European Commission

This fiche is part of the wider roadmap for cross-cutting KETs activities

'Cross-cutting KETs' activities bring together and integrate different KETs and reflect the interdisciplinary nature of technological development. They have the potential to lead to unforeseen advances and new markets, and are important contributors to new technological components or products.

The complete roadmap for cross-cutting KETs activities can be downloaded from:

http://ec.europa.eu/growth/industry/key-enabling-technologies/eu-actions/ro-ckets

Potential areas of industrial interest relevant for cross-cutting KETs in the Manufacturing and Automation domain

This innovation field is part of the wider roadmap for cross-cutting KETs activities developed within the framework of the RO-cKETs study. The roadmap for cross-cutting KETs activities identifies the potential innovation fields of industrial interest relevant for cross-cutting KETs in a broad range of industrial sectors relevant for the European economy.

The roadmap has been developed starting from actual market needs and industrial challenges in a broad range of industrial sectors relevant for the European economy. The roadmapping activity has focused on exploring potential innovation areas in terms of products, processes or services with respect to which the cross-fertilization between KETs can provide an added value, taking into account the main market drivers for each of those innovation areas as well as the societal and economic context in which they locate.

Taking the demand side as a starting point, cross-cutting KETs activities will in general include activities closer to market and applications. The study focused on identifying potential innovation areas of industrial interest implying Technology Readiness Levels of between 4 and 8.

MA.1.3: Mass production of functionalized surfaces and materials

Scope:

To develop scalable processes, either physical (additive manufacturing, laser, Physical Vapour Deposition (PVD)) or chemical (Chemical Vapour Deposition (CVD), sol-gel), for treating or coating surfaces so as to provide them high added-value functionalities as embedded sensing, adaptive control, self-healing, antibacterial activity, self-cleaning.

Demand-side requirements (stemming from Societal Challenges) addressed:

Depending from the application or the type of processes used for production, manufacturing and automation can especially contribute to tackle the following societal challenges:

- Secure, clean and efficient energy
- Climate action, resource efficiency and raw materials

Demand-side requirements (stemming from market needs) addressed:

- Provide for rapid and flexible production capabilities to match supply with volatile demand of today's rapidly changing markets
- Flexibly integrate design specifications into efficient operational routines by keeping a comparable throughput time in different configurations
- Provide for fast product/service systems able to combine rapid and flexible production capabilities with enhanced product design capabilities and exploit minimal distribution lead-times to match supply with volatile demand of today's rapidly changing markets
- Provide for the production of high-quality products
- Provide for the production of durable products
- Provide for alternative manufacturing approaches coping with the need of utilizing new and advanced materials in products, adding functionalities to products, dealing with complex structures and shapes

Specific technical / industrial challenges (mainly resulting from gaps in technological capacities):

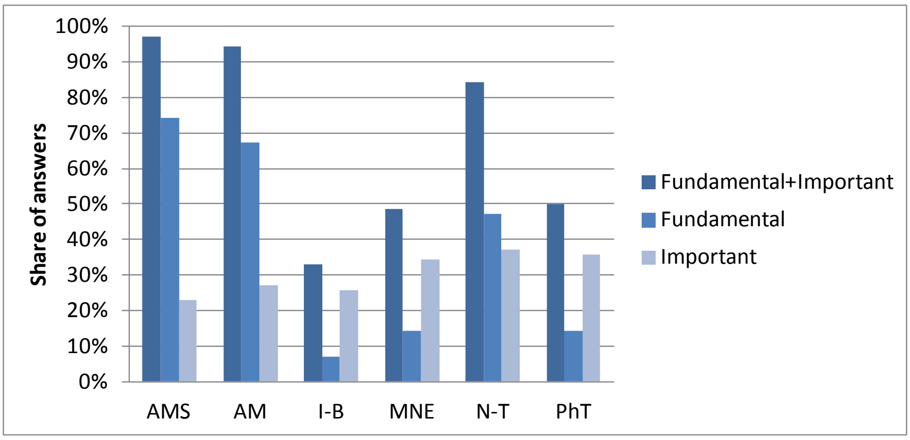
- Innovative use of physical, chemical and physicochemical processes
- Design functionality through surface modifications and coatings, using physical (additive manufacturing, laser or photon based technologies, Physical Vapour Deposition (PVD)) or chemical approaches (Chemical Vapour Deposition (CVD), sol-gel) to deliver high functionality and hence high value products
- Embed true smartness into structures through novel technologies and approaches and scale-up these processes

Contribution by cross-cutting Key Enabling Technologies:

In respect to this Innovation Field, the integration of KETs could contribute to the development of more advanced, scalable processes for treating or coating surfaces so as to provide them high added-value functionalities, thanks to the innovative use of physical, chemical and physicochemical processes, the development of material formulations for coatings as well as the related deposition processes, the development of processes for the modification of surfaces using physical (e.g. additive manufacturing, laser or photon based technologies, Physical Vapour Deposition (PVD)) or chemical approaches (e.g. Chemical Vapour Deposition (CVD), sol-gel).

