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Nanotechnology patenting in Piedmont: analysis and links with research and industrial environment in the Region

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Nanotechnology patenting in Piedmont: analysis and links with research and industrial environment in the Region

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ABSTRACT

The aim of the present paper is the analysis of nanotech patent activity in Piedmont. The experimental work at the core of the article is based on a database of patents that are relative to assignees located in Piedmont and belong to the Cooperative Patent Classification class B82, nanotechnology. Once prepared, the database is analysed under several aspects: time evolution of patenting, characteristics of the assignees, technological content. The present paper also tries to connect patenting activities with the local industrial and scientific environment. At the end of the work results are summarised and conclusions are drawn.

KEYWORDS: Nanotechnologies, nanosciences, Piedmont, patent, regional systems of innovation.

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CONTENTS

Nanotechnology patenting in Piedmont: analysis and links with research and industrial environment in the Region

UGO FINARDI

1 INTRODUCTION

The relevance of nanotechnologies for industrial innovation is witnessed both by scientific authors and by technological achievements and products that are widening their commercialization across time (Brabazon et al., 2018; Finardi, 2012, 2013, 2014; Hesto, Lourtioz, Dupas-Haeberlin, Lahmani, & Dubouche, 2016; National Research Council of Italy, Finardi, & Institute of Economic Research on Firms and Growth, 2013). Since 1990s, nanotechnologies (as well as nanosciences, the scientific area linked to them) have been considered a growing field both in research and in industrial innovation (Dowling, 2004; European Commission, 2018; Grinin, Grinin, & Korotayev, 2017; Zhu, Jiang, Chen, & Roco, 2017).

Once assessed the relevance of nanotechnologies and nanosciences, it is clear the importance of a continuous study able to highlight and deepen the past and present features, as well as the future development of this field. In particular, a relevant topic useful to outline the features of innovation paths at worldwide level is that of patenting.

Patenting of inventions in fact is by far the most relevant instrument used to protect a technology or, in general, a piece of knowledge that may be used for practical purposes. The analysis of patents has been considered, since the early years of *innovation studies*, one of the most relevant instruments apt to understand how technologies are discovered, disclosed, exploited and used in production. Patent analysis can also shed lightì on how and how much technologies spread across regions and countries. (Bacchiocchi & Montobbio, 2009; Breschi & Catalini, 2010; Schmoch, 1993).

The general topic of this paper, as well as that of other ones previously published, aims at deepening the features of the nanotechnology environment of Piedmont region, northwest Italy. It is relevant to state that the topic discussed in this paper, in particular that of patenting in nanotechnologies at regional level, is a topic seldom (or never) explored to the best of my knowledge. As the context of Piedmont is relevant in terms of industrial environment and of system of research, it seemed a case study apt to the scope. In specific, in order to better tackle the topic of nanotechnologies in the Regional context of Piedmont, the analysis of patents seemed an important instrument. Indeed, it would not be possible to perform a complete description of a nanotechnologies and nanosciences research and of the regional system of innovation without discussing patenting activities. This is due to the above described relevance of patenting for innovative activities. Moreover, as the following literature overview will show too, the specific topic of nanotechnologies in Piedmont has been studied rarely so far, and in particular no previous work exists on the specific topic of Patenting.

The main aim of the present paper is thus performing a description of the nanotech patenting activities performed in Piedmont. In addition it will try to offer some interpretation of the results, trying to link patent activities to research and industrial environment in the analysed region.

The remaining part of the paper is organized as follows. Section 2 contains a literature overview of the nanotechnologies' studies on in Piedmont and Italy. It continues presenting the theme of patenting in nanotechnologies, taking into account the specific target of studies related to regional contexts. Section 3 describes the methodology adopted in the present work in order to study patents, while section 4 presents the results. The fifth and last section adds some conclusion in order to summarize and recap the entire work.

