NANO*futures*
A cross-ETP Coordination Initiative on nanotechnology

Grant Agreement No. NMP4-CA-2010-266789

Task 3.3 Identification of relevant successful cases related to nodes developed in the project

Project Contractual Details

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1 Introduction

The activities carried out by the Platform led to the approval of the following **nanotechnology cross-sectorial key nodes** on which the NANO*futures* Roadmap will be based. Each key node is relevant for a number of industrial sectors (inputs coming from the European Technology Platforms) and addresses several non-technological horizontal issues such as technology transfer, innovation financing, skills and education, communication and networking.....The nodes identified are the following:

- **Safety and Sustainability:** *includes standards & best practise guidelines for handling nanomaterials (nanoparticles, nanopowders), measurement protocols for nanomaterials; risk assessment and risk management; environmentally friendly and sustainable nanomaterials production processes*

- **Design, Modelling and testing of materials**: *includes design of nanomaterials from concept to disposal and recycling, modelling, characterization, toxicity tests. Knowledge management including patenting, availability of knowledge repository on nanomaterial safety etc.*

- **Nanoenabled surfaces:** *nanocoating technologies and manufacturing for smart surfaces (energy efficient, high performance, active, sensing etc.).*

- **Nano-micro manufacturing:** *includes low cost and high efficient production of nanomaterials, nanoobjects, nanoparticles multi scale fabrication and scale-up processes.*

- **Nanostructures and composites:** *High yield, low dispersion, high accuracy manufacturing of nanostructures; up-scaling from lab to industrial processes; ultra-high performance composites with smart properties for different applications.*

In this document some relevant good practices and successful cases, with priority to industrial relevance, related to the nodes are described. It is an open document that will be update with more cases as soon as they are identified. The following template was used to facilitate the collection of the info:

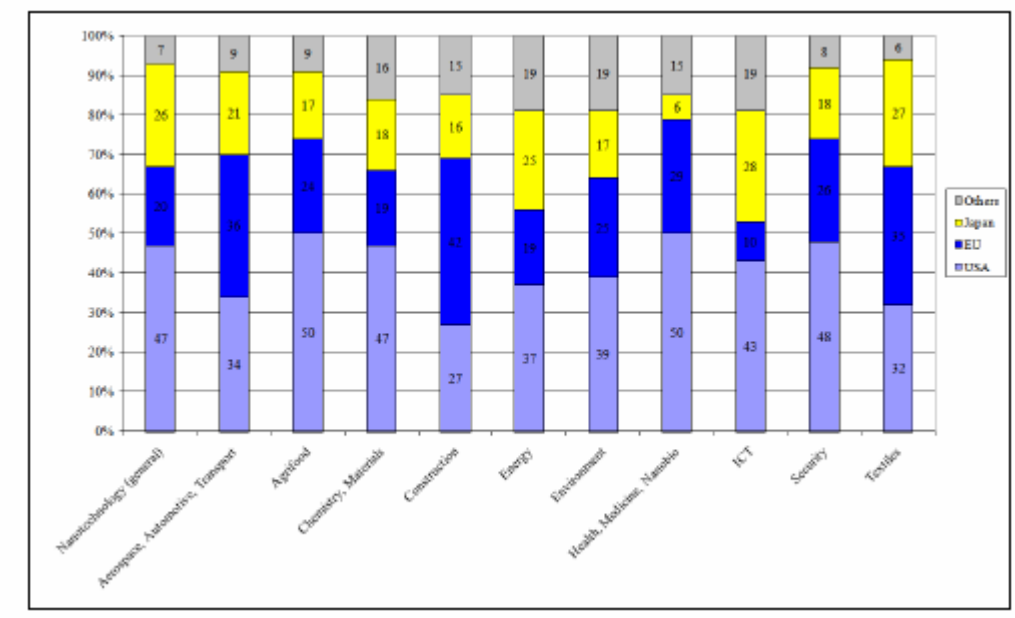
Company/entity	
Contact:	
Subject area and node to which is related or close to	
Summary of best practice/ successful case	
Target of best practice implementation	*Define the barrier, problem, need, or area of improvement that was the target of the best practice or that generate the successful case*
Objectives	*Specific goals did you want to achieve: i.e.; operations, enhancements, training, provider participation*
Challenges	*Significant challenges encountered in implementing the strategy.*

	How they were overcome.
Results and deployment	*Results of your strategy and how well did the outcome meet your goals? Benefits and by what measure the strategy as successful*?
Conclusions	

Moreover an analysis on patents and projects was carried out. The Information showed below capitalises on the following inputs:

- NANO*futures* Integrated Report of International Research Activities (Deliverable D1.3), including a detailed project analysis[1];
- ObservatoryNano Briefings and Reports, including patent and literature analysis on key industrial and research topics[2];
- NanoSafety Cluster reports on achievements of current European safety related projects[3];
- Public Findings of ProNano detailed analysis on 30 nanotechnology project results[4].

In general, ObservatoryNANO patent analysis highlighted for the whole nanotechnology area EU countries contribute with 20 % taking the third position behind the United States and Japan. The country assignment shows the United States and Japan in the leading positions with shares of 47 % and 25 % of all applications. **Germany** is following as the main European contributor with 8 % followed by **France** (4 %) and the **UK** (4 %).



[1] Available at www.nanofutures.eu
[2] Available at www.observatory-nano.eu
[3] Available at www.nanosafetycluster.eu
[4] Available at www.pronano.eu

Figure 1.-*Wordwide patent distribution in nanotechnology: EU in international comparison. From ObservatoryNANO Report 2010 on Statistical Patent Analysis*.

NANO*futures* project analysis also showed the leading position of Germany in terms of number of FP7 funded technology related research projects on nanotechnology. UK is the top country for FP7 safety related projects. The analysis considered the countries of project coordinators.

The leading position of UK and Germany is highlighted also by ProNano detailed analysis on successful European projects. In fact, they reported that the field work with the research community, the technology transfer structures and start ups clearly showed some discrepancies between the targeted European countries in terms of maturity of the technology transfer frameworks. In particular, the United Kingdom and Germany show mature technology transfer structures and the UK also experiences a more developed activity of business angels and venture capitalists in nanotechnologies. Indeed, most projects identified in these countries for ProNano support were close-to-market research results and young businesses in search of refined business plan and financing.

France and Spain, though benefiting from well developed public structures for technology transfer, are overall at earlier phases of research in the nanotechnology sector. This is clearly illustrated by the profiles of projects identified in ProNano, which are mostly in early stages of the commercialization process, still close to the lab: for instance in France out of 6 projects identified for coaching, 5 come from laboratories. Though, these two countries prove to have a strong public support structure for technology transfer, largely dominated by the national research organizations.

Looking more specifically to the different nanotechnology topics, ObservatoryNANO surveys and desk research identified some nanotechnology enabled solutions where there are some success cases by European industries and research centres.

From the evaluation of such inputs, integrated with NANO*futures* FP7 project analysis and NanoSafety Cluster reports, a list of successful topics and industries related or close to NANO*futures* key nodes has been identified. Such successful cases should be further evaluated and discussed during the upcoming inventive sessions (September - January 2011).

On the other hand, information regarding best practices in investment and commercialization of nanotechnology can be found in deliverable 2.3 of NanoCom[5]. project.