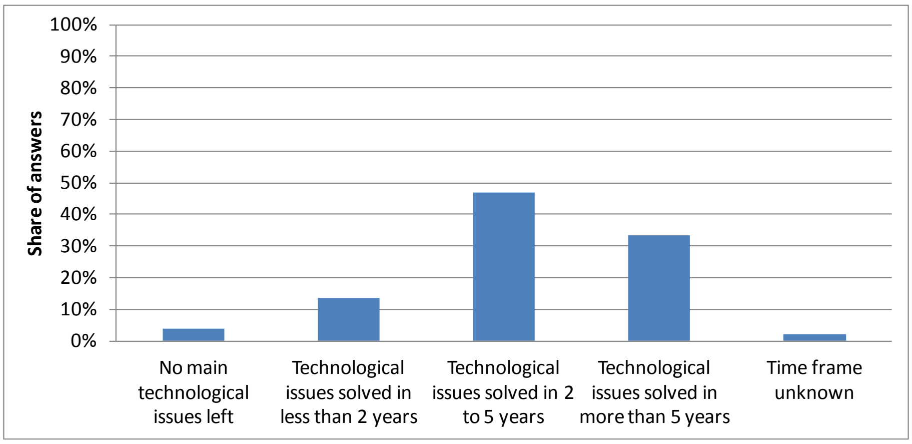
To this aim, the combination of KETs experts' opinions collected through the dedicated survey (whose result is depicted in the below bar chart), the examination of KETs-related patenting activity in respect to this Innovation Field, and desk research activities, have allowed identifying a rather strong interaction of KETs with respect to this Innovation Field, with either fundamental or important contribution mainly by the following KETs:

- Advanced Manufacturing Systems (AMS)
- Advanced Materials (AM)
- Nanotechnologies (N-T)



Timing for implementation:

According to the majority of KETs experts' opinions (whose result is depicted in the below bar chart), desk research, and in line with the KETs-related patenting activity in this field, it is considered that the main technological issues holding back the achievement of cross-cutting KETs based products related to this Innovation Field could be solved in a time frame of 2 to 5 years, yet significant consensus by experts indicates also greater periods being necessary:



Hence, depending on the specific technical and/or industrial challenges holding back the achievement of cross-cutting KETs based products related to this Innovation Field, the provision of support in the short to medium term should be taken into consideration within this framework.

Additional information according to results of assessment:

➢ ***Impact assessment:***

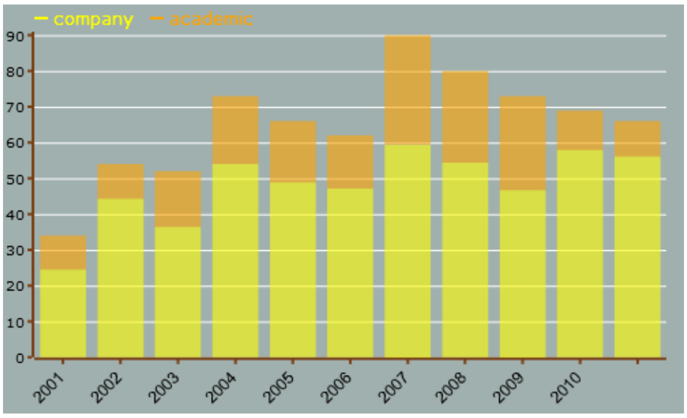
- Tailored surface modifications to impart specific physical, chemical or biological characteristics, different from the ones originally found, to the surface of a material have gained much attraction over the past 20 years. Such altering of the surface modifications, also termed surface engineering, can be brought to materials either through physical (e.g. additive manufacturing, laser, Physical Vapour Deposition (PVD)) or chemical means and methods (Chemical Vapour Deposition (CVD), sol-gel) or through coating. Despite the applied technique, the goal is altering the characteristics of the surface in order to provide enhanced capabilities of the material to stand external agents and environments. Characteristics of a surface that can be altered by surface engineering are, for example, its roughness, hydrophilicity, surface charge, surface energy, biocompatibility and reactivity.
- Surface engineering contributes very significantly in the manufacture of a vast variety of products, being particularly relevant in sectors like automotive, aerospace, power generation, electronics, biomedical, textile, steel, construction and even machine tools manufacturing. Surface engineering techniques can be used to develop a wide range of functional properties, including physical, chemical, electrical, electronic, magnetic, mechanical, wear-resistant and corrosion-resistant properties at the required substrate surfaces. Almost all types of materials, including metals, ceramics, polymers, and

