

Workshop

Materials characterization and software tools as key enablers in NMBP-35 projects: Towards industrial transition and wider acceptance of new methods and products

Common achievements of NMBP-35 projects so far, impact beyond the projects

Miguel A. Bañares, CSIC
CHARISMA coordinator

Athens, Nov.24th, 2022



EASI-STRESS

receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. **953219**



nanoMECommons

No. **952869**



CHARISMA

No. **952921**





WORK PROGRAMME call

NMBP-35-2020: Towards harmonised characterisation protocols in NMBP (RIA)

Specific Challenge: The increasing interest in **comparing and linking experimental data** to achieve reliable end-user products necessitates the **development of widely accepted standardised measurement methods as characterisation protocols for materials, processes and final product performance**. To **improve experimental data quality, reproducibility and traceability** there is a need to develop, test, validate and agree on methodologies for **measurement and characterisation** techniques – such as microscopy, spectroscopy and diffraction techniques, as well as micro- and nano-mechanical tests – that are used in a wide variety of industries and settings through **interoperable data exchange mechanisms**. It is therefore critical that developers and users of current measurement and characterisation protocols reach a **broad-ranging agreement on their standardisation**, paving the way for new technologies in response to the emergent needs of **Industry Commons**.



EASI-STRESS - EUROPEAN ACTIVITY FOR STANDARDISATION OF INDUSTRIAL RESIDUAL STRESS CHARACTERISATION

Athens, Nov 24th, 2022



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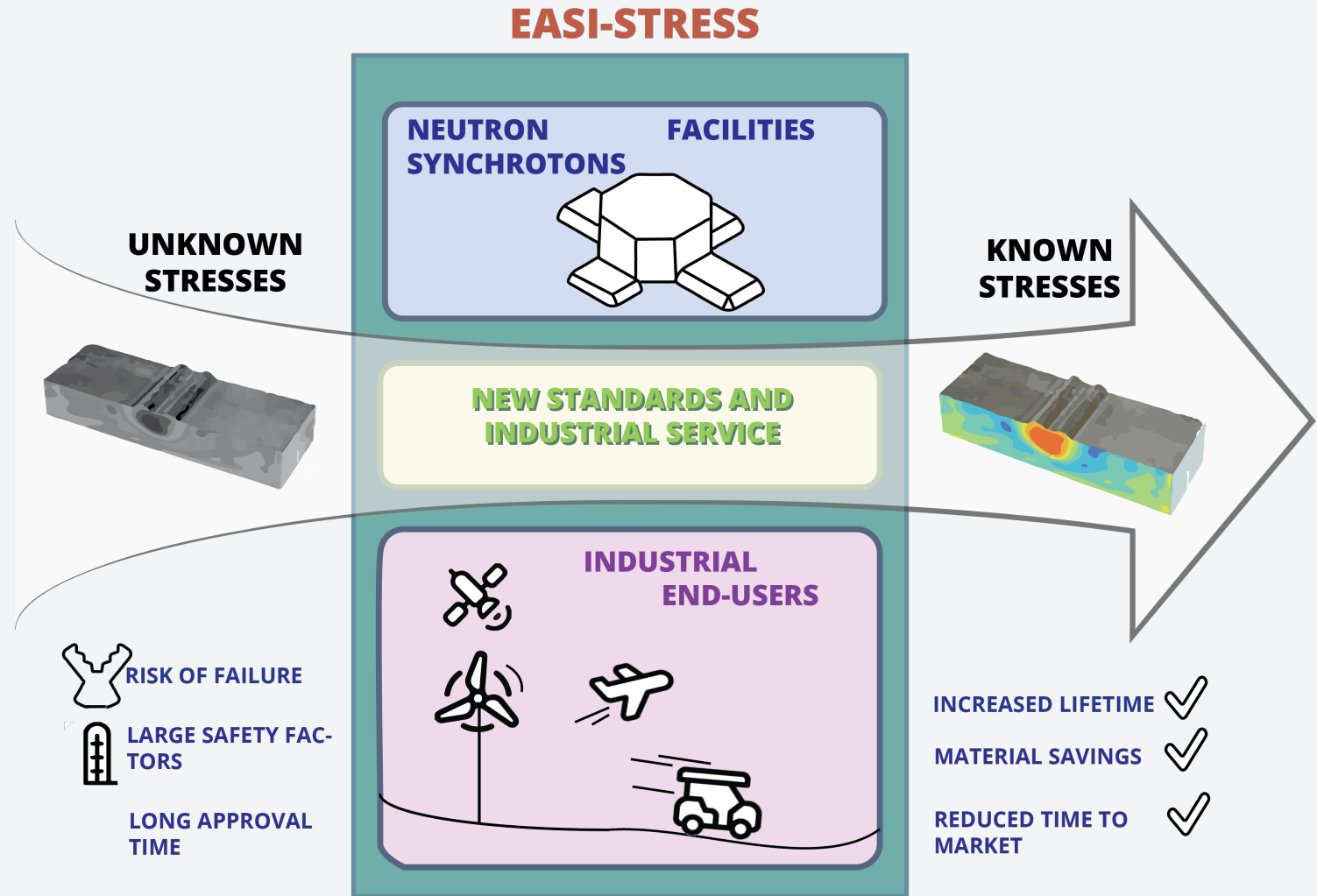


This project has received funding from
the European Union's Horizon 2020 research
and innovation programme under grant
agreement No 953219.



EASI-STRESS: PROJECT GOALS

- Start date: Jan 1st, 2021
- Duration: 36 months
- Budget: EUR 4.5 million





PROJECT OBJECTIVES AND IMPACT

1. To develop synchrotron x-ray and neutron diffraction-based **residual stress characterization tools for industrial use**.
2. To develop European-wide **characterization standards, protocols and data exchange procedures** to facilitate the industrial use of the characterization tools.
3. To strengthen **European industrial uptake of the characterization tools** through open access to data and protocols, development of a test bed service and collaboration/synergy/standardization activities.
4. To secure a **competitive advantage across European industrial sectors** through optimised component design, reduced material use through reduced safety factors and an estimated cost-reduction of 5% in a EUR 350 billion market through shortened time-to-market, and increased lifetime.
 - Increased component lifetime (or time in-between service). Target: +50%.
 - Reduced material usage. Target: -15%.
 - Reduced time-to-market. Target: -20%.

EASI-STRESS: CONSORTIUM

RTOs and
Universities



DANISH
TECHNOLOGICAL
INSTITUTE
(Coordinator)



The University of Manchester



Advanced Research Facilities



Centre for
Energy Research

Standardisation
Body



Industry



Rolls Royce PLC





EASI-STRESS: CONSORTIUM

RTOs and Universities



The University of Manchester

Standardisation Body



DANSK STANDARD



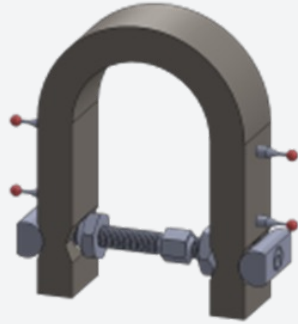
Research Facilities



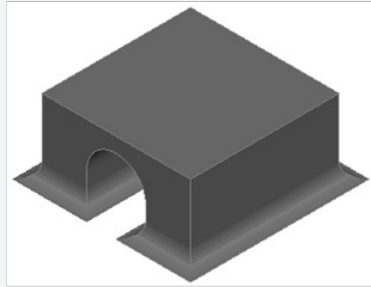
Centre for Energy Research



FROM BENCHMARK SAMPLES TO INDUSTRIAL COMPONENTS



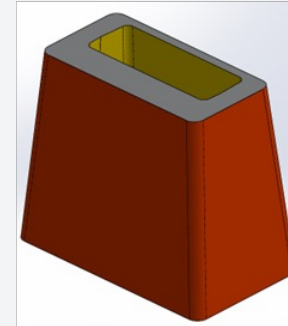
U-flexures/ U-bends
(S355 stainless steel)



Additively manufactured
arches (316 steel)



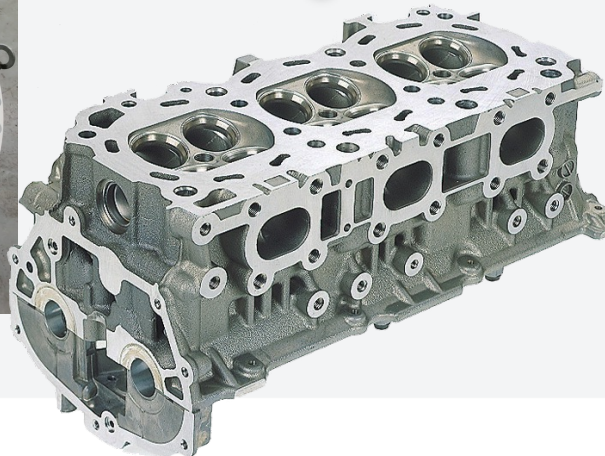
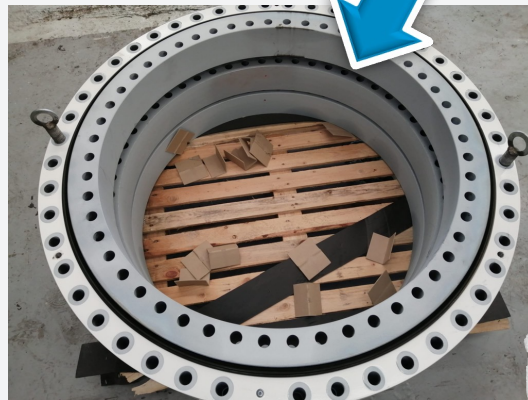
Inconel GTAW welded
plates (*NeT project*)



Cast wedge (AlSiMg)

Focus (until now):

- Develop and validate measurement techn.
- Select reference / calibration sample for standardisation



Focus (from 2023):