2 LITERATURE OVERVIEW

Nanotechnologies, as also described in the previous section, are a bourgeoning interdisciplinary field (Roco, 2001). Nanotechnologies and nanosciences stem out of traditional fields such as physics and chemistry of materials, biology and biotechnology, and materials engineering (Balzani, 2005). They have evolved since the end of the 20th century starting from laboratories all over the world and assuming a pervasive role in a wide number of industries and geographic areas ((Balzani, Credi, & Venturi, 2007; Wonglimpiyarat, 2005). Given the pervasive nature of nanotechnologies, it is difficult, if possible, to measure their global impact in terms of turnover, number of firms, employees, growth, etc. It is easier, instead, to tackle specific cases, either in a qualitative or quantitative way, in order to enucleate and highlight specific features of nanosciences and nanotechnologies. The present work, though being mainly descriptive, tries to offer a contribution in this sense.

Few studies have presented the state of nanotechnologies in Piedmont. The earliest one to date has been the work of Finardi and Vitali (2009) who tried to disentangle and describe the "cluster" of nanotechnologies in the region. Also Caputo *et al.* (2009) did devote a part of their studies to the regional assets in the field. More recently it has been Finardi (2018) to describe nanotech public research activities in the region.

Besides these contributions Piedmont's nanotechnologies are still underexplored. Some works tackle this topic at Italian national level. Escoffier (2007) for instance performed one of the first essays in this context. His analysis did present some of the most relevant features, starting from the number of public entities involved in nanotech (higher than that of firms) and from the presence of nanotech technological districts, coming to the vast number of scientific works published at that time and to the state-of-the-art of patenting: at that time there was an almost 50/50 subdivision of patenting between public research and the industry.

Arnaldi (2008; 2014; 2017) has devoted some articles to the study of the perception of nanotechnologies in Italy. His earlier contribution describes an extremely positive level of nanotechnologies' reception, while the latter two present figures of nanotech scholars and national regulations. Another perspective on Italian nanotechnologies is that of Baglieri *et al.* (2012) who, discussing the features of nanocluster, tackle more directly the nanoelectronics' cluster of Catania, Sicily.

Calignano (2014) and Calignano and Quarta (2015) exploit the network obtained through the European nanotechnology research projects to describe Italian nanotech features. The former of the two contributions aims at defining the role Italy plays in the European nanotech network. Results show the central role of the Country, and the predominance of CNR among research organisations. The latter of the two papers instead discusses the influence of new technologies on the path-dependence in the development of peripheral areas, using Italian regions as canvas . Results show the fact that nanotechnologies did incentivize the connection of the historical "industrial triangle" (Turin, Milan, Genoa) with other industrialized areas and have increased traditional regional disparities.

A further topic to be discussed in this literature overview is obviously that of patenting in nanotechnologies. A bibliometric search shows that also this stream of literature is not much

populated, at least to the best of my knowledge. An earlier contribution is that of Huang *et al.* (2003). Their work exploits several instruments in order to analyse USPTO patents in the interval January 2000 – April 2003. Results show that 79 % of patents were assigned to US inventors, and the rest mainly to Japan. Other countries did follow with a minor share. Patenting did show a very fast growth, and the leading topics were 'nucleic acids', 'pharmaceutical composition', 'laser beams', 'semiconductor devices' and 'optical systems'.

In the same year also Marinova and McAleer (2003) did analyse USPTO patents to build "Technological strength indicators". According to this indicator France was the best performing country in nanotech, followed by Japan and Canada, and the expertise was not equally distributed across technologically advanced countries.

Finardi (2011) contributes to the debate on nanotech patenting studying citations of scientific articles in patents. Results show that, to another, more traditional field, the number of such citations is higher and the time distance between cited article and citing patent is shorter.

A more recent contribution to this stream of literature is that of Milanez *et al.* (2014) who try to investigate the future trends of patenting in nanotech. Their dataset is based on a worldwide analysis of patents, and their results show that until 2010 there has been a bias in patenting directed towards chemistry/materials and electronics/electricity, as well as on instrumentation and industrial processes. Different subdomains characterize patenting in the different countries.