composites can be coated on similar or dissimilar materials. It is also possible to form coatings of newer materials (e.g., met glass. beta-C3N4), graded deposits, multi-component deposits, etc. (Source: P. Martin, Introduction to Surface Engineering and Functionally Engineered Materials, 2011).

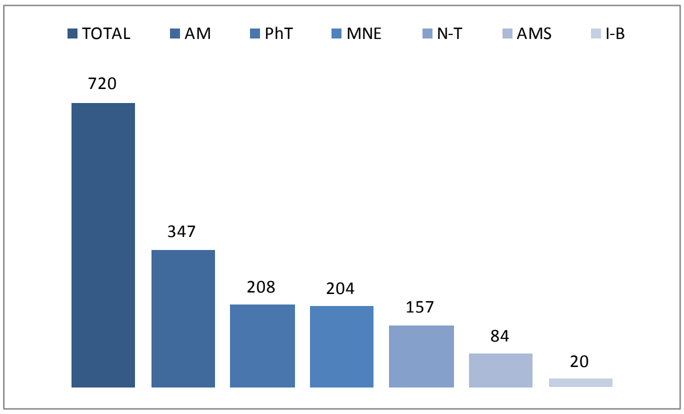
- To highlight the relevance of surface engineering in manufacture one shall consider that some 6% of the costs of manufacturing engines and transmission is involved in coating technologies. Organic finishes are highly decorative and functional. The steel shell and structural members require preparation as substrates so that, for example, an increasing number of components are galvanised and provided with appropriate conversion coatings to receive paint. Whilst metal is usually finished with an organic coating, so plastic may be metallised: here the established 'wet' processes compete with developments in Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD). Last but not least, in the medical industry, instrumentation as well as devices that are either permanently (e.g. implantable devices) or temporarily introduced in the body's cavities (e.g. catheters) are superficially treated or coated in order to enhance their biocompatibility and their resistance to fouling or corrosion (Source: Surface Engineering Committee of the Institute of Materials, Foresight in surface engineering, 2000).

➢ ***Results of patents scenario analysis:***

- 720 exclusively KETs-related patents identified in the period 2001-2011 for the specific Innovation Field
- Initially increasing then decreasing trend curve (number of patents per year) with downturn since 2008
- Highest share of industrial applicants:



- Patents by KET(s):

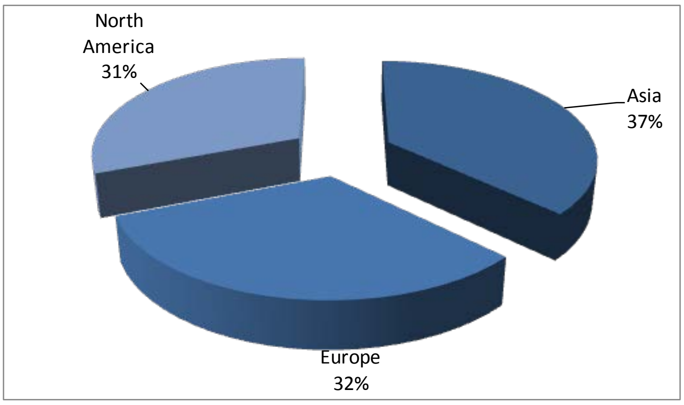


- Patents by KET(s) and relevant combinations of KETs:

KET(s)	*Number of patents*
AM	347
AM / IBT	7
AM / IBT / N-T	4
AM / MNE	45
AM / MNE / N-T	17

KET(s)	Number of patents
AM / MNE / N-T / PhT	5
AM / MNE / PhT	16
AM / N-T	104
AM / N-T / PhT	9
AM / PhT	44
AMS	84
AMS / AM	9
AMS / AM / N-T	2
AMS / MNE	16
AMS / MNE / PhT	2
AMS / N-T	4
AMS / PhT	5
IBT	20
IBT / N-T	5
MNE	204
MNE / N-T	26
MNE / N-T / PhT	8
MNE / PhT	75
N-T	157
N-T / PhT	13
PhT	208

- Patent distribution by (Applicant) organization geographical zone:



- Patent distribution by geographical zone of priority protection: