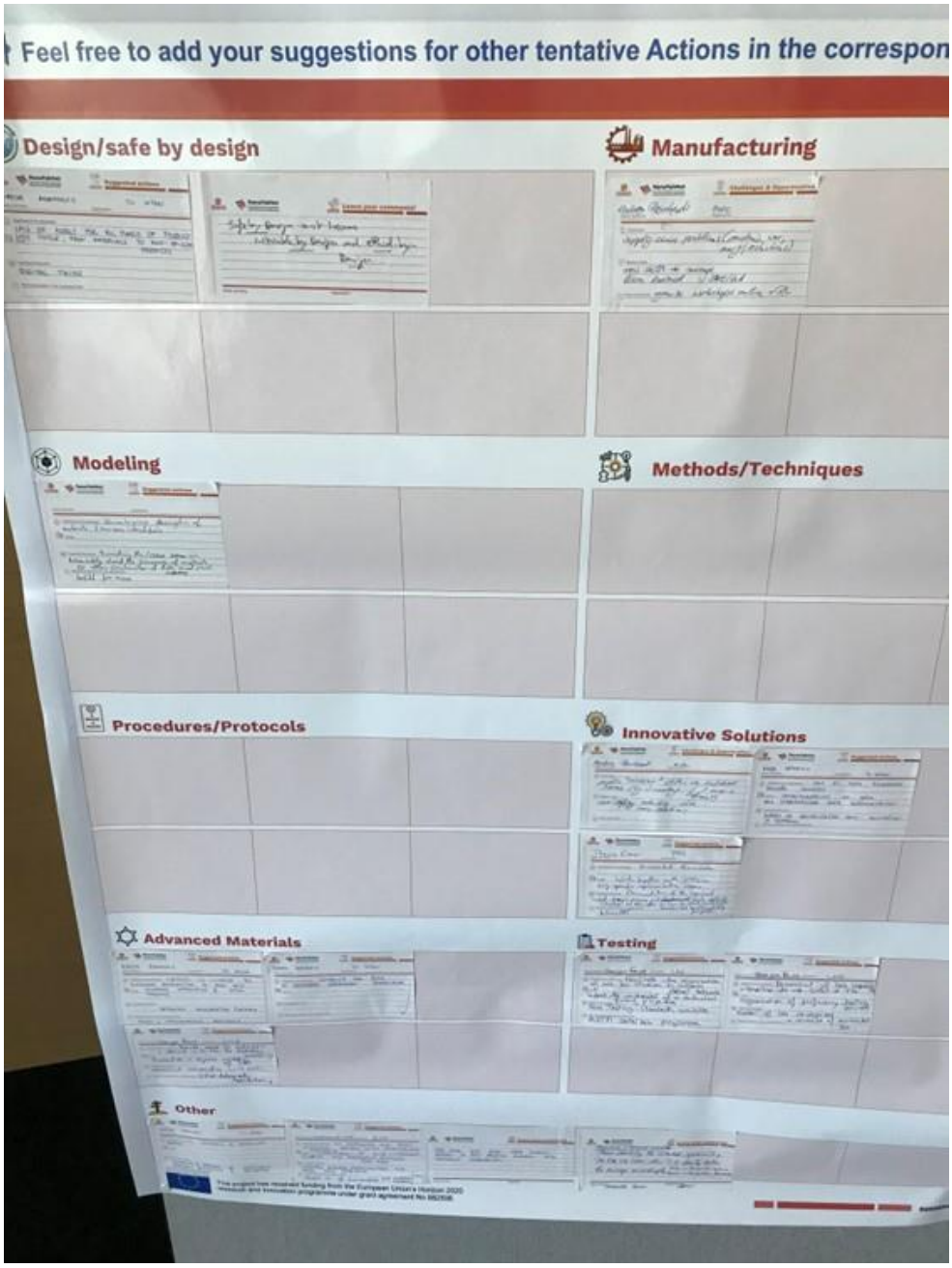

Fig.18 *Poster on other cross-cutting actions*

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