In the same year Zheng *et al.* (2014) tackled an original target, describing international collaboration in nanotechnologies via patent analysis. In this case USPTO patents are used to build the dataset. Internationally collaborated patents show a steady growth, and Europe has declined over time. Some countries collaborate with a wide number of partners: the USA, Germany, the UK and Japan. Other countries, conversely, are more selective under this point of view: Spain, Israel, Russia, Singapore and Taiwan.

Patents are one of the determinants analysed by Zhu *et al.* (2017) in their assessment of the nanotechnologies' development between 2000 and 2016. The article exploits patents from USPTO and WIPO. While the USA are still the leader in terms of patenting, P. R. China has shown significant growth. P. R. China and South Korea have shown faster expansion, while the US, EU27 and Japan are still leader in fundamental discoveries.

Nanotechnologies, in a world areas context, is also the topic of the work of Islam and Ozcan (2017). This work shows the catching up of Asian regions, and the divergence in terms of capability of the different countries.

Finally, nanotech patents are the basis for the study on technological proximity of European regions (at NUTS2 level) performed by Colombelli *et al.* (2014). The emergence and evolution of a new technology (nanotech) shows from results a deep path-dependency.

This short literature overview recaps some of the main contributions on the different topics related to the analysis of nanotech patents. The aim of the present work is thus of adding knowledge to the streams of literature described in this literature overview, specifically analysing a relevant regional case.

3 METHODOLOGY

The methodology adopted in order to build the dataset of nanotechnology patents from Piedmont is the following one. Data were retrieved on European Patent Office's (EPO) public database, Espacenet[1]. Data were collected in June 2018. The considered patents are those in the CPC (Collaborative Patent Classification) B82 Class (Nanotechnologies). CPC patent classification system has been enforced on January 1st, 2013. It has been developed jointly by the EPO and the USPTO, the United States Patent and Trademark Office. It has been designed for efficient searching, and it is subject to revisions by both offices: in consequence of this patents can be reclassified. CPC is the main EPO classification system.

[1] https://it.espacenet.com/, site accessed June 2018

Considered patents are those registered in Italy. This means that such patents are either Italian patents or Italian extensions of foreign patents. The query selecting B82 patents was in fact performed on Espacenet selecting the Italian database.

The query rendered a total of 368 Italian B82 patents. A further selection has been performed on this list in order to identify the patents relative to Piedmont-based applicants. The adopted criteria have been the following ones: applicants of the selected patents were either a firm or another type of body based in Piedmont, or the local branch of a national body or firm. A thorough search was performed, also exploiting the names of inventors (selecting those resident in Piedmont) in order to check if the patent was invented in one of the local (Piedmont) branches of large industrial group. At the end of the search a total of 43 Piedmont-based nanotech patents has been included in the final list.

This list has been in turn the basis for an analysis of several of the characteristics of the included patents. The first one of these analyses has been the study of the time evolution of patenting. Years of publication of patents have been plotted after being grouped together. The second performed analysis has been the classification of the typology of patent applicants (firms or public bodies) and of their dimensions as big, medium or small enterprise.

Another analysis has been performed retrieving and listing accessory patent classes over the full set of Piedmont's Italian B82 patents. It is known, in fact, that a patent can be classified under several classes according to its technological content. Each patent thus brings with itself, besides the patent class one is searching for when retrieving patents, also one or (usually) more further classes. This multiple classification is performed by patent offices in order to better specify the technological content of a patent. Furthermore, patents can also be reclassified after their publication, adding new classes to preassigned ones. This has with no doubt happened for the most part of analysed patents. A nanotechnology class has in fact been introduced only when CPC class has been enforced. Accessory patent classes have thus been listed in order to better understand the technological profile of nanotech patenting in Piedmont. This methodology (novel to the best of my knowledge) has been applied due to the specific characteristics of interdisciplinariety and complexity of nanotechnologies. The analysis of secondary patent classes, in fact, can help to better understand the specific nanotechnology subfield of the patent.