[5] Available at www.nanocom-eu.org

2 Successful Cases related to nodes

2.1 Safety and Sustainability node

2.1.1 Industry cases

Company/entity	NTC NANOTECH COATINGS GMBH
Contact:	Dr. Georg Wagner / Andrea E. Reinhardt http://www.ntcgmbh.com
Node	Safety and Sustainability
Summary of best practice/ successful case	Get better understanding how common certifications (e.g. ISO) benefit from international networking with standardisation and regulation groups, prepare for offering international customers more easy to understand information
Target of best practice implementation	Available short-cut information in some cases referring to different national needs
Objectives	Speed up international growth and stay in-line with global regulation
Challenges	Still fragmented information level
Results and deployment	Ongoing
Conclusions	Nanofutures working group results with EHS aspects expected as an easy to use way for SMEs in their way to grow international.

Company/entity	BAYER MATERIALSCIENCE AG
Contact:	Dr. Peter Krűger
Node	Safety and Sustainability
Summary of best practice/ successful case	Bayer advocates making use of the opportunities offered by nanotechnology, while at the same time ensuring their safe use and the protection of human health and environment. Bayer is working on the development of Multi-Walled Carbon Nanotubes (MWCNT) and applications in polymers and metals. This is why Bayer is assuming a pioneering role in safety, particularly as regards activities with carbon nanotubes, through product stewardship and sustainable development practices which are summarised in the 'objectives' section below.
Target of best practice implementation	To ensure safe handling and use of MWCNT-based products for workers, consumers/end users and for the environment.
Objectives	1. Developing and implementing a Product Stewardship Programme

	2. Driving safety research to address key relevant uncertainties regarding nanomaterials 3. Supporting stakeholder dialogue
Challenges	A key challenge in ensuring best practice in the development of nanotechnology products is the developing state of knowledge regarding nanotechnology EHS, safe handling and control. Bayer is taking an active role in ongoing safety research in order to ensure their practices reflect and apply current knowledge.
Results and deployment	Bayer has summarised their principles for working with nanotechnology in the Bayer Code of Good Practice with Nanomaterials (available http://www.sustainability2008.bayer.com/en/Bayer-Code-of-Good-Practice-on-the-Production-and-On-Site-Use-of-Nanomaterials.pdfx). Bayer has also been developed his Product Stewardship Programme, to support the safe handling of nanomaterials across the entire lifecycle, extending from product development, through to manufacture, application and disposal. As part of a responsible strategy for developing nanomaterials, Bayer has joined other members of the chemical industry in assessing nanomaterials from an Environmental, Health and Safety (EHS) perspective, contributing significantly to public safety research projects such as NanoCare, TRACER, CarboSafe, NanoGEM, CarboTox and CarboLifeCycle in partnership with universities and research institutes. Bayer is also working intensively on the international harmonisation of terminology and characterisation at the ISO level and on the sponsorship programme of the OECD Working Party of Manufactured Nanomaterials (WPMN). Bayer supports platforms that promote dialogue about the benefits as well as the concerns regarding nanotechnology with civil society and the general public in a climate of openness. Globally, Bayer participates in associations such as the American Chemical Council (ACC), CHEMSTAR Nanotechnology Panel and CEFIC (European Chemical Industry Council).
Conclusions	Bayer intends to continue to develop and implement best practice and safe development of nano-enabled products through supporting and further developing the activities described above.

Company/entity	**BRITISH STANDARDS INSTITUTION (BSI)**
Contact:	http://shop.bsigroup.com/en/Browse-by-Subject/Nanotechnology/
Node	**Safety and Sustainability**
Summary of best practice/ successful case	The British Standards Institution (BSI) has developed a guide to safe handling and disposal of manufactured nanomaterials (available http://www.bsigroup.com/en/sectorsandservices/Forms/PD-

	6699-2/Download-PD6699-2-2007/).
Target of best practice implementation	This guidance document is aimed at assisting those involved in working with nanomaterials undertake an adequate assessment of the risks involved, and implement an effective risk management strategy to ensure safe handling and control within the workplace. It is applicable to a wide range of nanomaterials and nanostructured materials, including nanoparticles, nanofibres, nanopowders, nanotubes and nanowires, generically referred to as nano-objects, as well as aggregates and agglomerates of these materials. It also covers any material or preparation in which such nanomaterials comprise a significant proportion.
Objectives	1. Providing a framework and giving guidance on assessing risks and recognising uncertainties in the development, manufacture and use of nanomaterials. 2. Developing and implementing an effective strategy to address and control the risks (based on established principles of substance risk management).
Challenges	This document recognises the considerable uncertainty about many aspects of effective risk assessment of nanomaterials, including the hazardous potential of many types of nanoparticles and the levels below which individuals might be exposed with minimal likelihood of adverse health effects. The guide therefore recommends a cautious strategy for handling and disposing of nanomaterials. Given the emerging state of knowledge concerning the risk assessment of nanomaterials, it is probable that important new knowledge will become available at some time. It is critical therefore that the risk assessments carried out in accordance with the Guidance are reviewed at least annually and that those involved in the process take steps to ensure that their knowledge is kept up-to-date.
Results and deployment	The document provides comprehensive guidance on: ▪ Manufactured nanomaterial types and characteristics ▪ Nanoparticle exposure and risk ▪ General approach to managing risks from nanoparticles ▪ Identification and competence of person conducting risk assessment ▪ Information collection ▪ Risk evaluation ▪ Control of exposure ▪ Health surveillance ▪ Measurement methods for evaluating controls ▪ Spillages and accidental releases ▪ Disposal procedures ▪ Prevention of fire and explosion
Conclusions	This document is a pragmatic guidance document which is being used by large and small organisations as the basis of an effective risk management programme. The document has been downloaded more than 1.000 times from the BSI website since its publication.

Company/entity	DUPONT / ENVIRONMENTAL DEFENSE FUND
Contact:	http://nanoriskframework.com/page.cfm?tagID=1082
Node	**Safety and Sustainability**
Summary of best practice/ successful case	The Environmental Defense Fund and DuPont have published the Nano Risk Framework (available http://nanoriskframework.com/page.cfm?tagID=1095), to establish a process for ensuring the responsible development of nanoscale materials, which can then be widely used by companies and other organisations. The document outlines a proposal for a comprehensive, practical, and flexible Nano Risk Framework to evaluate and address the potential risks of nanomaterials. It is intended to help users organise and evaluate what they already know; assess, prioritise and address data needs; and communicate clearly how they are mitigating risks related to nanotechnology. DuPont has conducted several case studies in order to evaluate the comprehensiveness, practicality, and flexibility of the Nano Risk Framework, which are further outlined in the 'objectives' section below.
Target of best practice implementation	DuPont will use the Framework on all products incorporating nanomaterials as a way of meeting its continued product stewardship commitment with regard to nanomaterials. It is intended that other companies could also adopt the Framework and its guiding principles as part of their product stewardship programmes. DuPont has conducted and published three case studies in order to evaluate the Nano Risk Framework for three different materials, namely: ▪ DuPont™ Light Stabilizer 210 ▪ Carbon nanotubes (CNT) ▪ Nano-sized zero-valent iron (nano-Fe^0) These materials differ in terms of composition, structure, intended application, stage of development, and DuPont's role in the development, evaluation, or potential use of the material.
Objectives	The Framework is a practical guide for use both on its own and as a supplement to existing product stewardship processes for the responsible development of nanomaterials. The Framework establishes a systematic and disciplined process for product developers to identify and reduce potential risks.
Challenges	The Framework is not a regulation – it is a guidance document for DuPont and any other company or organisation that chooses to adopt it. DuPont and Environmental Defense believe that a comprehensive, consistent, and appropriate regulatory policy for nanomaterial development is needed. The Framework is intended to help in the development of such a policy, as one piece of input in an open process. The Framework is intended to be complementary to other risk management processes and companies with well-established processes may find it relatively easy to supplement or modify