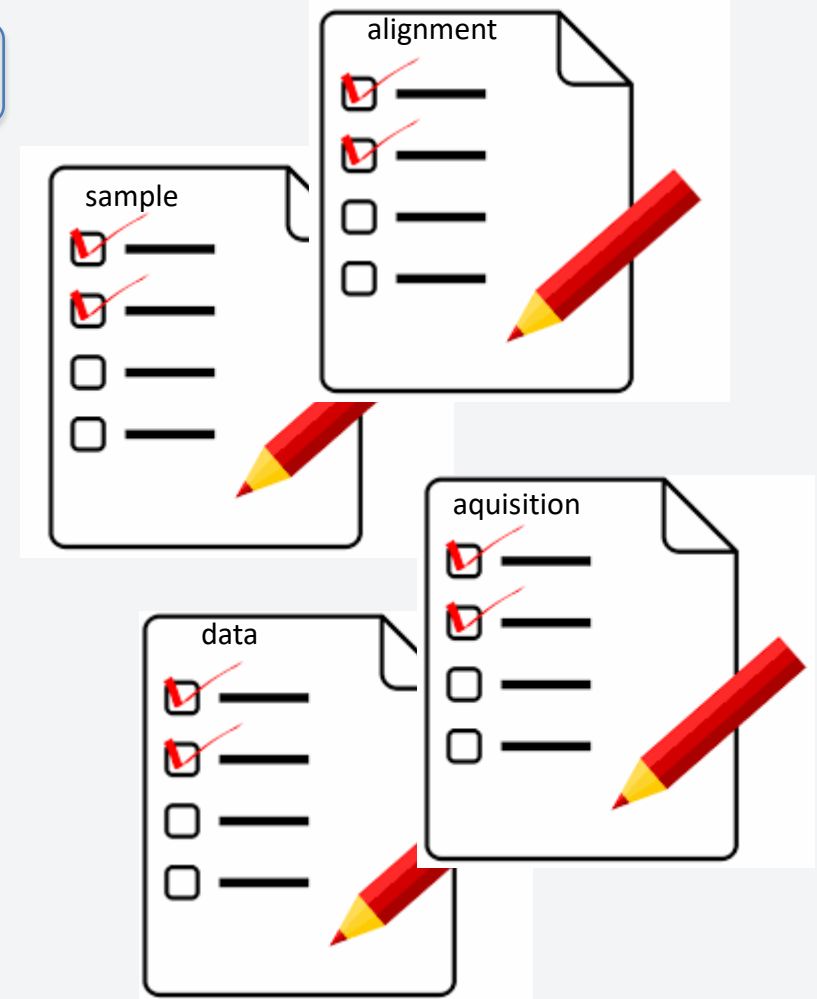
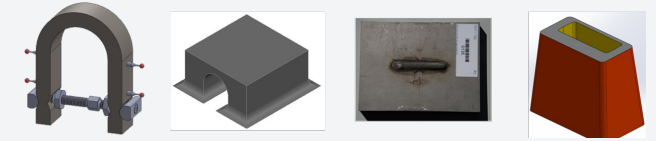
- Create value and impact at companies
- Develop industrial service

EASI-STRESS STANDARDISATION EFFORT

Standards are the language of industry

EASI-STRESS will develop and implement protocols/good practice guides for neutron and synchrotron x-ray stress measurement, e.g.:

- Calibration procedure and reference samples
- Definition of sample preparation
- Homogenise data acquisition
- Guidelines for data reduction and analysis



EASI-STRESS STANDARDISATION EFFORT

Oct 2022: Formal opening of TC138/WG10

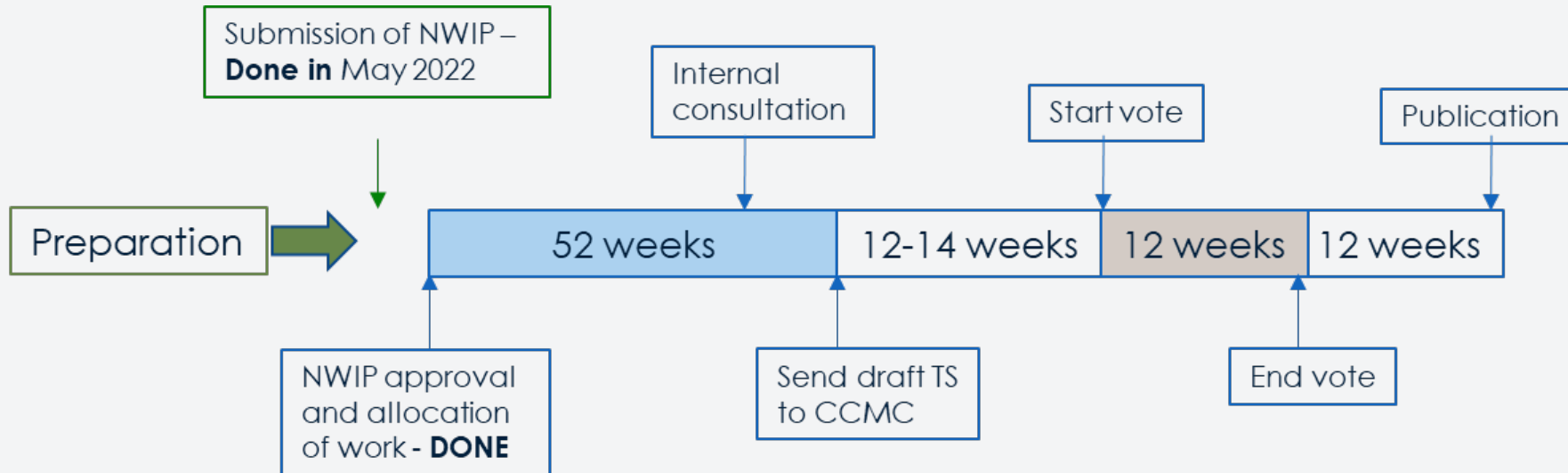
Dec 2022: First WG10 meeting

Mar 2023: Working Draft sent to WG10

- based on input from EASI-STRESS work packages

Aug 2023: Final draft sent to TC138 for vote

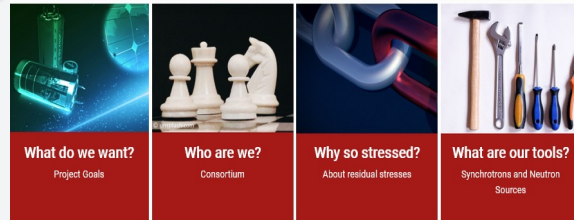
max. 52 weeks



ENGAGING INDUSTRIAL STAKEHOLDERS

Why?

Ensure broad industrial adaptation of the new techniques
AND recruit support for standardisation effort.

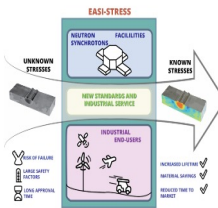


EASI-STRESS

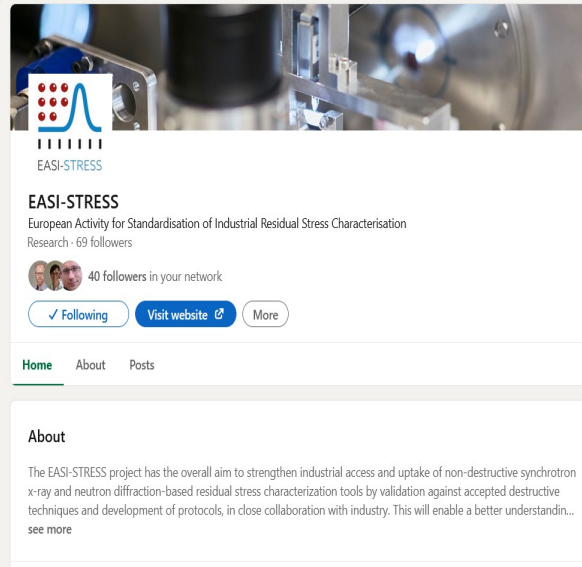
European Activity for Standardisation of Industrial residual STRESS characterisation

The EASI-STRESS project has the overall aim to strengthen industrial access and uptake of non-destructive synchrotron x-ray and neutron diffraction-based residual stress characterization tools by validation against accepted destructive techniques and development of protocols, in close collaboration with industry.

This will enable a better understanding of the formation and progression of residual stresses by direct comparison with and incorporation of the measured data into modeling tools. Incorporating this knowledge into the design process and lifetime assessment of metallic components will give more reliable products with increased lifetime and reduced material usage. Currently, conservative worst-case-scenario safety factors, e.g. as defined by EUROCODE, are used when designing metallic components exposed to cyclic loads. In knowing the actual internal stress levels, the safety factors can be reduced, resulting in an estimated material cost saving of around 15%.



Homepage: www.easi-stress.eu
Form for registration of interest



[LinkedIn Showcase](#)



Public webinars to share
technical insights

nanomeccommons

CALL IDENTIFIER: H2020-NMBP-TO-IND-2020-TWOSTAGE

**TOPIC: NMBP-35-2020 - TOWARDS HARMONISED
CHARACTERISATION PROTOCOLS IN NMBP (RIA)**

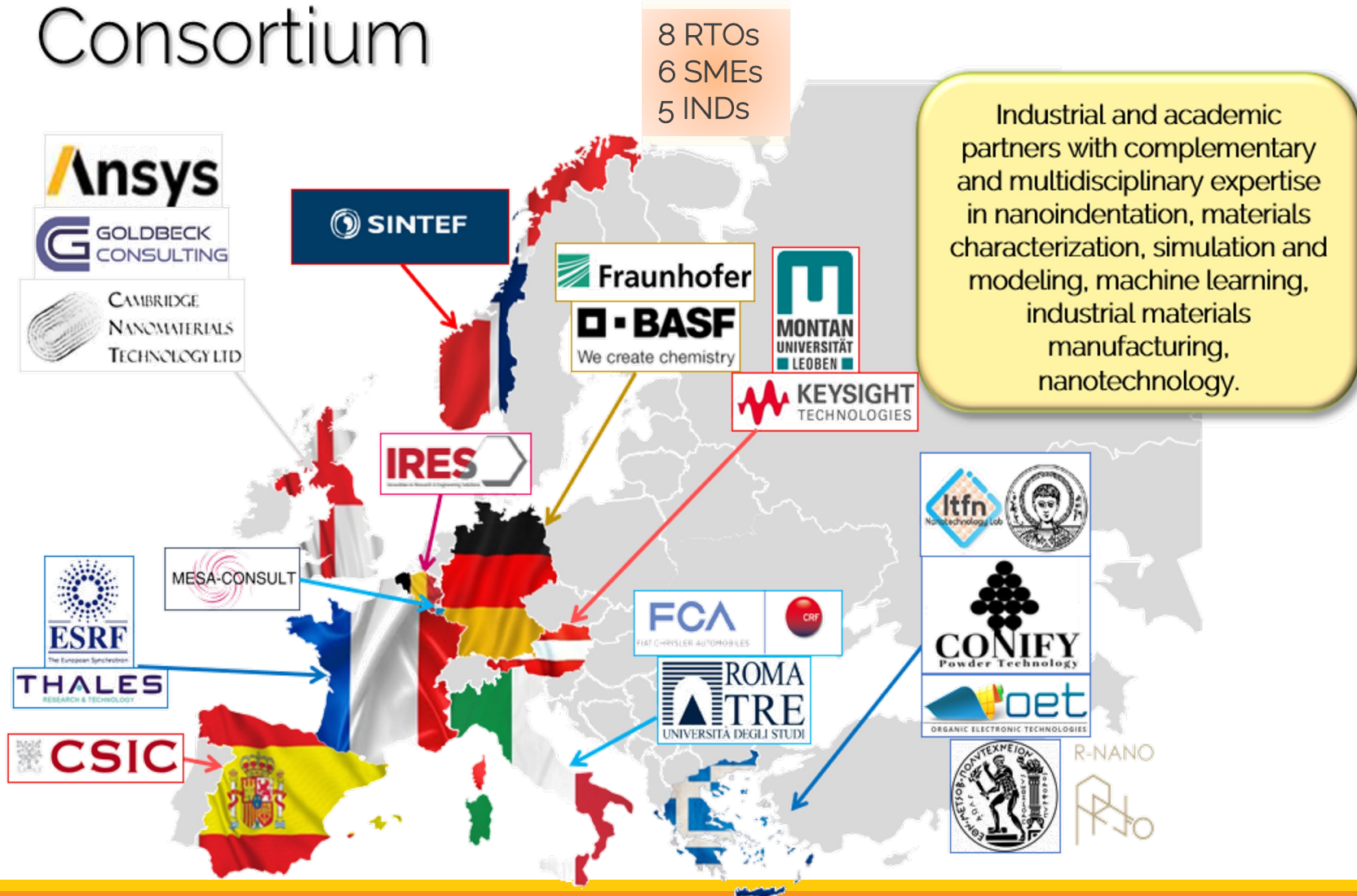
COORDINATOR: COSTAS CHARITIDIS (NTUA)



