# NANOTECHNOLOGY EXPERT GROUP AND EUROTECH DATA

# MAPPING EXCELLENCE IN NANOTECHNOLOGIES
# PREPARATORY STUDY

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December 2001

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# INTRODUCTION

The mapping of excellence exercise launched in March 2001 is based on the methodology, described in the Commission Staff Working Paper SEC(2001) 434 entitled HOW TO MAP EXCELLENCE IN RESEARCH AND TECHNOLOGICAL DEVELOPMENT IN EUROPE of 12 March 2001 and consists of a "modulated indicators approach" based on bibliometrics and patents studies, surveys and consideration of existing information. The outcome of the analyses will be evaluated by experts and compared in order to determine the entities, which will be considered as excellent or as competent.

The first mapping exercise is limited to three areas, Economics, Life sciences, and Nanotechnologies, within each of which four fields have been selected for the actual mapping. In August 2001, a preparatory study, based on limited bibliometric and patent analyses, was launched in the areas of Life Sciences and Nanotechnologies. The study was performed with the help of two STRATA-like expert groups appointed by the European Commission and a data service provider, Eurotech Data. Its aim was to identify problems and allow exploration of different alternatives if necessary, in order to prepare the first mapping exercise to be carried out, in the most efficient manner, with the assistance of contractors selected following an open call for tenders.

This report presents the results of the preparatory study in the area of nanotechnologies, consisting in bibliometric exploration and patents analyses that aimed to prepare the mapping of excellence in that area. This report has been prepared for the European Commission by the independent STRATA-like expert group for the mapping excellence in nanotechnologies composed of

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In the DEFINITIONS section, relevant background is discussed, such as the development of the area and its great heterogeneity. This is done with respect to defining a bibliometric search strategy for publications and patents.

The METHODOLOGY used for the bibliometric study is then described. The fact that, in bibliometric terms, no ready-made database or index system that could be used to define the area presents a great challenge to exploring the area. It was decided to start out searching for the term '*nano*' as word indicative that the publication or patent is in broad area of nanoscience and technology.

In order to define the four fields that were selected by the Commission keywords were added to correspond to the central aspects associated with them.[1] As not all keywords are equally relevant to

[1] The fields are described in the next section. A list of keywords can be found in Appendix 1.

each field, the field experts assigned weights. In order to qualify as a relevant paper for a given field, a threshold of keyword weights was used, which in practice meant that a paper/patent title, abstract and keywords considered together needed to comprise more than one keyword associated with that field. Considering the multidisciplinary character of the area, it was decided that a paper/patent could be assigned to more than one field.

In bibliometric terms, highly cited publications can be used as one of several approximate measures of excellence. Using this approach, for each field, the most cited papers of recent origin can be identified and ranked. Departmental listings can be derived from these citation-based rankings of publications. As publication volume is not considered here, the advantage of this approach is that there is no bias in terms of size of the department. Both large and small organizations have an equal chance to enter the top ranks. Data is given in the first part of the RESULTS section, and in APPENDICES.

There are a number of reasons to treat the results with caution. Firstly, there is a bias related the size of the fields within the area of nanotechnology. Secondly, a bibliometric study is a reflection of the past, not an indicator of the future. What’s more, a bibliometric study is the study of a communication system, that in itself contains some biases, such as the need to publish in order to obtain further funding, and techniques used to improve acceptance in well-known journals. Further, it would be of interest to look at evolution of activity over a period of time in order to identify trends in activity in the area. In a rapidly growing and changing area, some fields become fashionable for a short period; it would be necessary to cover over period of years on the rather than just a single year to identify such short-term effects. As APPENDIX 9 illustrates for review papers, publication activity in nanotechnology is still highly volatile with respect to yield distribution. Another consideration is the fact that new journals take some time to be included in the Science Citation Index, and so there is a bias against them. Yet another relates to the specificity of vocabulary: different organisations in different geographical areas might use different vocabulary to refer to the same thing, especially in new fields.

The following graph and table show the evolution of nanotechnology publishing and patenting activity.

FIGURE 0. NANO-PUBLICATION AND PATENTING OVER TIME.