	their established processes to incorporate the Framework.
Results and deployment	Examples in which the Framework has been applied have been published for three materials: 1. **DuPont™ Light Stabilizer 210:** DuPont generated a complete Output Worksheet for this product, addressed all of the base sets, completed a risk evaluation, and selected risk management measures. 2. **Carbon nanotubes.** DuPont developed an overview and Output Worksheet, but it did not address all of the base sets with data because the company's use of CNTs at this point is in the research and development phase, with potential exposures limited to lab workers. 3. **Nano-Fe^0.** DuPont did not generate a full Output Worksheet for nano-Fe^0. Rather, the company used the Framework to identify key uncertainties that must be addressed before DuPont would proceed further with evaluating the application.
Conclusions	Dupont / Environmental Defense Fund aim to continue to engage with other companies to help them understand the need for a thorough assessment of nanomaterial risk and adopt the Framework and its guiding principles into their own product stewardship processes. They will also provide input to inform appropriate government policies to ensure the responsible development of nanotechnology.

Company/entity	**BASF**
Contact:	Dr. Carolin Kranz, Communications and Government Relations Dr. Karin Wiench, Regulatory Toxicology Dr. Robert Landsiedel, Safety Research Dr. Stefan Engel, Hazardous Chemicals Management
Node	**Safety and Sustainability**
Summary of best practice/ successful case	BASF is a leader in the field of chemical nanotechnology, and is already applying this expertise in several products. BASF researchers work on the production and formulation of nanoparticles, as well as on the development of nanostructured surfaces and materials. BASF is committed to the safe development of its nanotechnology products and is taking a number of proactive measures towards developing and implementing best practice, which are outlined in the 'objectives' below.
Target of best practice implementation	The target of best practice implementation in BASF is to ensure that workers, consumers/end users and the environment are protected from any risks that their nanotechnology products may pose.
Objectives	BASF is working towards the safe development of nanotechnology products through the following objectives to ensure best practice: 1. Developing and implementing a code of conduct (clear principles for responsible use) 2. Undertaking safety research on nanomaterials 3. Ensuring safe handling of nanoparticles at the workplace

	4. Engaging with stakeholders and participating in public debate; 5. Transparent involvement in political decision making
Challenges	One of the key challenges in implementing best practice in the development of nanotechnology products at present is that the state of knowledge in the field is continually evolving and developing. BASF have tried to address this by taking an active role in ongoing safety research and maintaining an on-going awareness of the state-of-the-art.
Results and deployment	**1. Code of Conduct** To ensure a responsible handling of nanomaterials, BASF has introduced a Code of Conduct. This is consistent with the "Principles" of the German Federal Government. Details of how BASF implement their Code of Conduct, in production, risk management, product safety and dialogue, are available on the company website. **2. Safety research on nanomaterials** BASF have been participating for a number of years in the safety research of nanomaterials. This includes conducting their own safety research on nanomaterials in the BASF experimental toxicology and ecology department. These facilities are internationally recognised and are also GLP and AAALAC certified by independent third parties. BASF also participate in national and international research projects such as NanoGEM, NanoCare, MARINA, Nanosafe2, CellNanoTox, the HESI/ILSI Nano Safety Project and the Defra LINK Project PROSPEcT. A list of publications of the BASF Safety Research Group is available here. A key output is the development of a short-term inhalation test, which has been applied to test several types of nanomaterials including multi-walled carbon nanotubes. **3. Safe handling of nanomaterials** The principle underlying BASF's occupational safety practice is to prevent emissions of nanoparticles in the air at workplaces. BASF have adapted their risk management strategy specifically to meet the requirements for safe handling of nanomaterials and summarised this in a Guideline. As part of this, BASF have defined even stricter requirements for working with nanostructured materials, and use state-of-the-art measurement equipment to monitor exposure levels in the workplace. **4. Stakeholder engagement** BASF is committed to pursuing a dialogue with society based on openness and trust, which applies to the subject of nanotechnology. BASF is contributing to the social debate on nanotechnology in two ways: by providing information and by engaging in dialogues. Our employees present our activities worldwide at conferences and in publications. On our internet page www.basf.de/dialoguenanotechnologie we provide comprehensive, continuous, and up-to-date information on topics ranging from occupational safety to our Nanotechnology Code of Conduct. In 2008, the BASF Dialogueforum Nano, was launched in which representatives of environmental and consumer organisations, trade unions, scientific institutes and churches (Civil Society Organisations / Non Governmental Organisations /

	NGOs) work together with employees of BASF SE on various issues related to the subject of nanotechnologies. The 2009 / 2010 dialogue forums resulted in **recommendations** on how transparency and information can be guaranteed along the product life cycle. BASF has also contributed to stakeholder dialogue through a number of events, including the "Expert Meeting in Nanotech" (Berlin, June 2008). **5. Involvement in political decision making** BASF takes an active role in industrial associations and participates in political debates, in order to help create political framework conditions for the responsible use of nanotechnology. One example of BASF´s political involvement was the participation in the European Commission's "Sustainable Chemistry" technology platform, which is dealt with nanotechnology issues. With the involvement of all stakeholders such as regulators, the scientific community, non-governmental organizations, and industry, these efforts are aimed at boosting framework conditions for a sustainable chemistry in Europe. Moreover, BASF employees were also represented in the NanoKommission and NanoDialog of the German Government. This was a process in which stakeholders from politics, industry, science, as well as regulators and interest groups discuss the opportunities and risks of nanomaterials and develop recommendations for the responsible handling of nanomaterials. The **final recommendations** are published at http://www.bmu.de/english/nanotechnology/nanodialog/doc/47547.php In addition, BASF is involved in several industrial associations including the German Chemical Industry Association (VCI), the European Chemical Industry Council (CEFIC) and the American Chemical Council (ACC). BASF members also participate in the OECD and ISO working groups concerned with nanotechnology. BASF also responded to a recent appeal from the U.S. EPA by providing data relating to nanomaterials.
Conclusions	Ensuring and implementing best practice in the safe and responsible development of nanotechnology is an on-going process, which BASF aims to continue to implement through maintaining and further developing the activities described above.

2.1.2 Cases from patent and project analysis

2.1.2.1 The Dutch Observatory: Risks of Nanotechnology Knowledge and Information centre

The observatory was founded in 2007 and is called the Risks of Nanotechnology Knowledge and Information centre (KIR nano). It is part of the Dutch action plan on nanotechnology (Tweede Kamer, 2008). This action plan includes proposals on research, innovation, development, legal aspects, risk management, and communication to the public at large.

KIR nano aims to observe and monitor the potential risks of nanotechnology, gathering relevant scientific literature, and advising and informing governmental bodies and professionals. These activities are always performed from a risk assessment viewpoint. Until now, the focus was on engineered, free, insoluble and non biodegradable nanomaterials and their possible toxicological and ecotoxicological risks.

The communicative function of KIR nano is put into practice via participation in national and international networks such as:

- FP7 projects (European Nano Observatory, NanoImpactNet, ramingNano),
- OECD Working Party for Manufactured Nanomaterials
- Working Group on Health Safety and Environment of the European Committee for Standardisation (CEN)
- International Organisation for Standardisation (ISO)
- Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)
- Expert panel of the Task force Novel Foods and Nanotechnology of the International Life Sciences Institute (ILSI)
- Society of Environmental Toxicology And Chemistry (SETAC)

Furthermore, KIR nano advises the Dutch government who participates in the REACH Competent Authorities Subgroup on Nanomaterials.

2.1.2.2 UK Observatory: SAFENANO

SAFENANO is a partnership between the Institute of Occupational Medicine (IOM) and Napier University and is underpinned by partners in SnIRC (Safety of Nanomaterials Interdisciplinary Research Centre).
SAFENANO is an initiative which aims to enable industrial and academic communities to quantify and control potential risks from nanotechnology to their workforce, as well as to consumers, the general population and the environment. As a UK Government Centre of Excellence for Nanotechnology, it helps to ensure industry, academia, government and the general public clear & easy access to independent & impartial advice on health, safety and environmental aspects of Nanotechnology; it remains the only of these centres to have a principal focus on health, safety and environmental aspects of nanotechnology.
Through a combination of novel research, review activities, expert opinion and training, the SAFENANO initiative provides the information necessary for assessment of risks specific to nanotechnology, and facilitates responsible development of safe nanomaterials. Key to this is the initiative's maintenance of impartiality and independence of opinion.

In the last 2 years SAFENANO has become firmly established as a world leader in the field, providing independent expert advice and judgement to government, national and international authorities on all aspects of nanotechnology health and safety.

2.1.2.3 Observatoire des Micro et Nanotechnologies [Observatory of Micro and Nanotechnologies] (OMNT)

The Observatory of Micro and Nano Technologies (OMNT) is a joint unit between the CEA and the CNRS which are two French public research organisations. It was created in 2005 in order to precociously detect weak signals heralding rupture, by carrying out continuous strategic watch (both scientific and economic) on key topics of micro and

nanotechnology. OMNT publishes its work through different level of analysis, answering the requests of various stakeholders through written documents and workshops.

The strategic watch is performed at a worldwide level, analyses are carried out by a network of 235 experienced scientific experts supplemented by marketing experts. Scientific experts come from various French public research organizations: CEA, CNRS, Universities, "Grandes Ecoles"… They cover a broad spectrum of scientific skills: biology, chemistry, optics, micro-electronics, energetic, physics, materials, etc. They meet 4 or 5 times per year in order to exchange their point of view on the evolutions of the fields and in order to release a report summarising the results of the discussions. Thanks to experts meetings, OMNT is also able to release annual reports, annual workshop and specialised workshops.

2.2 Design, modelling and testing of materials node

2.2.1 Industry cases

Company/entity	**Cellendes (http://www.cellendes.com/), (Germany)**
Contact:	Dr. Brigitte Angres / Dr. Helmut Wurst http://www.cellendes.com
Subject area and node to which is related or close to	**Design, Modelling and testing of materials** Technology for controlled design of cell environments in 3-D cell culture. Areas of application include basic research, drug development and biomedical engineering.
Summary of best practice/ successful case	Cells cultured in vitro in three dimensions (3-D) resemble the physiology of their counterparts in vivo much better than cells cultured conventionally on flat surfaces of tissue culture plates. This is reflected in differential gene expression and a difference in cell behaviour and differentiation. The hydrogels produced by Cellendes can be easily modified with bioactive components to adapt the extracellular environments to specific needs of the cell culture. Robust gel formation is amenable to automation, injection and in situ gelation.
Target of best practice implementation	Many researchers culture cells in flat dishes, two-dimensional culture systems. A disadvantage is that the cells behave differently than they would in a living organism. Cellendes have developed synthetic transparent hydrogels for three-dimensional applications. Compared to other hydrogels on the market the ones developed by Cellendes can be much easier modified with bioactive factors such as peptides right at the bench.
Objectives	From a technical point of view, during the development of the hydrogels the main goal has been to make these components reproducible. Presently, the team is working at trying to make it possible to store and ship the gels at room temperature and not in refrigerated conditions, to save costs in shipping.
Challenges	Supported by ProNano (http://www.pronano.eu/),

	Cellendes coped with the challenge of improving the **business plan** and **secure financing**. Cellendes has secured financing through a single corporate investor, the German company Aesculap, which has provided enough money for the next few years.
Results and deployment	The invention has fundamental advantages over other hydrogels for three-dimensional cultivation, also on the market. Almost all of Cellendes' customers are doing basic research within the field of the life sciences. However, their hydrogels could also be useful in the chemical industry and within drug and cosmetic development. To establish a customer base and become profitable, Cellendes are now working on improving their website and product literature as well as setting up databases and new equipment.
Conclusions	ProNano project experts have supported the Cellendes team in detailing the business idea, moderating the spin-off process and the negotiations with the parent institute, developing the business model and writing a comprehensive business plan and sound financial planning. Next step will be to found a major medical technology company as a corporate investor.

2.2.2 Cases from patent and project analysis

2.2.2.1 Nano-enabled Innovations for Industrial Quality Control

The physical dimensions of nanostructures are far below the diffraction limit of visible light; preventing nanoparticles from being directly imaged by optical microscopy for example. Instead, utilisation of X-ray and electron based methods are widely required. Appropriate techniques are established in R&D, and even visualisations down to the single atom level have been realised1. Other nano-analytical characterisation methods are dealing with bulk entities instead of analysing individual structures. However, it is often possible to infer characteristics on the nano-scale out of the bulk properties.

Despite the high quality of European research in nanoanalytics, the US continues to dominate the scene. This is particularly true of research to market transfer for which patents are a useful indicator underlining US leadership.
However, Europe is in a comfortable position concerning industrial players in nanoanalytics, who are often backbones of nanotechnology in Europe:

- **Bruker AXS GmbH**, focused on X-ray microanalysis for SEM and TEM, Electron Backscatter Diffraction, AFMs, Micro X-ray Fluorescence, Profilometry;
- **Fries Research & Technology GmbH** (FRT), a SME active in Metrological surface measuring systems
- **Nanofocus AG**, a SME active on Profilometry and Sensors;
- **Nanotools GmbH**, a SME active on AFM probes
- **Oxford Instruments**, a medium to large scale enterprise focused on detectors, Coatings thickness measurements and Elemental analysers
- **SPECS Surface Nano Analysis GmbH**, a SME active on customised systems for surface analysis

2.3 NANOenabled surfaces node

2.3.1 Industry cases

Company/entity	NTC NANOTECH COATINGS GMBH
Contact	Dr. Georg Wagner / Andrea E. Reinhardt http://www.ntcgmbh.com
Subject area and node to which is related or close to	**Nanoenabled surfaces**
Summary of best practice/ successful case	Faster application of the patented NTC product lines and more international awareness of the wide range existing and proven solutions
Target of best practice implementation	Support users to switch from conventional coatings to NTC coatings (incl. taking benefit of e.g. better thermal transfer rates)
Objectives	Having NTC products used in every European country within next 5 years
Challenges	Nano is in some way still associated with “expensive”
Results and deployment	e.g. at ENF 2011 meetings used the possibility to explain industrial and SME companies the technical and commercial advantages of sol-gel based coatings with their multifunctional aspects (anti-corrosion, better thermal properties) and high efficiency (thinner coatings + longer lasting =>lower costs).
Conclusions	New leads for building a wider customer field, new customers contacts established to Scandinavia

2.3.2 Cases from patent and project analysis

2.3.2.1 Applications of nano-enabled photocatalysis

Both the technological and economic importance of photocatalysis has increased considerably over the past decade. Improvements in performance have been strongly correlated to advances in nanotechnology; for example, the introduction of nanoparticulate photocatalysts has tremendously enhanced the catalytic efficiency of specific materials. A variety of applications ranging from anti-fogging, anti-microbial and self-cleaning surfaces, through to water and air purification and solar induced hydrogen production, have been developed and many of these have made their way into commercial products. However, extensive research continues to further optimise this technology and to widen the spectrum of potential applications. Research and applications include anti-stick or anti-fingerprint coatings, soil repellence, and decomposition of organic matter such as microbes or fat.
Japan is the global leader in photocatalytic applications with respect to both production and consumption of photocatalytic products. However, the EU is quite well positioned, taking second position ahead of the US in terms of number of patents. In particular French **Saint-Gobain Glass** and the **Italian Italcementi** are among the top owners of

patents. Further successful European companies include **Kronos International, BASF, Reckitt Banckisers, Kemira Pigments and Evonik Degussa**.