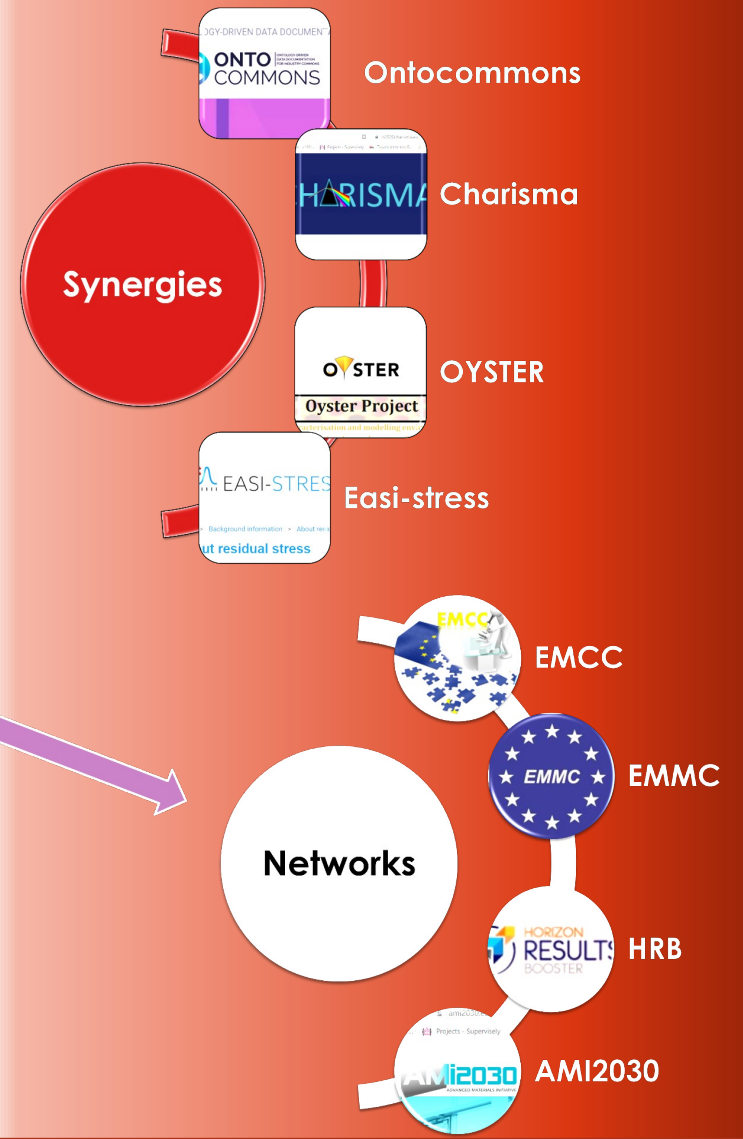
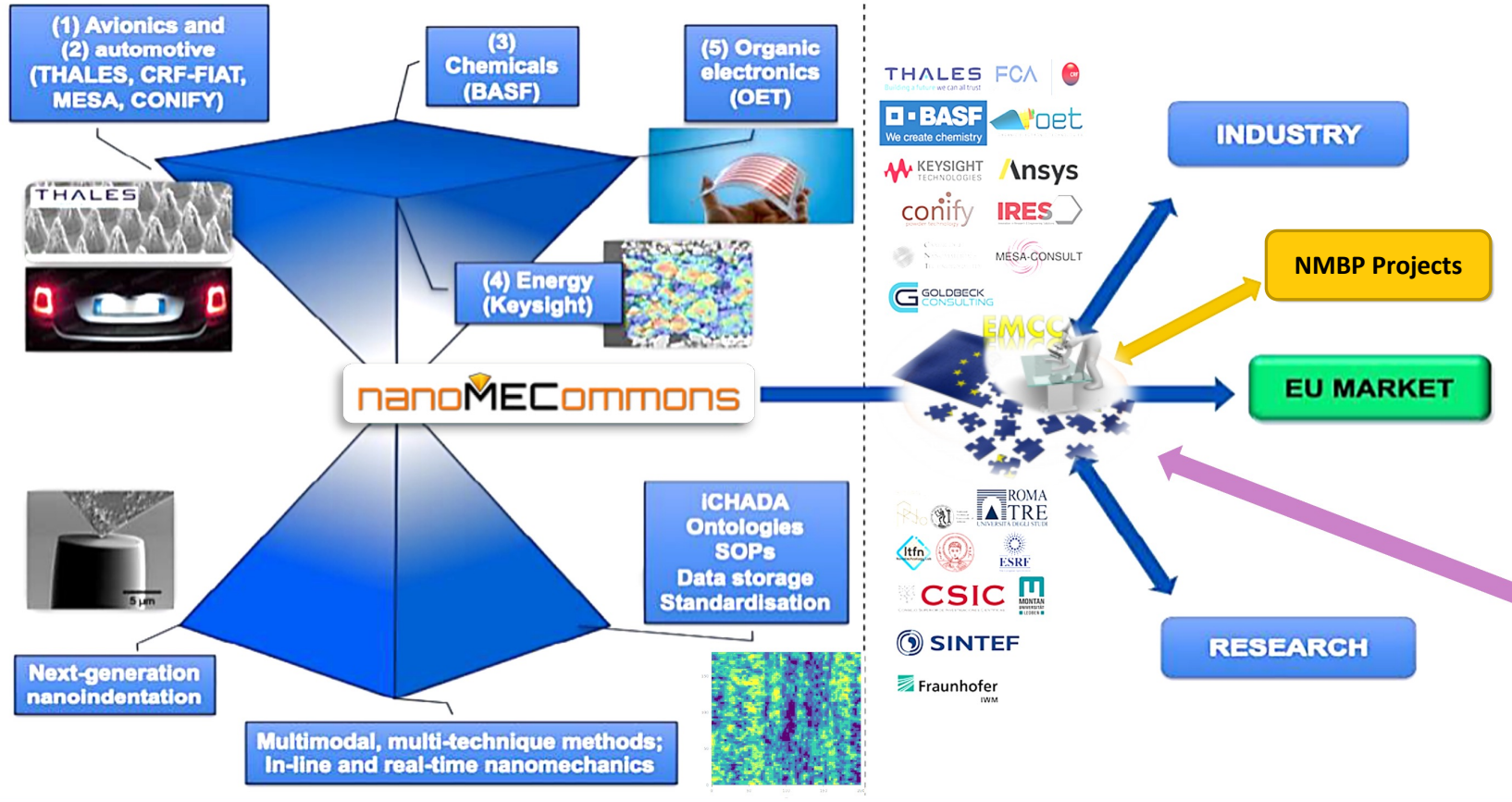
Introduction to NanoMECommons

- Full title: “Harmonisation of EU-wide nanomechanics protocols and relevant data exchange procedures, across representative cases; standardisation, interoperability, data workflow”
- Acronym: NanoMECommons
- Call identifier: H2020-NMBP-TO-IND-2018-2020
- Topic: NMBP-35-2020 Harmonisation of EU-wide nanomechanics protocols and relevant data exchange procedures, across representative cases; standardisation, interoperability, data workflow (RIA)
- Number of partners: 19
- Duration: 48 months (currently M22)
- Budget: ~6M €

Consortium

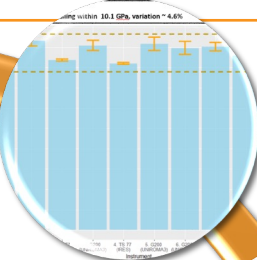


NanoMECommons as a whole

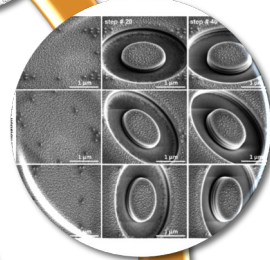
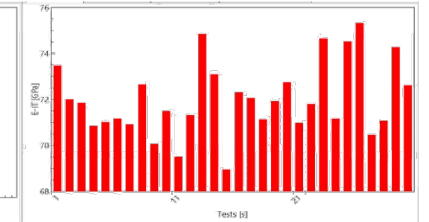
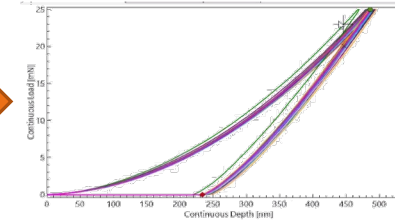
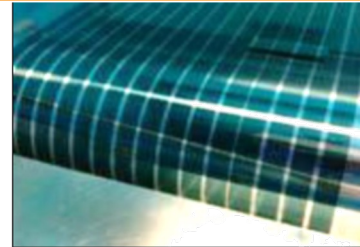


Standardization of testing

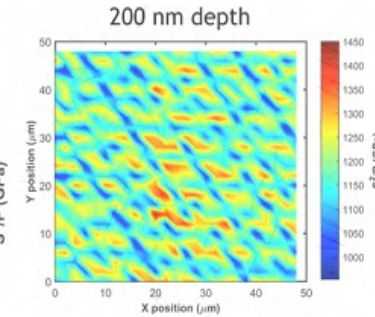
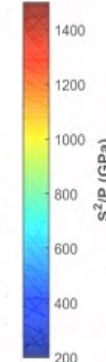
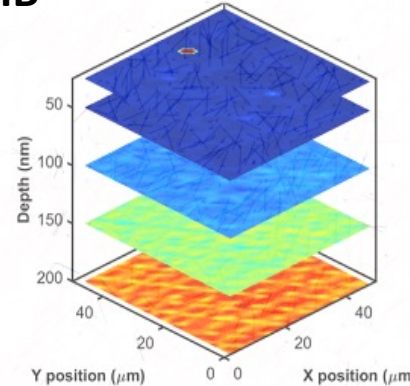
Harmonization of testing and protocols demonstrated at TRL 6