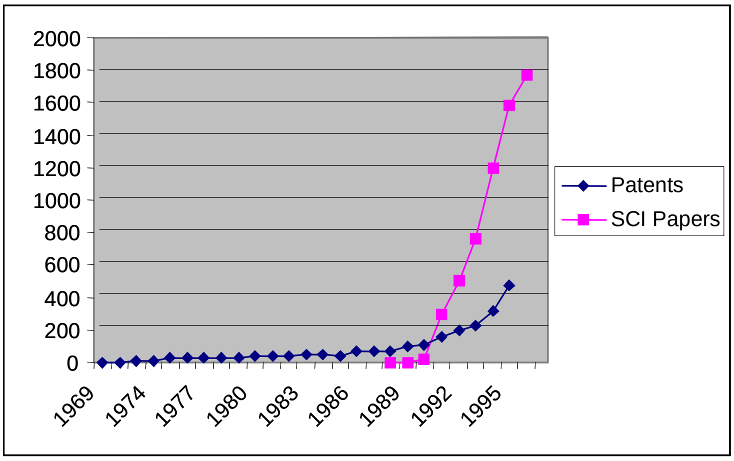



TABLE 0. GROWTH OF NANO RELATED RESEARCH PUBLICATIONS[2]

| Year | Articles | Reviews |
|---|---|---|
| 1990 | 315 | 6 |
| 1991 | 392 | 5 |
| 1992 | 537 | 11 |
| 1993 | 770 | 13 |
| 1994 | 1128 | 28 |
| 1995 | 1517 | 37 |
| 1996 | 2491 | 66 |
| 1997 | 2873 | 81 |
| 1998 | 3520 | 68 |
| 1999 | 4702 | 84 |
| 2000 | 5274 | 106 |
| 2001 | 6662 | 147 |

The second bibliometric indicator studied is patenting activity, and in particular patent invention activity. As significant resources are invested at each stage of the patenting process, a study of patent inventor addresses may represent significant worthwhile inventor activity in the geographical area. Once again, though, these results need to be treated with caution, for example because of the different policies related to patenting in different countries, and different institutions within one country.

There is, therefore, clearly the need for additional indicators to supplement bibliometrics.

One standard scientific method is peer review. Results from a reputation assessment exercise are given here; there remain many provisos such as with regard to the distribution of the questionnaires, to the heterogeneous geographical coverage in the responses received, and to their objectivity.

[2] Note: Title search with nano* in SCI via Web of Science (update as of December 15, 2001). Year 2001 has incomplete data.

Another indicator given is collaboration on EU funded projects. Some experts have questioned whether this is really an indicator of excellence.

This report concludes with a number of RECOMMENDATIONS for future mapping exercises.

Certain data included herein are derived from the Nanotechnology Topical Citation Report of the Institute for Scientific Information®, Inc. (ISI®), Philadelphia, Pennsylvania, USA: 

# DEFINITIONS

## WHAT IS NANOTECHNOLGY(IES)?

This section illustrates the heterogeneous nature of nanotechnology by pointing to the various definitions. Formulating an appropriate search strategy for the mapping exercise depends critically on how the area that is to be mapped is defined. Typically, emerging fields are characterized by a multiplicity of definitions, none of which is generally recognized.

As a recent study shows, there is little consensus on what exactly nanotechnology is.[3] Twenty-four European experts from various areas of science and technology could not agree on more than four out of more than fifteen fields as be relevant for nanotechnology.

The great variation in expert opinions is due to the nature of this emerging area as a potential area that integrates so far separate, autonomous and to some extent unrelated disciplines. A look at the history of nanotechnology will clarify this.

The term nanotechnology appeared on the scientific scene for the first time in the early 1970s. Taniguchi introduced it in 1974 to describe ultra-fine machining, or more specifically the precision manufacture of mechanical parts with finishes and tolerances in the nanometer range. Nano is of Greek origin and means dwarf. A nanometer is one billionth of a meter, or: $10^{-9}$ m. Taniguchi defined the range of nanotechnology as being from 0.1 nanometers (nm) to 100 nm.

In the course of the past decade, the term nanotechnology has been broadened well beyond the original meaning, which limited it to the areas of physics and precision engineering. It includes now a variety of other topics. For instance, it is applied to *"almost any materials or devices which are structured on the nanometre scale in order to perform functions or obtain characteristics which could not otherwise be achieved."*[4]

The nanotechnology expert group was not able to agree on a definitive delineation of nanotechnology, but came up with the following:

***Working Definition:***

Nanotechnology - the manipulation, precision placement, measurement, modelling or manufacture of sub-100 nanometer scale matter.