Photocatalytic water treatment applications have almost become a mature market. Small-scale photocatalytic systems with artificial UV-light have already been on the market for several years (http://www.ube.es/index.html), whereas solar photocatalytic water treatment plants are at a demonstration phase (http://www.raywox.com) and pilot projects for drinking water purification in developing countries have only just started (http://www.rcsi.ie/sodis/). Among EU industries there is the German **KACO New Energy**, which successfully distributes nanoscale iron salt as a photocatalyst, but has also been successfully tested with a suspension of nano-TiO_2.

2.4 Nano-Micro scale Manufacturing node

2.4.1 Industry cases

Company/entity	**Single Quantum (www.singlequantum.com)** founded in early 2012
Contact:	Sander Dorenbos, Val Zwiller, Floor van de Pavert
Subject area and node to which is related or close to	**nano-micro manufacturing**
Summary of best practice/ successful case	Single Quantum is a start-up company that commercializes the invention of scientists from the University of Delft. They developed a new device based on superconducting nano-materials that helps to detect single photons with higher efficiency. They are already selling the product on the market.
Target of best practice implementation	To date, people working with single photons are mostly scientists. Chip manufacturers also use single photon detectors to check their products. In the future, single photon detectors will be likely used for medical imaging
Objectives	The current main objective is to identify new markets and new applications and to look for commercial products in which the technology could be embedded.
Challenges	After they developed their single photon detector, the scientists gave it to other laboratories As they got requests from other scientists; they realized it could become a commercial product. The device was an improvement of an existing detector, so they had to obtain a licence with the owners of the original patent. The coaching they got from the Pronano project (www.pronano.eu) was very helpful to establish the company and to negotiate the licence deal.
Results and deployment	Single Quantum provides single photon detector systems. Detectors are based on a technology developed at the Delft University of Technology. Single photon detection is achieved with superconducting nanowires and offers high detection efficiencies over a large wavelength range. Other key parameters such as time resolution, dark noise, dead

	time and after pulsing are better than single photon detectors based on avalanche photodiodes
Conclusions	The technology is established and successfully marketed. Are working to increase the efficiency further. They now aim to develop arrays with multiple detector chips that could work like extremely sensitive cameras, opening the way to new applications

2.4.2 Cases from patent and project analysis

2.4.2.1 Nano-enabled thermoelectricity for energy harvesting

Thermoelectricity (TE) is the conversion of heat into electricity (Seebeck effect), or of electricity into heat or refrigeration (Peltier effect). The use of the Seebeck effect could allow heat to be saved which would be otherwise lost. Although the conversion efficiency is very low, it has been enjoying renewed favour for several years, and novel research and development leads have been investigated, such as new materials and the structuring of matter at the nanoscale.
The most promising applications of TE, in the context of energy saving, concern thermal engine heat recovery (particularly in transport applications), and human body heat scavenging to power portable devices. TE for energy harvesting has several barriers to overcome: low conversion efficiency; toxicity; and low availability of chemical elements constituting part of the most interesting thermoelectric materials. In this context, the main challenges for nanotechnology are to demonstrate high efficiency improvement, and to display low cost implementation in thermoelectric materials.

More than 300 research laboratories in the world currently work on thermoelectric materials. Even if there are 100 labs located in Europe (including 35 in Germany and 15 in France), and there are currently over 1000 patents concerning thermoelectrics in Europe, only a few European companies produce and commercialise thermoelectric devices, as for example:

- **Micropelt, Laird,**
- **Beakon Technologies**
- **Termo-Gen**.
- **BASF** (29 patents in the field of thermoelectrics).

For the last three years, the automotive industry has increasingly invested in R&D projects on thermoelectricity. In Europe, the FP7 program finances large projects including German, French, Italian, and Swedish car and part manufacturers. For instance, the HeatReCar project coordinated by **Fiat Research Centre** is focused on developing a TE device which could produce up to 3kW in a combustion engine vehicle. In Germany (**BMW, VW, Daimler, Opel**) and in France (**Renault, Valeo**) specific programmes are lead by car and truck manufacturers.

2.4.2.2 Nanotechnology for Flat Panel Displays

Display devices play a critical role in information sharing as they are used in our everyday life in different applications. Cathode ray tubes have dominated the display industry for over 70 years but the demand for better quality displays is driving

technology development. Consumers call for suitably priced displays with improved features in thinness, brightness, contrast ratio, viewing angle, longevity, size, and reduced weight and power consumption. Nanotechnology, an emerging approach to upgrade flat displays, improves the performance and quality while taking environmental aspects into account. These advances also provide novel features such as foldability and flexibility. Several competing display technologies have recently emerged to satisfy the needs of the display industry. Each of these emerging display technologies has their advantages and disadvantages and no single technology provides all the required properties.
Indium tin oxide (ITO) is the most widely used transparent oxide electrode film in different display technologies. It suffers from the high cost, a limited supply of indium, fragility, and lack of flexibility. To surpass these difficulties, CNT and graphene have both been widely studied as promising replacements for ITO due to their excellent electronic properties and suitability for displays. If successful, ITO replacements will remove the need for using scarce indium, and at the same time provide novel, and highly desirable features, such as flexibility.

By the introduction of novel technologies, EU has a good chance of re-entering the display industry. There is a high level of expertise present in European companies and research organisations including **Cambridge University (UK)** and **Fraunhofer Institute (DE)**. However, the largest challenge lies in the industrial eco-system and completeness of value chains.
Experts believe that Europe's strengths in long term science and technology research benefit especially the demand of inventions of new principles, new materials and technology breakthroughs for new displays. Also the mature industry (as LCDs) needs continuous technique evolvement and upgrades.
One successful example of new European display industry is **Plastic Logic** that builds on the **expertise from Cambridge University's Cavendish laboratory** and has recently announced to build a production plant in Russia while continuing production in their existing plant in Dresden.

2.4.2.3 Nano-enhanced automotive plastic glazing

Driven by the need to reduce vehicle weight, the desire for more design freedom, and for higher levels of safety, the automotive industry has been investigating the substitution of mineral glass windows by polymers (more specifically polycarbonate) glazing for decades. However, until recently some key performance specifications had not been reached; scratch resistance and long term ultraviolet (UV) resistance remained challenges. Recent advances involving nanotechnology are helping polycarbonate window developers to overcome these challenges. Due to these advances the automotive sector expects that in 2020, 20% of automotive glazing will be produced from polycarbonate.
EU headquartered **Bayer** is in a leading position both in terms of production volumes as well as in terms of connections to the automotive value chain. On top of that, several main research institutions and highly innovative smaller companies are based in Europe (such as **GXC-Coatings**). Additionally, some large polycarbonate suppliers with headquarters outside of the EU do have substantial EU based research, production, and marketing activities and thus further enhance the European capability to bring the results of such research to the market. Finally, the presence of innovative car makers provides opportunities for strategic collaborations such as those between **Bayer and Daimler**.