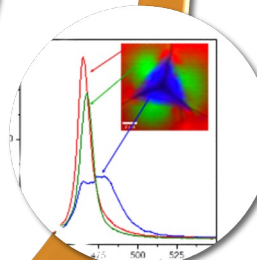
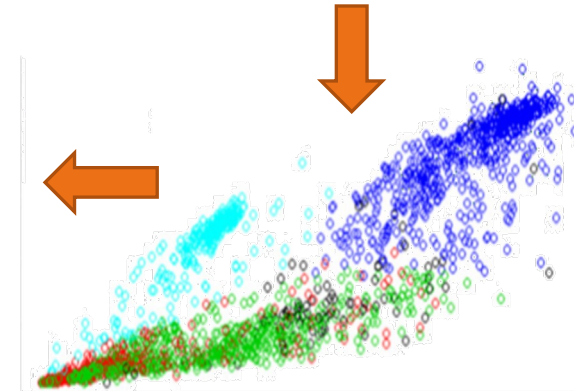
Validated 4D Nanoindentation protocols



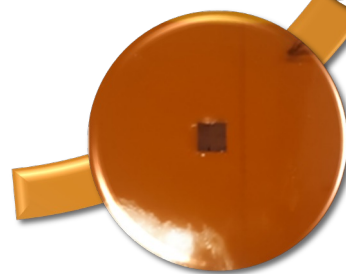
Automated FIB-DIC with improved resolution



4D mapping at high speed



Multimodal indentation protocols



Development of multimodal strain microscope

Open Innovation Environment

Open Innovation in NanoMECommons

- Integrates and harmonises nanomechanical tests with electron microscopy, diffraction and optical spectroscopy, to develop widely accepted and reliable protocols;
- Develops the i-CHADA data structure and protocols for improved interoperability of characterisation for improved knowledge management



Standardization and Digitalization



Utilize **previous** knowledge/ properties/ models with **Materials domain ontology** for knowledge management

Develop and integrate **Artificial Intelligence** toolboxes to establish process-structure-properties relationships

Validation activities on current/**emerging** characterization toolboxes

Improve the **capacity** of characterization

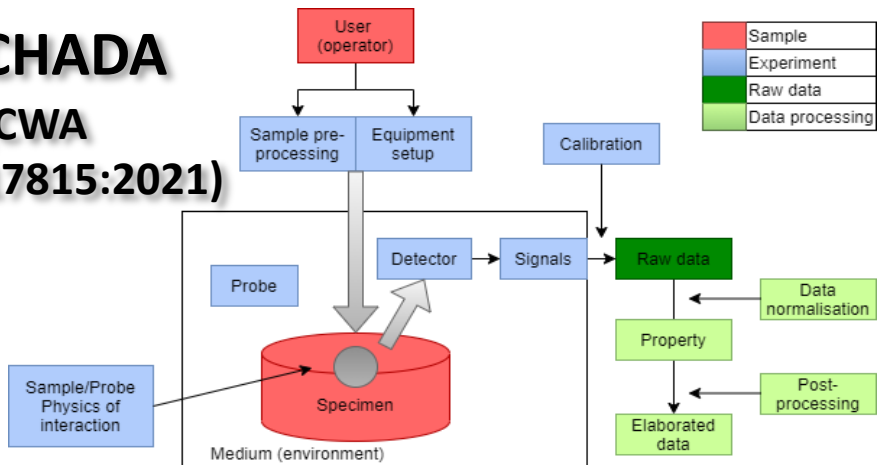


Characterisation domain ontology

Solutions

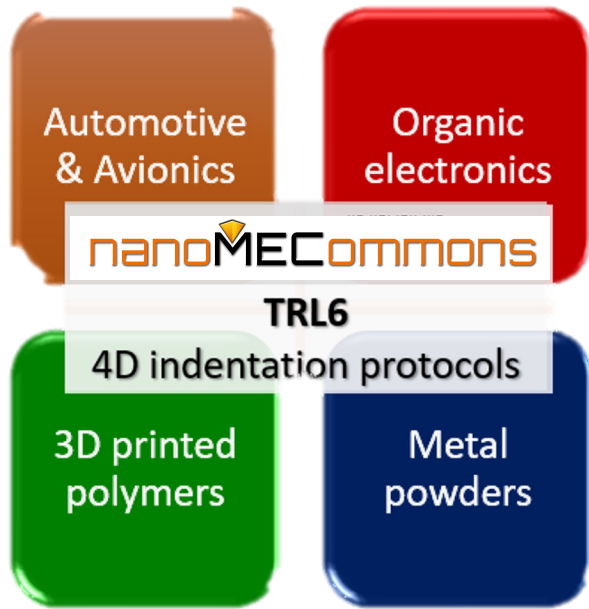
- Artificial Intelligence **data-driven** representations
- **Scalable** algorithms to handle **BIG data** of large-scale
- Benchmarking of novel industrial **materials**
- **Fast and 4D materials assessment** with nanoscale resolution for Industry

CHADA
(CWA 17815:2021)



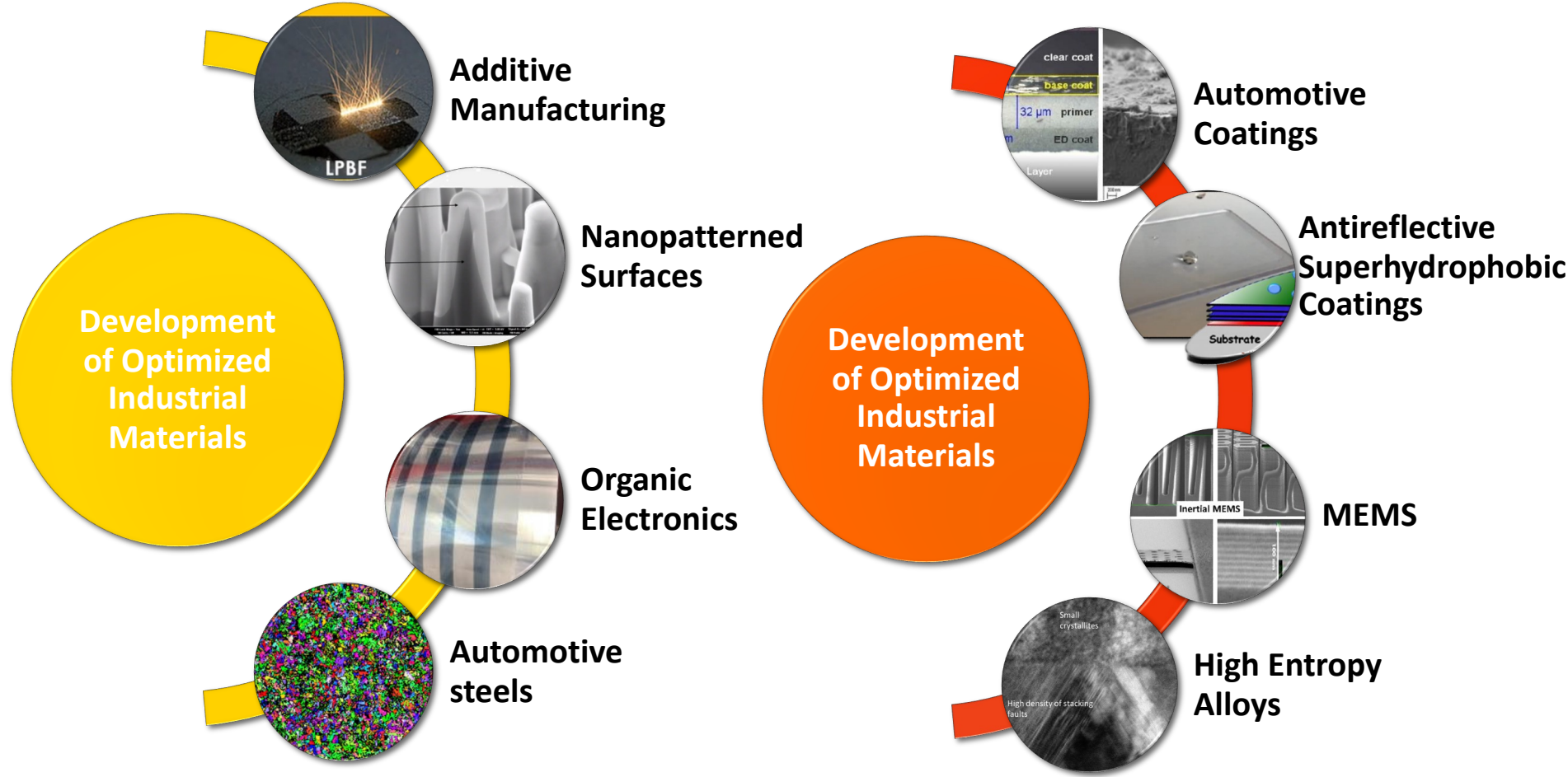
iCHADA
(new CWA activity in NanoMECommons)





Use Cases

NanoMECommons is directly connected with End Users in the consortium



Support Green Economy

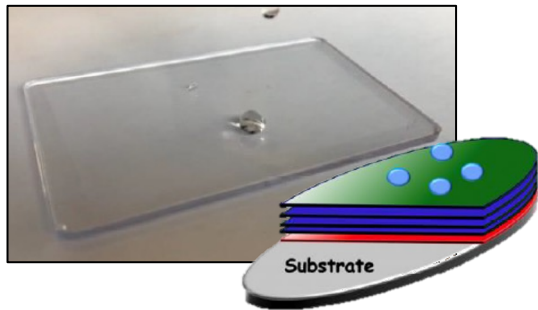
- Health prognosis/diagnosis of industrial materials
- Extend life-span
- Zero defect manufacturing.