This lack of agreement has a considerable implication in terms of our study. The fuzziness of the concept does not allow a straightforward search strategy. Fuzziness occurs also at the scale-level and in terms of fields to be included. Finally, there is also disagreement as to what functions, like manipulation, precision placement, measurement, modelling and manufacture to include as nanotechnology.

[3] Malsch, I. (1997). Nanotechnology in Europe: Experts' Perceptions and Scientific Relations between Sub-areas. Seville: Institute for Prospective Technological Studies/JRC.
[4] Whatmore, R.W.; Corbett, J. Nanotechnology in the Marketplace. Computing & Control Journal, June 1995, pp.106-107.

In comparison to other fields of science and technology there is no readily available subject database or system. For instance, there is no sophisticated nano-publication database or a nanoscience or technology indexing system. There is no bibliographic representation neither of nanoscience nor of nanotechnology.

*Use of 'nano' to select publications*

The fuzziness and variety of definitions also indicate the lack of social coherence of the nano-community. For instance, there are no or only a few journals dedicated to nano-science and only a few organizations resembling parts of nano-scientific communities. The only way to approach ‘nanotechnology’ and related sciences in bibliometric terms appears to be through keywords. The question that the bibliometrician asks in this context is which words or terms characterize the field. Given the dissent among analysts in general and the experts in particular, the way chosen to begin this feasibility study was to use the term ‘*nano*’; results have shown a number of important papers are not retrieved by this method.

It is readily acknowledged that on one hand this term just covers a very small part of the nano-universe and it also neglects the scale-dimension of our working definition. However, with this strategy the analyst knows what is retrieved. If other words were to be identified at a later stage, they can be added because our strategy generates a coherent subset in terms of recalling all papers with ‘*nano*’. The term is principally non-discriminatory even though the use of that terminology may vary from field to field. Especially in biotechnology-related areas ‘*nano*’ is not as frequently used as in other fields.

The Commission decided to explore a subset of nanotechnologies, which encompasses four fields in particular:

Field 1: Nanotechnology for interacting, sensing, actuating and microsystems
Field 2: Nanotechnology for Biotechnology
Field 3: Nanotechnology for information processing, storage and transmission
Field 4: Nanotechnology for materials and surface science

It should be noted that the above definitions of four fields represent one of many possible breakdowns of the area of nanotechnology into four fields.

In order to define these four fields in bibliometric terms it was decided to use a keyword approach in which each field is represented by a set of keywords in addition to the nano-word.

# WHAT IS EXCELLENCE?

In bibliometrics the indicator that comes closest to the concept of excellence is some sort of citation measure.

A straight count of articles produced by an organization is hardly a relevant measure of excellence, since it merely reflects the publication activity. If articles are weighted by the citation impact of the journals in which they are published one gets an indication of impact of the channels used for publications rather than the impact of the papers.

If the articles are weighted by the citations actually received by them, the result comes closer to a measure of real scientific impact. However, if citations are used then, it is necessary to decide if some sort of average measure applies or if only the highly cited papers should be considered. Furthermore, it is a well-known fact that that citation values are context dependent - they vary a lot between fields, because the number of citing articles differs as well as the number of references made in the papers. This means that one should not compare absolute citation frequencies across fields. Finally, one should mention the problem self-citation, for which one would ideally like to be able to measure the degree of objectivity.

Considering that the recall of nano relevant papers by the search strategy used in this study is quite low and that they cover only the publication year 2000, it is not adequate to identify excellence by counting citations to these papers. On the other hand, excellence could be defined in terms of other papers being frequently cited by the nano-papers. Then references of the 2000 nano-papers can be looked upon as a pointer to major and influential works of the field.

When it comes to patents, citations could also be an approximate measure of the technological impact. A patent being cited by another patent is an indication that the latter's technology is partly building upon the former. However, such a citation analysis is not appropriate on European Patent Office applications, which were used for this study, because of the rules for including citations in a European patent[5].

Applying for a patent is a relatively long and costly process. The very fact that organizations or individuals dedicate considerable financial resources to protecting their intellectual property rights indicates to some extent that the developers associate some degree of technological or economic relevance to the technology for which they seek protection under the patent laws. In this sense patents are used as such as potential pointers to excellence.

[5] PATENT CITATION ANALYSIS: A CLOSER LOOK AT THE BASIC INPUT DATA FROM PATENT SEARCH REPORTS, Jacques Michel and Bernd Bettels, Scientometrics, 2001

# METHODOLOGY

The work for mapping nanotechnologies commenced in August 2001. Experts, in collaboration with Eurotech Data, compiled publication and patent data for an informetric regional and institutional analysis of nanotechnologies.

## PUBLICATION DATA

The nanotechnology publications database includes all papers indexed by ISI during the year 2000 with the term '*nano*' appearing in either the article title or author keywords. The database, delivered in MS Access format, included complete bibliographic data for each paper (all author names; all addresses; journal title, volume, page, year; article title; keywords; abstract; annual and cumulative citation counts to each paper, cited references: all author names, all addresses, year). The database contained 7006 records, of which 4605 are potentially relevant (limitation to Article/Review/Note).

## PATENT DATA

The patent database is compiled on the basis of data retrieved by the European Patent Office (EPO). The database includes both European and World Patents applications that contain the term '*nano*' for the publication years 1996-2000. For search and retrieval, EPO used a combination of EPODOC and EUREG databases. Nano-patents information retrieved was as follows:

a) the following fields from EPODOC:

> Publication Number; Application Data; EPO Classification (IPC) (Cross-Searching EC); IPC Issuing Office (Cross-Searching IC); Priority Data; Applicant name; Inventor name; Title of the Invention; Abstract of the Invention; Publication Date; Applicant name; Inventor name; Patents cited in the search report; Literature cited in the search report.

b) the following fields from EUREG:

> Licensee name; Licensee address; Licensee country; Licensee name; Inventor address; Inventor country; Applicant address; Applicant country; Designated States (intention to pay/payment received); Renewal fees Art. 86; Date of filing; Date of grant; Earlier application/publication number(s); Refusal of application; Date of lapses; Withdrawal of application.

Where there were both European and World Patent applications for the same patent (family members), the European applications were chosen. A total of 2,108 records were compiled.

# RELEVANCE EVALUATION AND FIELD ASSIGNMENT

Expert evaluations formed the basis for further bibliometric analysis. They involve a combination of

(1) keyword hits/weights and

(2) expert relevance judgements.

In the case of (1), the scientific and technological experts indicate the degree of association (on a scale from 1-10) of a given keyword with one of the four fields. Figure 1 shows how weights can be used in order to assign fields to publications and patents. The weights determined after (1) can be combined with the occurrence of keywords in a document. The document will be finally assigned to the field(s) for which the sum of expert-weighted keywords is above a certain threshold.

Further, a set of irrelevant *'nano'* keywords, such as $NaNO_3$, was created, and documents containing only these keywords were excluded. A listing of keywords both for field assignment and exclusion is given in APPENDIX 1.

The search for *'nano'* keywords gained less results for biotechnologies than for the other fields. Actually, scientists working in some important and rapidly developing research areas, such as, drug delivery, drug targeting, gene therapy, gene delivery, cell therapy, tissue engineering, modular chemistry on immobilized templates, etc., have seldom used *'nano'* words in publications and patents. The publications come under nanotechnologies dealing with the manipulation, precision placement, measurement, modelling or manufacture objects consisting of biological and synthetic macromolecules. *'Nano'* word specification is not necessary there because the nanometer scale of the objects is evident. Generally, keywords chosen by experts for characterization the biotechnology apply to most of the areas, however, the requirement on their association with some *'nano'* word disqualifies many publications. As the individual keywords, e.g. DNA, enzyme, antibody, refer to an unprocessable wide group of publications, specific combinations of keywords will be necessary to characterize the field.[6]

The keyword approach appears to be effective in assigning the papers to the four fields. APPENDIX 4 contains a ranking of subject categories of cited journals by field. It seems reasonable that, for instance, applied physics/coindensed matter /materials science and physical chemistry/chemical physics play a strong role in the micro-nanotechnology area. Similarly, it appears sound that multidisciplinary, pharmacology & toxicology, biochemistry & biophysics categories are most prominent in the biotechnology field. Naturally, there are overlaps to be expected between the four fields (see the map of keyword co-occurrences in the figure in APPENDIX 4).