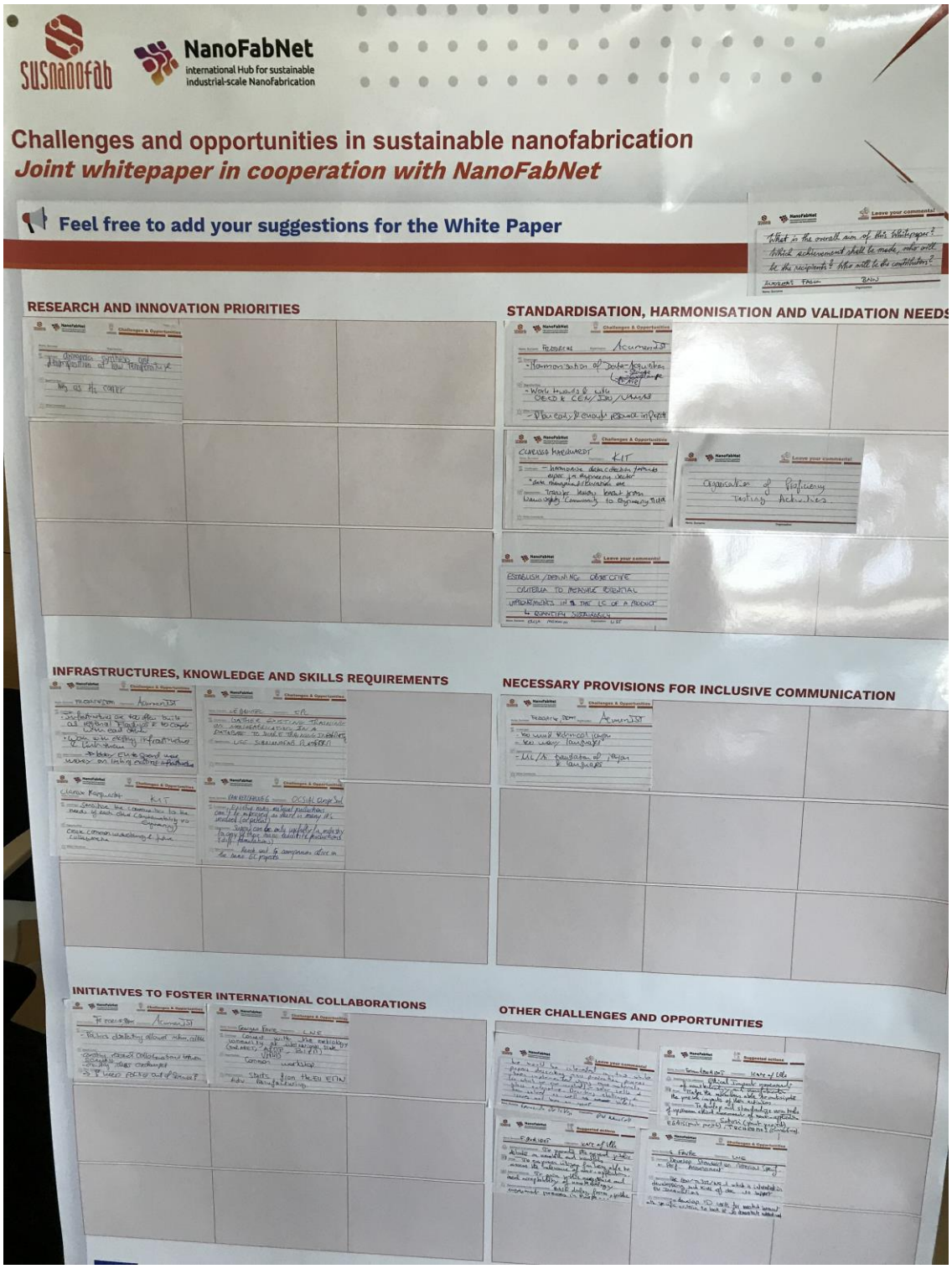

Fig.19 *Poster on Challenges and opportunities in sustainable nanofabrication*