Industrial innovation

- Closed-loop optimization (data-driven)
 - Reduce time-to-market
- Support the resource and energy management

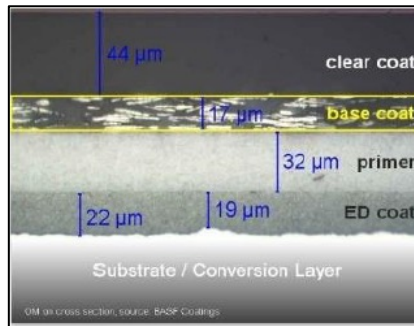


Antireflective Superhydrophobic Coatings



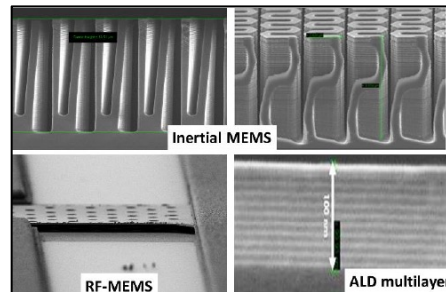
- **Well-defined multilayer** using FIB-DIC technology
- **High mechanical resistance**
- Validation of **homogeneity** with high-speed nano-indentation

Automotive Coatings



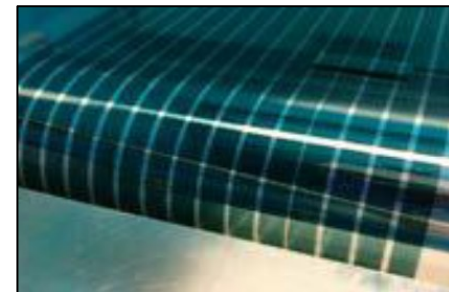
- **Detection of phases** in complex alloys
- **Identify explicit correlation** between *microscopic* and *macroscopic* behavior

MEMS



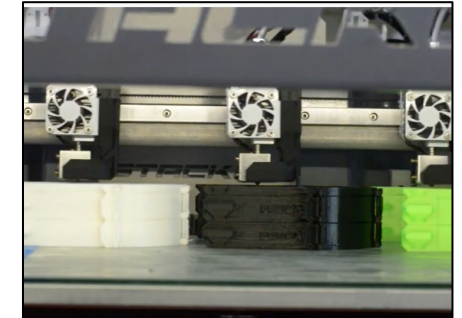
- **Prediction** of RF-MEMS properties based on **architecture & materials parameters**
- Insight of stress gradients **by-layer**

Organic Electronics



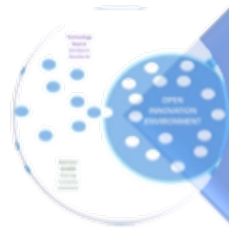
- **Accelerate the development** of **new** nanomaterials and **advanced** device architectures
- Boost the **stability and lifetime**
- data acquisition & **prediction** of large OE devices behavior

Additive Manufacturing

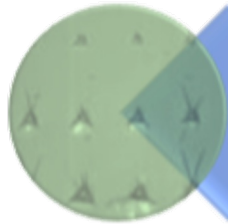


- Tailor the conditions for **high-throughput** production
- Higher **material purity**

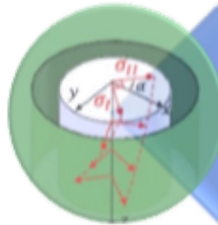
Scientific Objectives



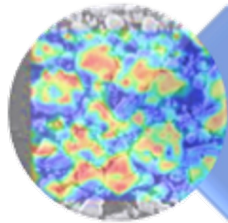
SO1. Interoperable Characterisation Data structures



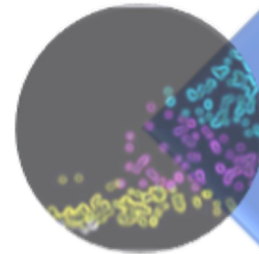
SO2. Accepted standardized high-speed nanoindentation in real industrial environments



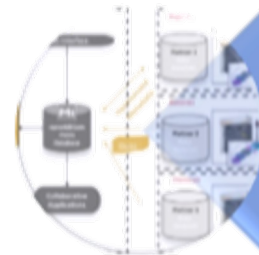
SO3. Nanoscale digital image correlation and residual stress analysis



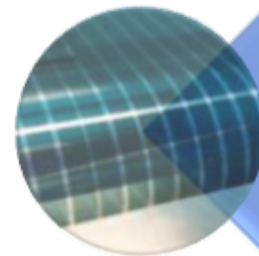
SO4. Multi-modal, in-situ characterisation methods and data exchanging procedures



SO5. Materials ontology and standardization for nanomechanics



SO6. Open Innovation platform and synergies with European Platforms and Networks and relevant NMBP projects

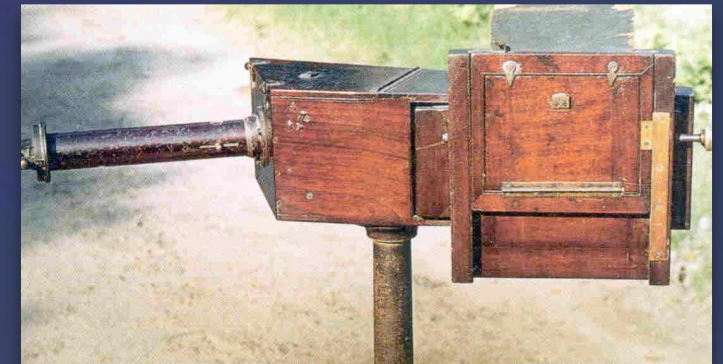


SO7. Industrial case demonstrations on the manufacturing of nano-engineered materials and films

CHARISMA

Characterization and HARmonization for Industrial
Standardisation of advanced MAterials

Miguel A. Bañares, CSIC
Athens, 22.Nov.2022



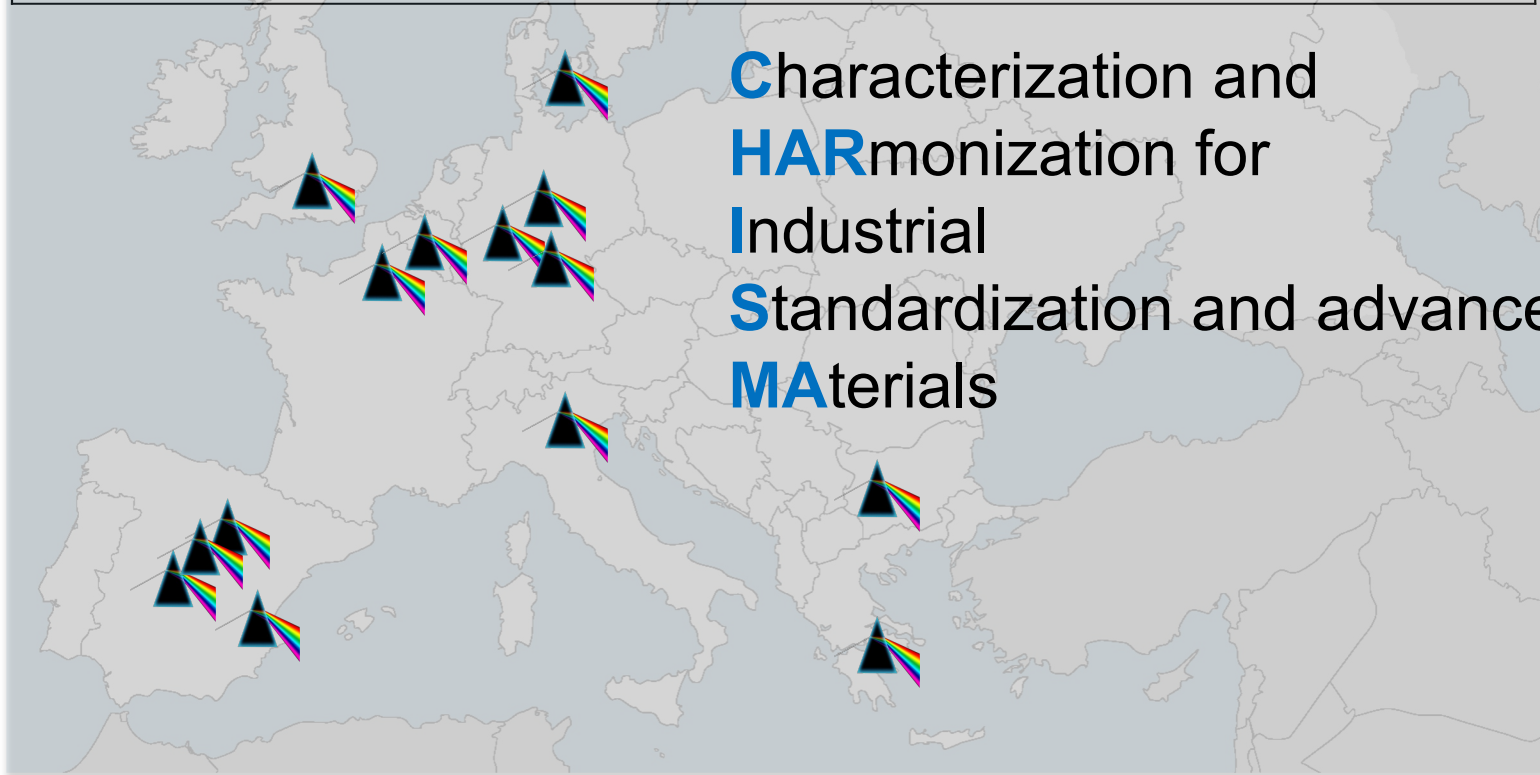


**14 partners; 9 countries
 5 M€**

R&D, catalysis, synthesis,
 spectroscopy, counterfeit, food
 safety, materials and standards,
 material modelling,
 chemometrics, spectroscopy
 hardware, spectroscopy
 software,
 datasets, API's, normalization
 and standardization,
 dissemination, ...