In order to slightly deepen the topic accessory patent classes have been retrieved also for the cases of the three most relevant assignees of the list.

Finally, it has been performed a study on the title words of the patents in the list (see also Finardi, 2018). The titles of the patents have been scanned in order to create a list of (meaningful) words, descriptive of a general trend in regional patenting. Due to the relatively low number of patents the analysis is only sketched.

4 RESULTS

Tables 1 reports the evolution over time of the number of Piedmont's B82 patents retrieved and present in the database. Patents have been grouped according to decades in order to show the time evolution of patenting. The oldest patents date back to 1976. Besides absolute numbers also the numbers of patents per year have been calculated. Results show a slight growth across time of nanotechnology patenting in the Region. The most populated decade is the 2001-2010. More in specific the peak of patenting activities has been in the years between 2001 and 2005 with an average of 2.2 patents per year, while the following years have witnessed a decrease. It is important to note that the most part of the patents in the list have been reclassified as B82 after the introduction of the CPC class. Another relevant point to consider is that relative to timing of patenting. The time gap that usually exists between an invention, its disclosure and the publication of a patent can be of some years. Therefore, it is likely that more "nanotech" inventions have been disclosed at the time of the patent search, and are still waiting to be published.

Patent applicants have also been analysed in order to delineate their characteristics. The analysis resulted in the presence in the list of 38 patents assigned to firms or private research labs, and 5 to public actors. Table 2 presents the list of the most active nanotech applicants in the region, while table 3 presents the time evolution of their patenting activities.

The most active patent applicant in B82 category in Piedmont has been Montedison Spa. Montedison was one of the main Italian chemical industrial groups, and ceased its activities as such in the first decade of the 21st century. Montedison patents were in fact published prior to 1990, and thus, have been reclassified as B82 after the nanotech patent class was introduced with the new CPC classification.

The second assignee in terms of number of patents of the list is FIAT with 7 patents. One of the patents is assigned to FIAT Auto and was published in 1992, while the other ones are assigned to FIAT ricerche and are more recent. FIAT – Fabbrica Italiana Automobili Torino has been a car making company, based in Torino and founded at the end of 19th century. FIAT is now part of Fiat Chrysler Automobiles, but its plants are still in function, as is Centro Ricerche Fiat, one of the most important private research centres of the Region.

The third assignee of the list, CSELT, is another private research centre, not existing anymore as such. CSELT was founded in 1961 by Italian telephone companies STIPEL and STET as research centre on telecommunications. According to Bonaccorsi (2000) CSELT was one of the most important patent assignees in Italy. Notwithstanding the fact that its patents were less numerous than those of other firms, the patent quality, always according to Bonaccorsi, was very high, with a large number of citations and a very fast technology cycle time. CSELT, in fact, has had through its life a relevant patent portfolio; its nanotech patents date back to the 1990s[2]. Most part of CSELT has been integrated in 2001 in the new research centre TIlab of Italian telephone company Telecom Italia.

The only public body in the list is Politecnico di Torino, Turin's engineering and architecture technological university. Its three nanotech patent (one of them has been obtained together with University of Torino) are relatively recent, as they date to the years after 2006. This probably corresponds with the recent hype at national level towards valorisation of research results and technology transfer.

Bracco SpA (also present in the list with three patents, published between 1991 and 2005) is a major Italian pharmaceutical corporation, and has branches and plants in several Italian regions. Istituto Donegani (with two patents dating before 2000) is instead an important chemical research centre part of ENI, Italian national hydrocarbons society.

The last one of the list, Tecnocarbon ANT (Advanced Nanotube Technologies), is the youngest firm present in the list of assignees, as this SME was founded in 2010. Obviously its two patents date after 2011.

The remaining 12 patents have been assigned to 9 firms, 2 public research bodies and 1 foundation, in the years going from 1991 to 2010.