[6] To characterize the areas a search could be performed according to the following keywords, which one of the field experts tentatively tested using Chemical Abstracts. Combinations of words encompass: drug delivery and [polymer, (or) particles, (or) encapsulation, (or) conjugate]; drug targeting and [polymer, (or) particles, (or) encapsulation, (or) conjugate]; gene therapy and [polymer, (or) particles, (or) encapsulation, (or) conjugate]; gene delivery and polymer, (or) particles, (or) encapsulation, (or) conjugate; immobilized and [DNA, (or) templates, (or) primers, (or) oligonucleotides]. Single keywords include biochip, tissue engineering, cell therapy, tissue replacement

[7] To characterise the areas a search could be performed according to the following keywords, which one of the field experts tentatively tested using Chemical Abstracts. Combinations of words encompass: drug delivery and polymer, (or) particles, (or) encapsulation, (or) conjugate; drug targeting and polymer, (or) particles, (or) encapsulation, (or) conjugate; gene therapy and polymer, (or) particles, (or) encapsulation, (or) conjugate; gene delivery and polymer, (or) particles, (or) encapsulation, (or) conjugate; immobilized and DNA, (or) templates, (or) primers, (or) oligonucleotides. Single keywords include biochip, tissue engineering, cell therapy, tissue replacement

In method (2), the experts evaluate on a one-by-one basis the documents' association with a field. The first approach of weighted keywords was applied to both publications and patents. Given the much smaller size of the patent sample, experts carried out also a one-by-one evaluation.

Validation studies (see APPENDIX 2) indicate that even though both methods rely on expert judgements, they can lead to different assignations of documents to fields. This has profound implications in terms of recall performance and validity of search strategy. As for *citing* papers, a case study of fullerene publications indicated that one should be cautious when interpreting the bibliometric data in our sample as representative of the entire nano. A set of fullerene papers were retrieved from the SCI and asked our field experts to evaluate the relevance of these papers in terms of nanotechnology. Among the papers judged as relevant for nano science and technology the recall ratio using *'nano'* as search term varies between 12.5 to 13.1 percent. This is a consistent pattern meaning that regardless of the expert used a maximum 15 percent of the relevant papers using *'nano'* as search term are retrieved. In terms of precision, the percentage of papers considered as relevant varies considerably between the experts 10-62 percent for all fullerene papers and 8-53 percent for those containing *'nano'*. This means that one cannot expect experts to agree on which papers are relevant.[8]

Another option beyond analysing the articles that were retrieved in the original search is to examine their knowledge base, i.e. the papers they cite ('*cited* papers'). As for highly cited papers, a very different situation is found. The recall here is very good using the *'nano'* word. *'Nano'* papers are typical for the most influential papers in nanoscience. Table 1 lists the recall ratings of cited papers by field.

TABLE 1. THE RECALL OF CITED PAPERS BY NANO IN TITLE ONLY

| Field | N of titles with nano among top 50 cited papers |
|---|---|
| **Field 1** | 49 |
| **Field 2** | 25 |
| **Field 3** | 45 |
| **Field 4** | 41 |

In light of the much better recall rates for cited papers, it was decided to focus on analysing them in this report rather than citing papers. The data presented in APPENDIX 3 supports this decision. It illustrates how low the publication rates are on the citing side at the level of departments. This makes its use in terms of excellence mapping problematic.

# SEARCH AND DATA MANIPULATION STRATEGY

Our strategy for both papers and patents is as follows:

- Use keyword lists with expert average weights
- Refine the list, for example by removing meaningless words and the misallocated words. Make the field assignment using a sum of weights that has been renormalized to take account of the number of keywords in the field

[8] This result was underlined by the patent one-by-one evaluation. See the patent section and appendix for more details. One expert suggested more detailed and precise definitions of nanotechnology and the four nanotechnology fields could make the experts' judgements more consonant.

- After all patents and papers have been assigned to their fields, addresses are added.

This procedure will allow us to carry out the following analyses:

- Geographical distribution of nano-publications and nano-patents at the level of Member States and associated countries (based on inventor addresses)
- List of publishing and patenting organizations, sorted by frequency
- For publications, a list most cited organizations.