Nov. 2020 to Nov 2024

N.	Proposer name	Country	Total Cost	%	Grant Requested	%
1	AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	ES	870,941.25	17.47%	870,941.25	17.47%
2	HALDOR TOPSOE AS	DK	473,750	9.50%	473,750	9.50%
3	Encapsulae S.L.	ES	406,051.25	8.14%	406,051.25	8.14%
4	FABRICA NACIONAL DE MONEDA Y TIMBRE-REAL CASA DE LA MONEDA	ES	473,907.5	9.51%	473,907.5	9.51%
5	NATIONAL TECHNICAL UNIVERSITY OF ATHENS - NTUA	EL	250,000	5.01%	250,000	5.01%
6	UNIVERSITA DEGLI STUDI DI MILANO	IT	281,500	5.65%	281,500	5.65%
7	SORBONNE UNIVERSITE	FR	227,500	4.56%	227,500	4.56%
8	VRIJE UNIVERSITEIT BRUSSEL	BE	265,020	5.32%	265,020	5.32%
9	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	DE	305,648.75	6.13%	305,648.75	6.13%
10	ELoDiz ltd	UK	647,447.5	12.99%	647,447.5	12.99%
11	IDEACONSULT LIMITED LIABILITY COMPANY	BG	211,390	4.24%	211,390	4.24%
12	ASOCIACION ESPANOLA DE NORMALIZACION	ES	108,600	2.18%	108,600	2.18%
13	YORDAS GMBH	DE	254,750	5.11%	254,750	5.11%
14	EUROPEAN RESEARCH SERVICES GMBH	DE	208,900	4.19%	208,900	4.19%
Total:			4,985,406.25		4,985,406.25	

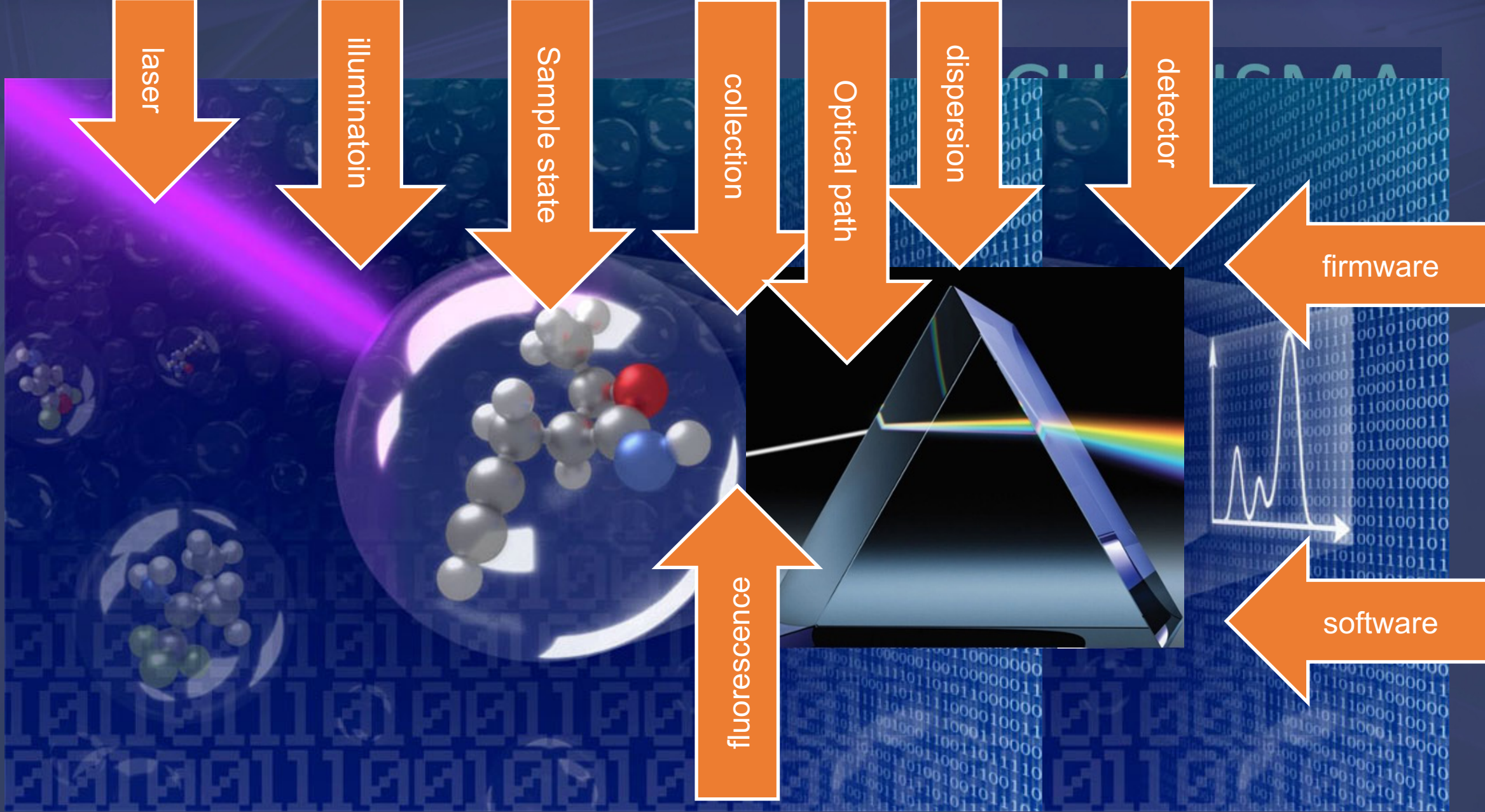


**Characterization and
 HARmonization for
 Industrial
 Standardization and advance
 MAterials**



CHARISMA receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No **952921**





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Universally describing Raman spectra

Lack of interoperability among different spectrometers
Increasingly softer hardware
Internet of things



Nanomaterials
Synthesis

Security
Nanomarkers

Food Safety and
Traceability

FAIR

CHADA

CHARISMA

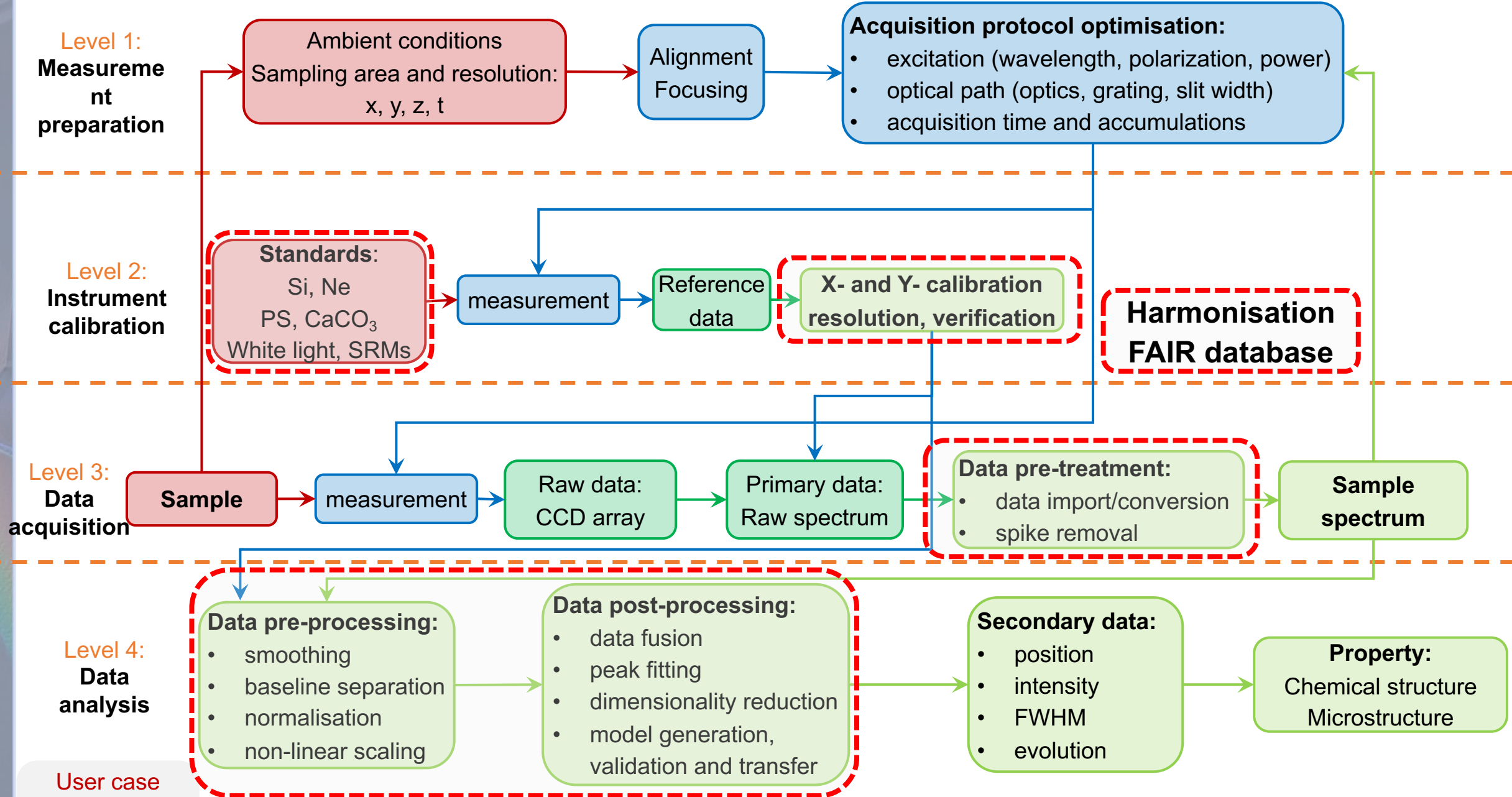


CHARISMA objective

to harmonize Raman characterization of materials, developing

- **hardware** and **reference** master samples;
- **algorithms** and protocols for spectra acquisition and computational quantitative analysis;
- and **correlations** between Raman **data** and **process or product** descriptors.

... interoperable datasets integration: **FAIR** Findable
Accessible
Interoperable
Reusable