A further relevant point analysed in the present article is that of the accessory patent classes. It must be recalled here that a patent can be classified under several classes in order to better specify its content, to facilitate its retrieval and to better protect inventions. Patent classes other than B82 so can be analysed to obtain further information on the nature of the invention protected in the patent. This analysis has been performed both in general and for the three most relevant assignees, considering classes with more than 10 occurrences in the sample. The analysis has been performed at the second level (4 digits classes) omitting subclasses. Table 4 presents the class, number of occurrences and definition of the most populated classes in the sample. Table 5 instead presents the occurrences of the most populated classes in the patents of the three top assignees of the list. Patent definitions are not repeated in the text for sake of conciseness.

[2] CSELT, an acronym for Centro Studi E Laboratori Telecomunicazioni (Telecommunications study centre and laboratories) is world famous due to one of its most relevant achievements, the invention of MPEG and MP3 audio-video standards.

The first thing to note is the fact that no B82B patents are present. B82B class definition is "NANOSTRUCTURES FORMED BY MANIPULATION OF INDIVIDUAL ATOMS, MOLECULES, OR LIMITED COLLECTIONS OF ATOMS OR MOLECULES AS DISCRETE UNITS; MANUFACTURE OR TREATMENT THEREOF". 46 occurrences of B82Y class are present. B82Y is defined as "SPECIFIC USES OR APPLICATIONS OF NANOSTRUCTURES; MEASUREMENT OR ANALYSIS OF NANOSTRUCTURES; MANUFACTURE OR TREATMENT OF NANOSTRUCTURES" and its Definition statement claims "Applications and aspects of nanostructures which are produced by any method, and is not restricted to those that are formed by manipulation of individual atoms or molecules". The definition highlights the fact that no "manipulation of individual atoms or molecules" is required for this class. The fact that B82Y is present 46 times in 43 patents simply means that in three patents two subclasses are claimed.

Nevertheless, the most populated patent class is C01P, with 81 occurrences. Out of these ones 64 occurrences are present in the 10 Montedison patents. This last fact can be easy understood due to the fact that Montedison was a chemical multinational company. The rest of the occurrences show that some interests in the region towards nanotechnologies in chemical application is present.

A61K, the third one of the list, sees no presence in the patents of the three top assignees, nevertheless it witnesses an interest towards medical applications of nanotechnologies. The occurrences are present in 7 patents, mostly assigned to biomedical firms and one to the Politecnico of Torino.

The fourth class, G02F, presents a number of occurrences that is less than the half of the former one. All occurrences of this class are in the patents of FIAT (FIAT ricerche) and CSELT, witnessing the interest of these two research centres towards applications of nanotechnologies in optics and optoelectronics.

The fifth class, C04B, relative to inorganic materials exploited mostly in the building industry (such as cements, artificial stone, ceramics, refractories, treatment of natural stone…), might suggest an interest towards this industry. But a closer look at the database shows that the 14 occurrences are all relative to a number of subclasses of a single patent, a method to prepare nanostructured ceramic materials; its assignee is the National Interuniversity Consortium for the Science and Technology of Materials, and inventors are a group of researchers belonging to the same Consortium and based in Turin.

The sixth and last class, C08J, is present three times in one FIAT patent, and further occurrences are present in other four patents in the list.

The last one of the analyses described in the methodology, that of title words, has been sketched only. This is due to the relatively low number of patents, not allowing for clustering of relevant numbers of words. At the top of the list is "MATERIALI" (materials) with 7 occurrences. This is followed by "PARTICELLE" (particles) and "SFERICHE" (spherical) with 5 occurrences each, and by four words recurring three times in the patents: "ALLUMINA" (alumina), "CARBONIO" (carbon), "LASER", "MAGNETITE". This list of words allows to think that nanostructured materials are probably the most present topic in this set of patents.