2.4.2.4 Nano-enabled insulation materials for buildings

The construction sector is the largest energy consumer (40%), and the main contributor to greenhouse gas emissions (GHG), at over 36% in the EU. Heating, ventilation and air conditioning (HVAC) accounts for 10% of EU's energy consumption and greenhouse gas emissions.
However, buildings are generally long-lasting, with average lifetimes of greater than 60 years. This makes it difficult to drastically improve the energy efficiency performance of the entire European building stock only through applying superior insulation and thermal management technologies to new buildings.
To have a substantial impact within a shorter (10-20 year) timeframe, existing buildings must be upgraded (retro-fitted) in terms of their thermal performance.
As a general rule denser materials exhibit poorer insulation performance; in porous materials a larger pore size also equates to greater heat transfer and poorer insulation. Nanoporous materials such as aerogels have the lowest known density of any existing solid, in addition to a nanoscale pore size, and therefore act as excellent insulators.Other nanotech-enabled insulation materials include coatings and paints. These materials are especially effective in reducing the radiation related heat transfer.

In Europe, research on nanofoams and aerogels has up to now been below critical mass, despite the collaborations initiated during the Framework Programmes, never reaching substantial markets or mature large volume production capability. However, recently several large chemical industries have increased their interest in these materials, focussing on more robust and less costly polymer nanofoams (also referred to as organic aerogels) and seeking lower cost production routes.

For window films, Solutia, Bekaert and 3M are probably the global leaders; of these **Bekaert** has its headquarters in Belgium. EU funding has only recently begun to address the opportunities found here, awarding funding to some projects in recent FP7 calls. Given the size of the market opportunity and the societal relevance of successful research it seems justified to enhance such EU support on research that can overcome key challenges. From an industry perspective**,** key companies include **Arkema (France), BASF (Germany), Beneq (Finland), Bekaert (Belgium), Hanita Coatings (Israel).**

For nano-enabled insulation materials, the present position of the EU is weak compared to the strong field of US-based industries, though some have production capacity in Germany (**Cabot Aerogels**). However, the EU chemical industry has the ability and the strategic intent to develop and commercialise organic nanofoams, which are expected to reach the market between 5 to 10 years from now.

2.5 Nanostructures and Composites node

2.5.1 Industry cases

Company/entity	**BIOD, Bio-Optical Detection (Spain)**
Contact:	Miguel Holgado.
Subject area and node to which is related or close to	**Nanostructures and composites**

Summary of best practice/ successful case	BIOD has carried out research and development of a label-free immunoassay system utilizing advanced optical and micro-nano technology to be applied in several fields. This technology is of easy infiltration and requires very little amount of original sample (on the order of one microliter) and it is sensible enough for the majority of the bio-applications. Ultimately, the aim is to develop high quality, cheap point of care diagnostic and High Throughput Screening allowing for multiple diagnoses in a square inch. This will be a detection kit like a tablet about the size of a sample holder (1x5 cm) with several wells each of whom has multiple BICELLs with the capability of analysing multiple diagnostics per well.
Target of best practice implementation	The developed system is to be applied in several fields including clinics (disease detection), pharmaceutics (development of new drugs), agrifood (detection of pesticides, toxins etc), environment (i.e. virus detection), food traceability and doping. This kit will have an approximate cost of 14 euro and might be sold in drugstores. The business model they think of would be similar to Nespresso's. The kit would be disposable and the platform would be the coffee machine that would be universal for all the bioapplications
Objectives	The company's objective is to create value by the combination of three advanced technologies from the optical metrology and micro-nano-fabrication sectors, in order to create a highly-competitive 'label-free' offering for the bioassay market compatible with label-targets detection. The main advantages are: easy to evaluate, simple analyte infiltration, high throughput, high sensitivity, high reliability, label-free and well-matched with standard formats.
Challenges	The BIOD team already had a business plan and in 2009 had won an award from the Universidad Politécnica de Madrid) as best innovative idea. The challenge for BIOD was to reach the market. Supported by Zabala within the framework of ProNano (http://www.pronano.eu/), the company found its strategic vision, that is in understanding which ways of getting public funding they could really take advantage of"..
Results and deployment	BIOD has developed and patented (patent approved in Spain and underway in Europe), a technology based on BICELLs, Biophotonic sensing cells, that is the design of biophotonic biosensitive cells that change in their optical properties. The main part of the biophotonic cells are nanostructures, nanopillars. Each nanopillar is a sensor, therefore what they do is put a lot of them together and examine the contribution of all of them. The prototype of a detection kit that will be brought to the market in 18 to 24 months and that is now being brought forth. The idea is for BIOD to become one of the group's IVD (in vitro diagnostic) companies in a way that BIOD might hold the power of managing their business.

Conclusions	The collaboration with ProNano has brought BIOD to find seed finance from a Spanish Biotech Group (whose name BIOD prefers not to reveal yet) and public funding to develop the prototype of a detection kit that will be brought to the market in 18 to 24 months and that is now being brought forth. The idea is for BIOD to become one of the group's IVD (in vitro diagnostic) companies in a way that BIOD might hold the power of managing their business.

Company/entity	**MAST Carbon (http://www.mastcarbon.co.uk/), UK**
Contact:	Professor Steve Tennison
Subject area and node to which is related or close to	**Nanostructures and composites** MAST Carbon develops polymer derived nanoporous carbon materials with excellent adsorption properties suited to a diverse range of applications .
Summary of best practice/ successful case	By virtue of numerous contract research and collaborative projects since its formation, MAST Carbon has built up a uniquely strong IP portfolio in the synthesis of nanoporous carbon materials as fibres, beads and monoliths. Recent projects have led to the identification of a number of high growth market opportunities including carbon dioxide recovery, solvent and automotive emissions control, energy storage, and a range of biomedical applications. With the support of ProNano. (http://www.pronano.eu/), the company now has a clearly defined business model and mechanisms for commercialising IP.
Target of best practice implementation	ProNano support was aimed at helping MAST Carbon to realise the commercial potential of its IP in nanoporous carbon materials including the identification and profiling of multiple business opportunities. and defining routes to commercialisation.
Objectives	Realise the commercial potential of nanoporous carbons in a number of high growth markets.
Challenges	In common with many nanomaterials, nanoporous carbons have multiple potential applications. MAST Carbon's existing business provided insights into a stream of opportunities but it was difficult to prioritise between them and then to devise routes to market.
Results and deployment	ProNano helped MAST Carbon to work out how the technology could be commercialised in different applications and what approach should be taken, whether through in-house venturing, licensing or new business spin out. Several large scale licensing opportunities have been identified, as well as opportunities for in-house ventures and spin-outs.
Conclusions	The support from ProNano has helped MAST Carbon focus on what would be better for the company to concentrate on. This led MAST Carbon to decide to establish a spin out company specifically to commercialize

	its biomedical carbons. The new company, Rescala Biomed, is just being established. A new management team has been appointed to market and sell products developed by MAST Carbon in the biomedical sectors.