User case
 Experiment
 Raw data
 Data processing

SMA receives funding from

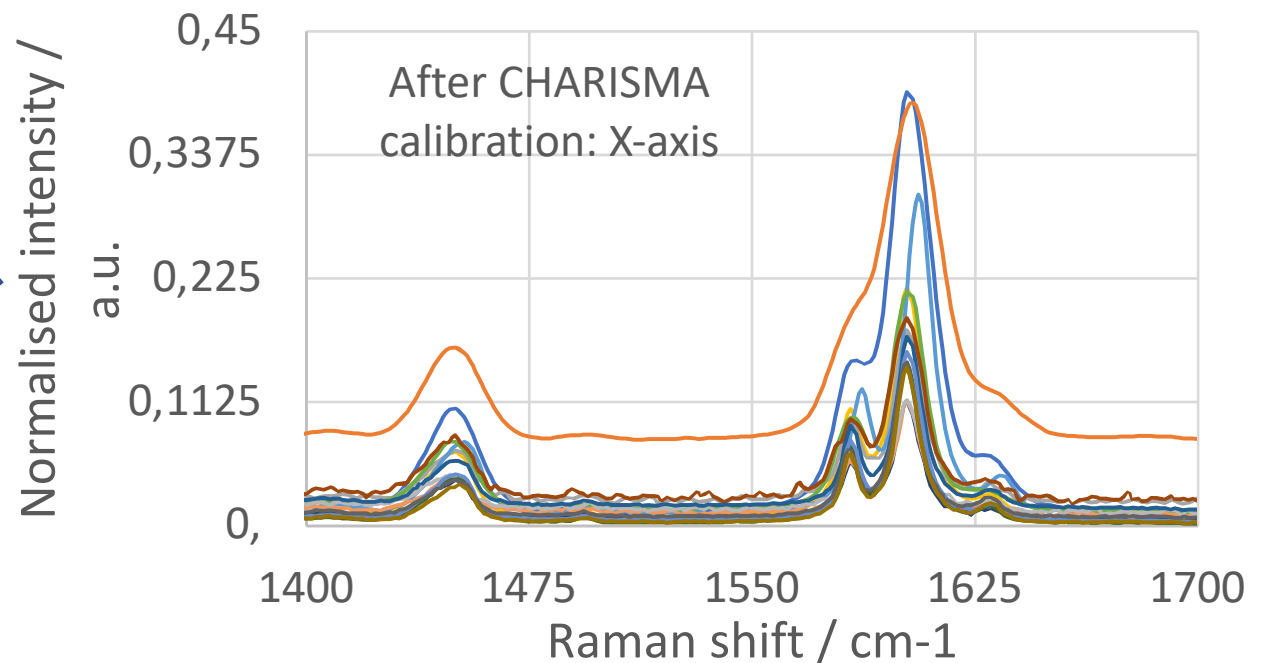
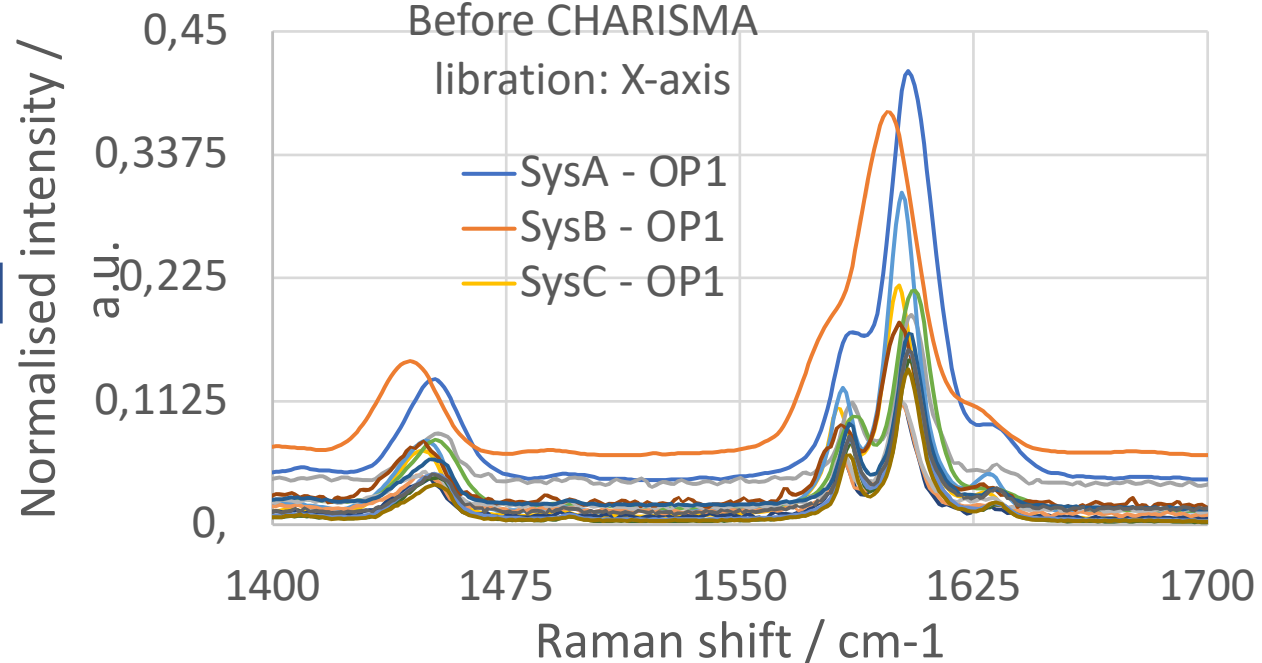
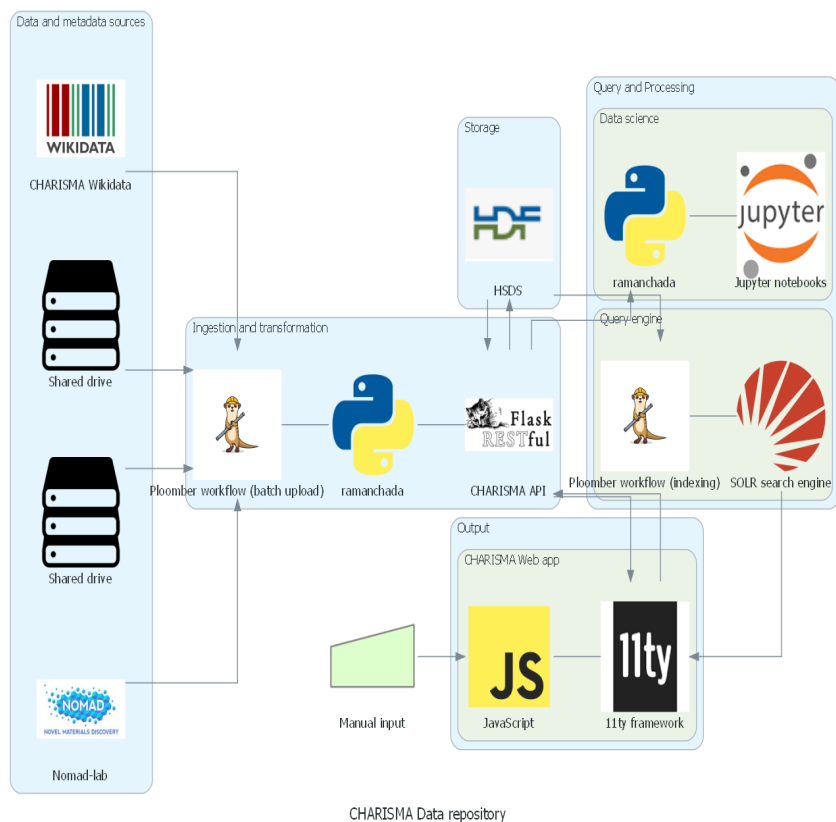
Raman characterisation experiment

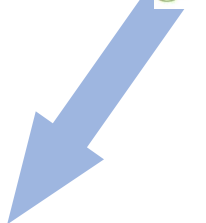
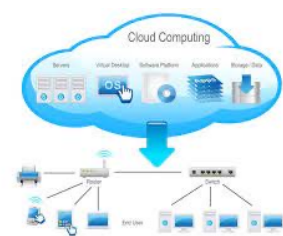
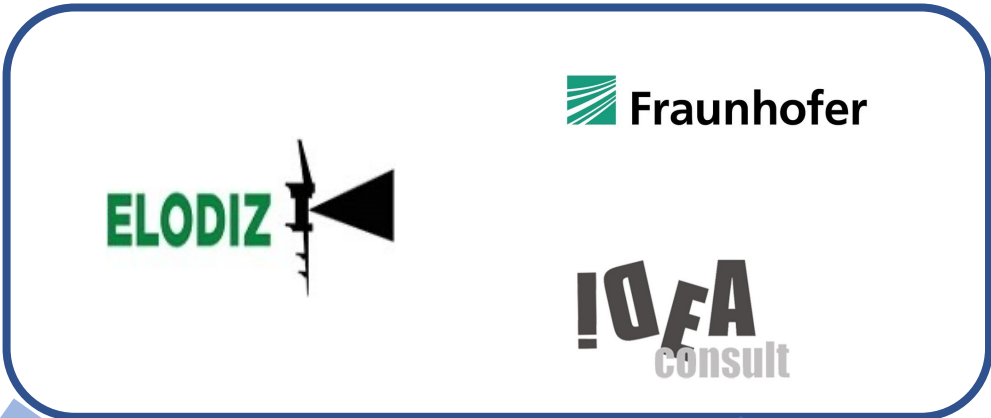
it No 952921



FAIR Raman data repository, harmonization

- 10 systems, high and low end
- 532 nm, 633 nm and 785 nm
- 15 optical paths (objective, grating, confocality etc.)



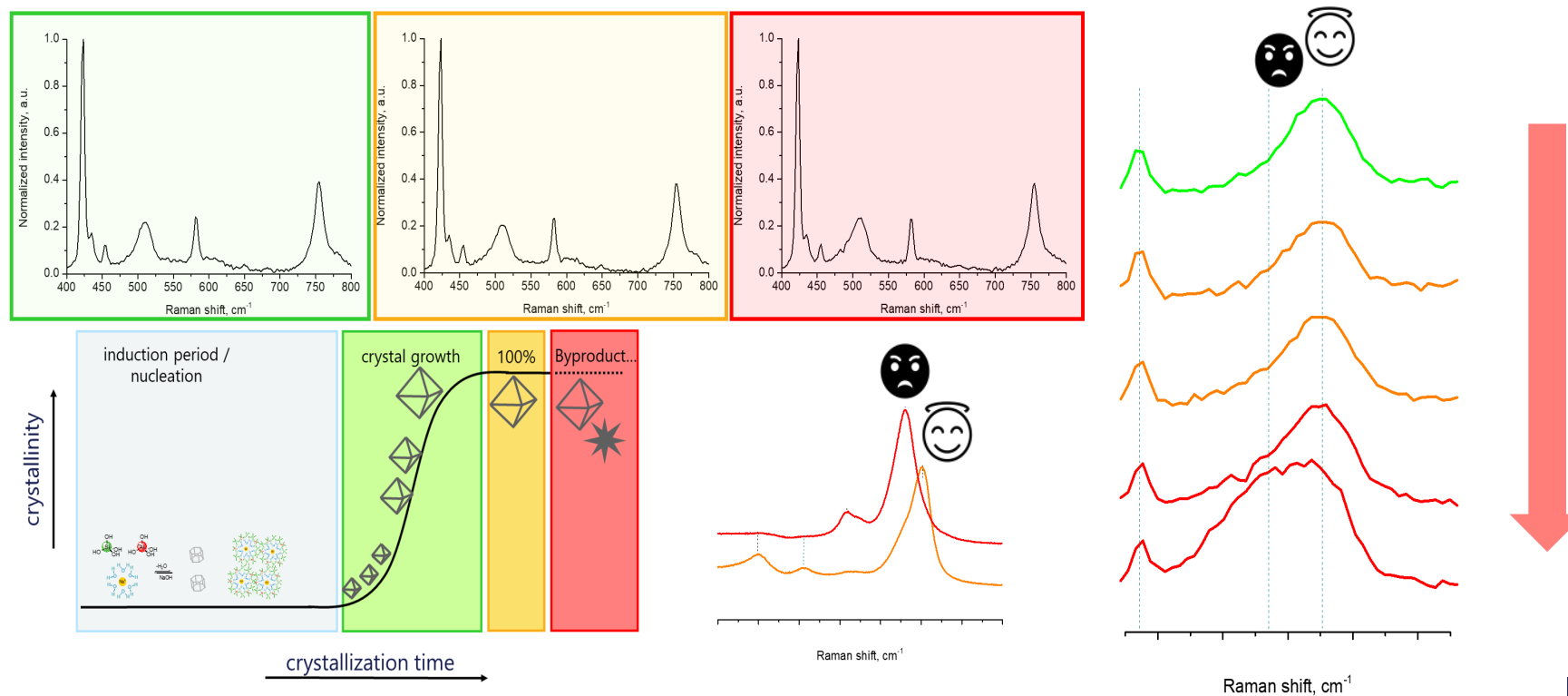


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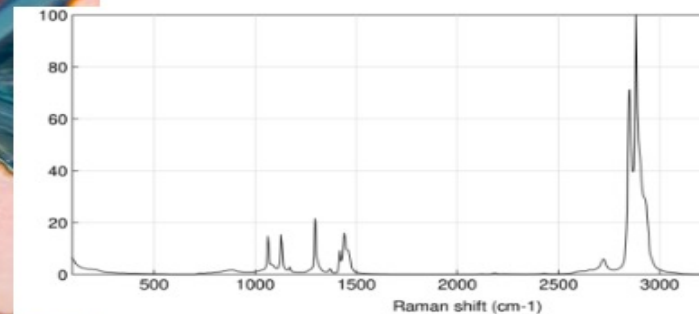
Nanomaterial synthesis, harmonised Raman measurements

- Synthesis product and by-product **identified** by Raman spectroscopy.
- Complete crystallization process **monitored** by *in-situ* Raman spectroscopy.
- Established sample extraction and measurement protocol to establish XRD-Raman **correlation**.