5 CONCLUSIONS

The analysis of patenting activities in the context of a Regional Innovation System is a rarely analysed topic in previous literature. For this reason it seems relevant to perform a preliminary descriptive case study. The chosen case has been Piedmont, an industrial Region in north-western Italy. Piedmont is a technologically advanced industrial Region, with a wide system of research. Its patenting activities in nanotechnologies, as highlighted by an analysis of Italian B82 CPC class patents, have been described and analysed. Most part of the patents date back to the years preceding the institution of the B82 class, and thus have been obviously reclassified as such. Once assessed this fact, it is possible to say that nanotech patenting has continued, more or less steadily, since the 1990s. The number of patents has grown with time, showing a peak in

the 2001-2010 decade, and more specifically in its first half. The decay in the number of patents per year after this time may also depend on the natural time lapse existing between the beginning and the end of the patenting process.

The analysis of patent assignees shows that most part of the patents have been assigned to big industrial groups (or to their research centres), and the fraction of public research bodies or foundations is slightly below 15 %. Thus, as it might seem obvious, the widest interest towards nanotech patenting derives from the private sector. Moreover, it is important to note that among the most relevant assignees a wide number of patents is assigned to now defunct companies or research centres. These patents constitute the core of least recent patenting, while more recent nanotech patenting derives from the activities of public and private research centres and small enterprises.

Nanotechnologies, as discussed above, are a strongly interdisciplinary field of research. Thus, it seemed relevant trying to disentangle the contribution of the different nano-subfield to patenting in Piedmont. This study has been achieved through the study of accessory patent classes. The results show the presence of a very differentiated set (in terms of technologies) of accessory classes together with B82 class. This fact should be considered together with data concerning the time evolution of the different accessory classes in the patents. These data are reported in table 6. First of all, it must be noted that most part of C01P occurrences are relative to the years prior to 1990, that is, mainly to the patenting activities of Montedison. In more recent year other classes catch on in this table. In particular, C04B and C08J are present only after year 2001. C04B occurrences, as above described, belong to a single academic patent, witnessing the interest of regional research on the exploitation of a specific technology (that of nanostructured ceramics). From this point of view it must be noted what has been reported by Finardi (2018): the most relevant research field in Piedmont in nanotechnologies is that of materials sciences (thus, nanostructured materials). This hypothesis is supported also by the above reported word title analysis.

Another point is that relative to A61K and G02F classes. The former of the two is present in the database over three decades. This fact witnesses a steady interest of bio-pharma industry and research towards nanotechnologies. The latter class is also present in in a wide range of time (8 occurrences in the 1990s and 11 in the 2010s). The involved assignees are in this case CSELT and Centro Ricerche Fiat. This might entail the presence of a diffused scientific knowledge relative to the application of nanotech to optics and optoelectronics.

Summing up, patenting activities in nanotechnologies last since the end of the 20th century and have continued until recent years. Due to the nature of this paper no comparison with other regions has been performed. Patenting activities in nanotechnologies show a rather diffused attention at regional level, mainly deriving from firms and more in specific from big industrial groups. Moreover, patenting in nanotechnologies has tackled several nanotechnological fields (or, differently said, several technological fields connected to nanotechnologies).

The present work has several limitations, also due to its nature of preliminary study on the topic. The main limitation resides in the fact that only Italian patents, and no foreign extensions, have been included in the database. Nevertheless, due to the fact that almost all patent assignees are either locally based, or local branches of Italian firms or institutions, this should not be a relevant limit, as the usual path for patenting of invention starts from a national patent that is successively extended to other Countries. Another limitation resides in the fact that no comparison with other regions has been performed in terms of timing, number of patents, technologies, etc. Nevertheless, this should be the topic of a future work discussing a parallel topic.

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7 TABLES AND FIGURES

Table 1 – Time evolution of patents

YEARS	PATENTS	PATENTS/YEAR
Unitl 1980	4	
1981-1990	7	0.7
1991-2000	9	0.9
2001-2010	16	1.6
2011-2018	7	0.9
TOTAL	**43**	

Source: elaboration on Espacenet data.

Table 2 – List of the most relevant patent assignees

PATENTEE	TYPE	NOTE
Montedison SpA	Large enterprise	Montedison does not exist anymore as such since the beginning of the 2010s.
FIAT	Large enterprise	FIAT is now part of FCA – Fiat Chrysler Automobiles
CSELT	Private research centre	CSELT has been reduced in dimensions at the beginning of the 2000s and then became TIlab
Politecnico di Torino	University	
Bracco SpA	Large enterprise	
Istituto Donegani	Private research centre	Istituto Donegani is part of ENI – Ente Nazionale Idrocarburi
Tecnocarbon ANT Srl	Medium enterprise	

Source: elaboration on Espacenet data.

Table 3 – Time evolution of patents for the most relevant assignees

ASSIGNEE	PATENTS	NOTE	Until 1990	1991-2000	2001-2005	2006-2010	From 2011
Montedison SpA	10		10				
FIAT	7	1 as FIAT Auto, 6 as FIAT Ricerche		1	5		1
CSELT	4			4			
Politecnico di Torino	3	1 with University of Torino				2	1
Bracco SpA	3			2	1		
Istituto Donegani	2		1	1			
Tecnocarbon ANT Srl	2						2
Others	12	9 firms, 2 public research bodies, 1 foundation		1	5	3	3
TOTAL	**43**		**11**	**9**	**11**	**5**	**7**

Source: elaboration on Espacenet data.

Table 4 – Description of most relevant accessory patent classes present in the database

CPC CLASS	PATENTS	DESCRIPTION FROM CPC
C01P	81	INDEXING SCHEME RELATING TO STRUCTURAL AND PHYSICAL ASPECTS OF SOLID INORGANIC COMPOUNDS
B82Y	**46**	**SPECIFIC USES OR APPLICATIONS OF NANOSTRUCTURES; MEASUREMENT OR ANALYSIS OF NANOSTRUCTURES; MANUFACTURE OR TREATMENT OF NANOSTRUCTURES**
A61K	42	PREPARATIONS FOR MEDICAL, DENTAL, OR TOILET PURPOSES
G02F	19	DEVICES OR ARRANGEMENTS, THE OPTICAL OPERATION OF WHICH IS MODIFIED BY CHANGING THE OPTICAL PROPERTIES OF THE MEDIUM OF THE DEVICES OR ARRANGEMENTS FOR THE CONTROL OF THE INTENSITY, COLOUR, PHASE, POLARISATION OR DIRECTION OF LIGHT, e.g. SWITCHING, GATING, MODULATING OR DEMODULATING; TECHNIQUES OR PROCEDURES FOR THE OPERATION THEREOF; FREQUENCY-CHANGING; NON-LINEAR OPTICS; OPTICAL LOGIC ELEMENTS; OPTICAL ANALOGUE/DIGITAL CONVERTERS
C04B	14	LIME, MAGNESIA; SLAG; CEMENTS; COMPOSITIONS THEREOF, e.g. MORTARS, CONCRETE OR LIKE BUILDING MATERIALS; ARTIFICIAL STONE {(roofing granules E04D 7/005)}; CERAMICS (devitrified glass-ceramics C03C 10/00); REFRACTORIES; TREATMENT OF NATURAL STONE
C08J	13	WORKING-UP; GENERAL PROCESSES OF COMPOUNDING; AFTER-TREATMENT NOT COVERED BY SUBCLASSES

Source: elaboration on Espacenet data.

Table 5 – Accessory patent classes vs. three most relevant assignee

CPC Class	PATENTS	Montedison	FIAT	CSELT
C01P	*81*	*64*		
B82Y	**46**	**10**	**8**	
A61K	42			
G02F	19		11	8
C04B	14			
C08J	13		3	

Source: elaboration on Espacenet data.

Table 6 – Time evolution of accessory patent classes

	1981-1990	1991-2000	2001-2010	2011-2018	TOTAL
C01P	71	5		5	**81**
B82Y	7	9	19	7	**42**
A61K		11	11	21	**43**
G02F		8		11	**19**
C04B			14		**14**
C08J			8	5	**13**
TOTAL	**78**	**33**	**52**	**49**	

Source: elaboration on Espacenet data.