Company/entity	Ecole Polytechnique (EP) in Palaiseau (F) KWR Watercycle Research Institute (NL)
Contact:	François Plais, Ecole Polytechnique Bram van der Gaag, KWR Watercycle Research Institute
Subject area and node to which is related or close to	**Nanostructures and composites**
Summary of best practice/ successful case	Ecole Polytechnique developed a sensor membrane, made with a polymer called PVDF and with nanopores that trap metal ions in the water. Basically, it works like a sponge for waste-water monitoring. The laboratory results still need validation in a real-world setting
Target of best practice implementation	To assess the quality of drinking water pumped from lakes, reservoirs or rivers, or to monitor pollution from industrial waste. By providing immediate results, it could change the way of monitoring water quality, as far as heavy metals are concerned.
Objectives	To speed up and improve the sensitivity of the water monitoring process
Challenges	A group of researchers at the Ecole Polytechnique (EP) in Palaiseau developed this new solution. They needed to find a suitable partner to test their technology in real-world applications. To resolve this issue, the Pronano (www.pronano.eu) consortium matched the French group with the KWR Watercycle Research Institute, a Dutch company amongst others specialized in methods to ensure water quality, and a set of potential integrator and end-user companies across Europe.
Results and deployment	A new nanomaterial-based sensor for monitoring heavy metals in drinking water. The system is portable and can be used on site; sensitivity and accuracy are one order of magnitude higher than the current laboratory standards. KWR are planning to collaborate with some companies that routinely perform water monitoring in different environments, and with SMEs providing water monitoring services and interested in integrating the new sensor. They will use the new sensor to monitor drinking- and surface- and waste waters at different times and in different situations. To verify the accuracy of data, they will compare the results from the sensor with that obtained with standard laboratory methods.
Conclusions	This type of sensor may be an improvement for decentralized purification systems, since it is portable and gives real-time results. It can also detect metal ions at traces levels, as the sensitivity is higher than the available commercial products.

2.5.2 Cases from patent and project analysis

2.5.2.1 Nanosensors for explosive detections

The spread of terrorist events over the globe in the last decade has emphasised the importance of detecting concealed explosives and led to calls for new advanced technologies to protect the public. Because most explosives release little vapour, it is not possible to detect them effectively by methods widely used on other chemicals.
Nanotechnology based sensors have strong potential for meeting all the requirements for an effective solution for the trace detection of explosives.
Though nanotechnology is also implied in some screening technologies (e.g. X-rays, IR), the really promising and developing sector is that of nano enabled sensors, which will provide advanced sensitivity and selectivity of explosive detection systems and does not seem to present the issues induced by screening.
ObservatoryNANO analysis of publications and patents and qualitative responses from experts have shown that EU research is complementary to the US for chemical and explosives detection but lacks the appropriate level of support for technology transfer required for future leadership. The measures included in the Action Plan, in particular, funding research and industry collaboration under the FP7 and national programmes constitute a part of the EU response to this issue.
Examples of EU funded collaborative projects for the development of nano enabled technologies include:

- HAMLeT (Coordinator: **German Aerospace Center,** Germany)
- GUARDED (Coordinator: **ECA**, France)
- DOTSENSE (Coordinator: **Justus Liebig University Giessen**, Germany)
- OPTIX (Coordinator: **Indra**, Spain)
- S3 (**Sensor Lab** of CNR and University of Brescia, Italy)
- PREVAIL (**Swedish Defence Research Agency**, Sweden)
- COMMONSENSE (Coordinator: **Tyndall National Institute**, Ireland)

2.5.2.2 Biodegradable food packaging

Food packaging waste is predicted to increase as a result of an ever increasing demand for convenience food, and individual wrapping of fresh produce (such as fruit). Plastic packaging (useful for its water-tightness and rigidity) has been designed with little consideration for disposability or recyclability, resulting in concerns over the environmental impacts when they enter the waste stream.
Nanocomposite materials currently used, or being developed, for the food packaging industry contain a polymer plus a nano-additive. Polymer nanocomposites containing nanoclay particulates are currently leading the food packaging market. However, bio-based nanocomposites (PLA clay, cellulose nanofibres) and metal (oxide)-polymer composites are also being developed.

Europe is major contender in the production of knowledge and the coordination of research collaborations.
In Europe Valencia (ES) is a hub for polymer and packaging R&D with institutes such as **ITENE** (The Packaging, Transport and Logistics Research Centre), **AIMPLAS** (Technological Institute of Plastics) and many university departments involved in the field. ITENE coordinates a large number of research activities in the area of advanced

food packaging coordinating FP7 NAFISPACK and were also involved in FP5 SUSTAINPACK.
Nanobiomatters, a medium sized firm is based in Valencia and the greater Valencia region. Over the past 6 years Nanobiomatters has developed R&D and production capabilities for nanoclay powder (Commercial Additive Plant of 2500t/year) and polymer-clay nanocomposite production (Commercial Extrusion Plant of 4000t/year). Commercial products are currently available, and with €4 million invested in development of its manufacturing facilities, and a diverse portfolio of nanobioplastics (including antimicrobial and gas scavenging functionalities), Nanobiomatters is rapidly becoming a major player in the field of biodegradable packaging, especially with regards to scavenger and antimicrobial versions (BactiBlock and NanobioTer+).
These activities, the relationships with the local universities, and the emergence of firms such as Nanobiomatters makes Valencia a hub for nano-enabled packaging R&D.

2.5.2.3 Next generation DNA sequencing

DNA sequencing technologies over the last three decades have been based on principles first developed by Frederick Sanger in the mid-1970s. Subsequent improvements have led to an increase in the length of DNA fragments able to be read and a move away from radioactive labelling towards detection using fluorescent markers. Next generation sequencing (NGS) has taken some of the later developments of the Sanger method and has added another dimension in the form of high-throughput technologies that can parallelize the process, that integrate reactions at the micro- or nanoscale on chip surfaces, and that produce thousands or millions of sequences at once. These high-throughput sequencing technologies are intended to lower the costs of DNA sequencing far beyond that possible with earlier methods.
Nanopores and nanoparticles are the novel elements that nanotechnology has brought to sequencing lie in the extreme miniaturisation of the process that becomes possible.
exceptions include
European companies leaders in this field are **Roche Diagnostics** (France) and **Oxford Nanopore Technologies**, UK. There are also a number of companies offering NGS as a service in many European countries with the UK, France, and Germany leading this list.

2.5.2.4 Nano-enabled protective textiles

Protective textiles have been selected by the European Commission as one of the areas of the Lead Market Initiative for Europe, aimed at creating an innovation friendly market framework to re-launch conventional industrial sectors and reduce time to market of new goods and services. In this context, nanotechnologies may play a fundamental role. Novel surface treatments and coatings, nanocomposite and nano-scale fibres, and functional nanoparticles offer textile products providing improved levels of protection together with a lower weight, higher comfort, new or multi-functionalities, or more environmentally friendly processes.
Based on several industry inventories ObservatoryNANO identified a number of key European companies such: **Elmarco** (CZ), **TenCate** (NL), **d3o**(UK), **Peratech**(UK), **Smartex** (IT), **Slam** (IT), **Grado Zero Espace** (IT), **Mectex** (IT), **Thuasne France** (FR), **Intelesens** (UK), **Steiger** (CH), **iXscient** (UK), **Nanocyl** (BE), **Devan Chemicals** (BE), **Norafin Industries GmbH** (DE), **Vandeputte Safety** (BE) and **Bekaert Textiles Group** (BE).

2.5.2.5 Nanotechnology for anti-counterfeiting applications

Counterfeiting is a global phenomenon, affecting individuals and communities in small villages and major cities right up to big retail stores and pharmaceutical companies.
By providing non-reproducible technological features, nanotechnology based developments are expected to offer a significant move forward in preventing illicit copying intellectual properties and products. Ultimately, the implementation of the novel techniques will considerably reduce tax revenue losses through counterfeiting and improve citizens' safety and quality of life.