Food protection against bacteria

- Preventing bacteria biofilm formation
- Antimicrobial property



Identify, quantify, determine state

Handheld Raman

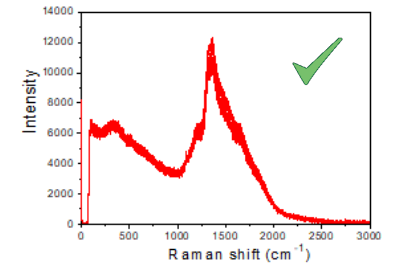
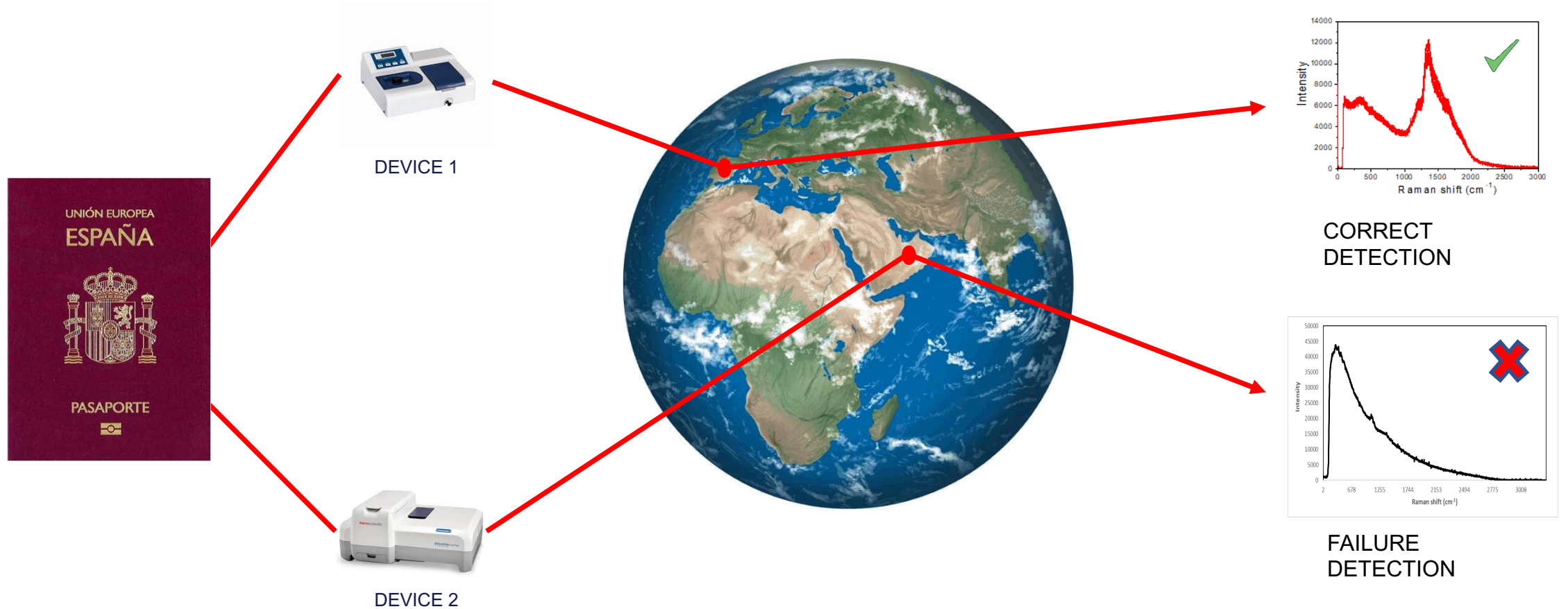


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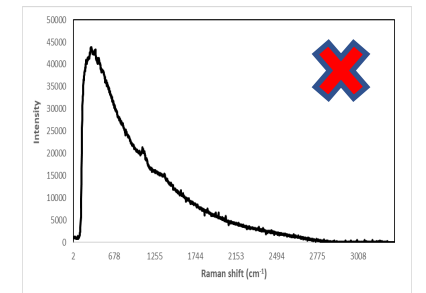


Distributed validation of Raman-marked documents

SPANISH PASSPORT RAMAN NANOMARKED **WITHOUT** HARMONISED SYSTEM



CORRECT
DETECTION



FAILURE
DETECTION

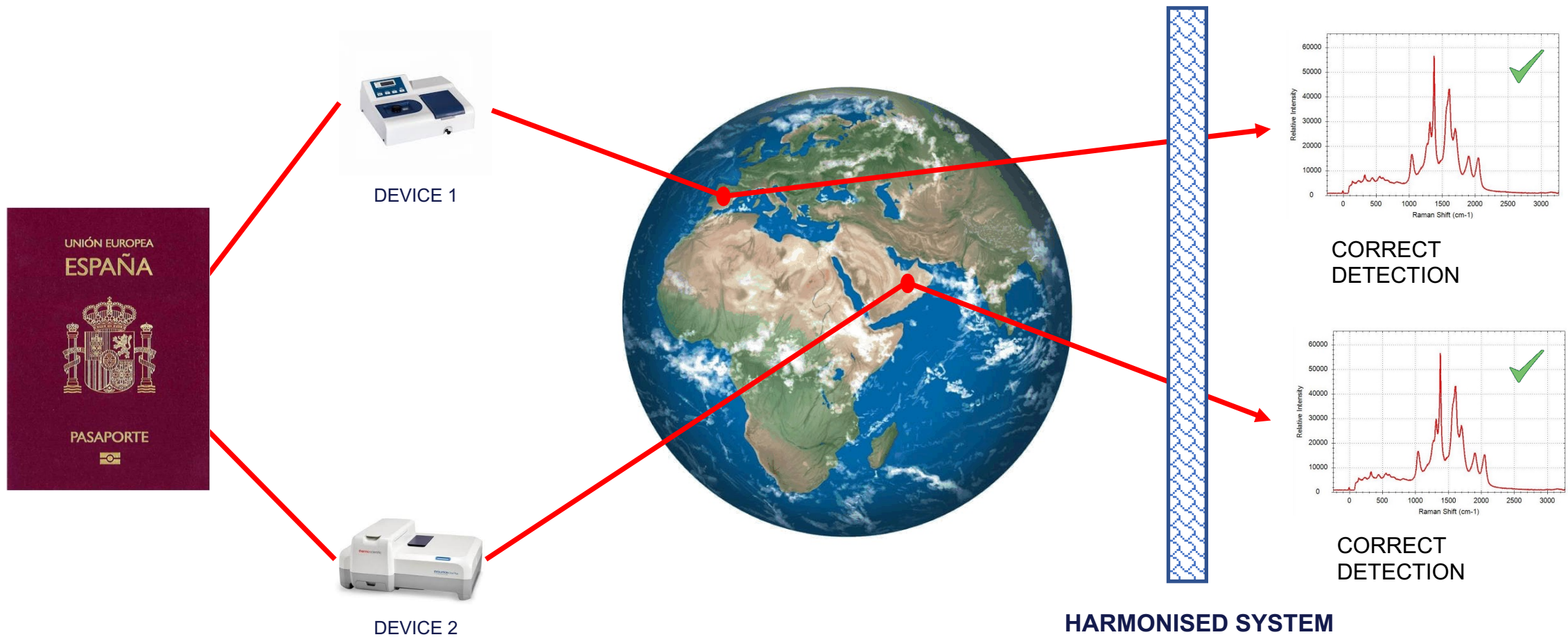


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Distributed validation of Raman-marked documents

SPANISH PASSPORT RAMAN NANOMARKED WITH HARMONISED SYSTEM



CHARISMA impact

- industrial implementation of Raman spectroscopy as real-time, in-line and distributed monitoring and control/decision tool, improving the business of existing products/processes due to improved product quality and trust, waste minimization and time and energy saving.
- foster new business based on Raman-active nanomaterials that face different societal challenges related to energy, security, or safety.

STANDARDIZATION TARGETS: harmonized Raman spectra and data

- Calibration and Verification of Raman spectrometers - Procedure to obtain harmonised spectra by adjustment of the Raman unit
- Raman data harmonization → harmonised Raman data storage



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Thank you!

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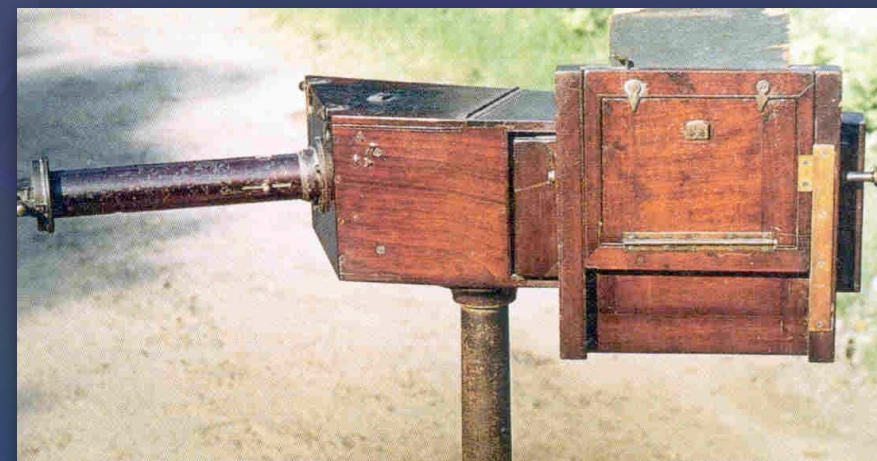
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CHARISMA

Original Raman's Raman spectrometer



Mumbai, India



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