Several European start-ups have been founded in recent years to exploit nanotechnologies for anti-counterfeiting (including **Ingenia Technology** and **Scriba Nanotech**). Whilst current market share and employment is low, the companies have been successful in attracting external investment.

2.5.2.6 Improving delivery of essential vitamins and minerals

The increase in global population is putting pressure on the food sector. Alongside the need to promote a mixed diet and a healthier lifestyle, there are certain cases where nutrient supplements are required particularly in poorly soluble compounds. Encapsulation provides a promising approach, and R&D expectations point to a real contribution in increasing the bioavailability of nutrients. Moreover, novel processing techniques are indicating that inclusion into processed foods themselves (so called fortified foods) is a means of including these supplements into the diet of the European citizen.

With regard to nutritional supplements, nanotechnology has been long used to reduce the particle size of various compounds for improving their absorption. Among several approaches that have proved to be very effective in creating nanoparticles, the best way appears to be through encapsulation.

In Europe, one of the major players is **AQUANOVA**, based in Germany, it provides nano-micelles for delivery of many types of nutraceuticals.
Many European companies are becoming involved in the encapsulation technology marketplace, including some traditional food production firms. For example, **La Morella Nuts**, a firm located in Spain which has a history in confectionary and nut ingredients, has been involved in R&D in nanotechnology in relation to functional foods. Also, the Italian pasta firm **Antonio Amato** has invested time in encapsulation via participation in the FP7 NANOFOODS project. In Israel, there are a number of companies dealing in this area: **Nutralease** develops micelles that can be used to encapsulate a variety of food related substances, such as vitamins, aromas, etc. (www.nutralease.com); **Karmat Coating Industries Limited** has 20 years of microencapsulation experience and has been active in exploring nanoencapsulation possibilities.

2.5.2.7 Organic photovoltaics

The development of clean alternatives to fossil and nuclear energy is vital for the growth of sustainable economies. One of the most attractive alternatives is photovoltaic (PV) conversion, the possibility to harvest solar energy.
Among the different technologies already available to directly convert solar light into electricity, organic photovoltaics (OPV) offer several possibilities such as a low weight and a high compatibility with flexible substrates. The fabrication process itself is potentially very versatile, low cost and compatible with mass production via printing processes.

Due to its early stage of development, the great part of OPV sector activity is still characterized by research activities on fundamentals, materials and integration technologies. Europe is very active at this level (almost 40% of the worldwide publications), and the presence of teams, leaders in their field, like Prof. Grätzel lab at **EPFL** (for DSSC), is noticeable.
On the industrial side, the European position is controversial: while having several R&D oriented start ups [**G24i** (GB), **Solaronix** (CH), **Solarprint** (Ireland), **Konarka** (Aus/USA), **Heliatek** (D)] and strong players in the materials supply for the OPV value chain (such as **Merck, Solvay, Rhodia**), there are, as yet, no published major production investments.

2.6 Other cases

2.6.1 Spin-offs from RTDs

Company/entity	**NANOGAP SUB-NM POWDER, S.A. (Spain)**
Contact:	Dr. Daniel Fernández Mosquera - Innovation Manager d.fernandez@nanogap.es
Subject area and node to which is related or close to	Production and commercialisation of nanomaterials. Scale-up.
Summary of best practice/ successful case	Created in 2006 as a spin off from University of Santiago de Compostela (Spain), NANOGAP produces a broad range of novel nanomaterials, including spherical nanoparticles between 5 and 50 nm, unique to NANOGAP sub-nm Atomic Quantum Clusters (AQC) and high aspect ratio nanofibers. These products, with a broad range of properties and benefits, find applicability in a diverse variety of applications and markets.
Target of best practice implementation	NANOGAP is a nanomaterial company built on a technology platform of precisely controlled wet chemistry, expertise developed over 20 years by its co-founders, as the leaders of the NANOMAG research group from USC. NANOGAP achievements have been possible due to success in scaling up laboratory synthesis procedures to pilot plant scale, preserving both quality and control on dimensional features. In addition, tight collaboration with the University research group provides NANOGAP the ability of translate to the market results from nanochemistry cutting edge research.
Objectives	NANOGAP's goal was to establish a model of knowledge transfer between academia and industry. Market profitable results from research are rapidly identified by NANOGAP and explored for industrial exploitation.
Challenges	The main challenge was to find the right way to the market, introducing a small company in the very competitive field of nanotechnology by offering first class quality nanomaterials and flexibility to fit customer needs. Support from investors (UNIRISCO and UNINVEST) was fundamental to provide

	enough resources until market orders become important. Participation in R+D funded projects and international market was also crucial to support steadily growth since 2006.
Results and deployment	Now, more than 80 worldwide organizations have requested NANOGAP nanomaterials. Heavy investment in internal R+D and a strong intellectual property policy have set up solid base for future developments.
Conclusions	Spin off companies need solid scientific basis and mid-long term financial support to fully develop potential capabilities. NANOGAP`s case reveals that academic knowledge transfer mutually benefits to both research and market ecosystems.

2.6.2 Infrastructures

Company/entity	Karlsruhe Institute of Technology/KNMF/EUMINAfab
Contact:	Dr Susan Anson www.euminafab.eu http://knmf.fzk.de/
Subject area and node to which is related or close to	Nano-Micro scale manufacturing
Summary of best practice/ successful case	Within the framework of the FP7 Capacities project EUMINAfab and the Karlsruhe Nano and Micro Facility (KNMF-funded via the Helmholtz Association) researchers from both Industry and academia can access high end installations for nano and micro structuring, replication and characterisation. The access is without cost for the Users.
Target of best practice implementation	Innovative ideas based on solutions using micro and nano fabrication technologies require access not only to high end equipment but also the essential highly skilled personnel. It is not possible for SME's or even most research departments to justify investment in a comprehensive range of technologies and trained personnel, especially when the need is to try out the feasibility of a new idea or develop a one off tool. With the establishment of the KNMF and the enhanced offer of service resulting from the consequent integration into a European Research Infrastructure (EUMINAfab) this expertise and capabilities are made available to external Users. As such new or alternative methods can be tried, the feasibility of new functional structures evaluated and hands on experience in new technologies gained, all at no cost.
Objectives	The main objective is to provide a platform of technologies and expertise to external users. In the case of academic researchers the aim is to generate excellent publications. In the case of industrial users the aim is to enhance the product development chain.

Challenges	We find that most of our Users come from the community of scientists known to our technology experts. The main challenge is to highlight the opportunities of such infrastructures to users with whom we as yet have no contact. We hope that Platforms such as NANO*futures* will assist greatly in breaking the barriers with the wider MNT community
Results and deployment	From our experience with both EUMINAfab and KNMF it is clear that there are benefits not only for academic users, young scientists and established researchers but also that industry SME's can benefit from such infrastructures. A particular example is that of the SME **Trinean nv, Belgium.** Trinean designs and manufactures versatile instruments that are able to rapidly analyze very small samples. Trinean's first product, the DropSense96®, is a multichannel spectrophotometer combined with disposable microfluidic microplates, suitable for the quick & precise spectral analysis of microliter droplets of DNA, RNA, proteins or small compounds. It was for use inside this piece of apparatus that the micro-sensor was required Thanks to the funding offered by the EUMINAfab Infrastructure project, the User was able to get quick access to laser technologies and know how of the experts at KIT. After completing this project the sensor has become a stable tool for the calibration of the SME's apparatus.
Conclusions	The use of infrastructures for micro and nano fabrication is becoming established in Europe. Improved information channels will enable the spread of the services to a wider circle of users.