FIGURE 1. ILLUSTRATION TO THE USE OF WEIGHTS

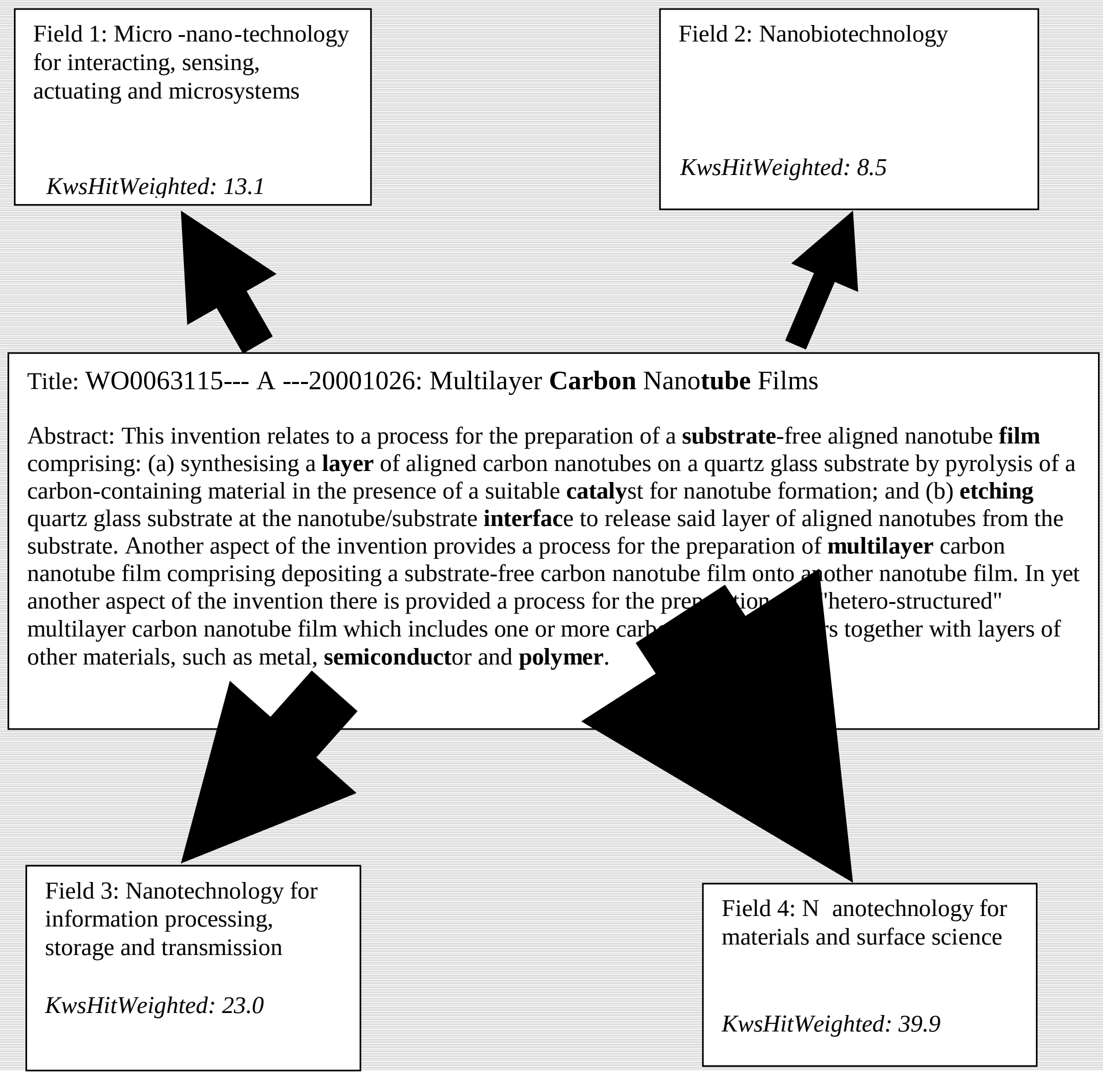
Note:This patent will go to fields 3 and 4 since the sum of expert keyword weights is >=20 for that field. The arrow thickness is proportional to weight.

Field 1: : [tube (weight 6)] * (32.75 / 15)

Field 2: : [multilayer (weight 8)] * (32.75 / 31)

Field 3: : [tube (weight 8) + layer (weight 9) + etching (weight 7) + semiconduct (weight 7)] * (32.75 / 44)

Field 4: [carbon (weight 8) + substrate (weight 10) + film (weight 8) + cataly (weight 6) + etching (weight 6) + interfac (weight 8) + polymer (weight 4) ]* (32.75/41)



# RESULTS

This part of the report introduces the results of our bibliometric analyses of publication and patent data. Findings from our citation analyses at the level departments are presented. In particular, there is a focus on highly cited papers. The nano-patents were analysed by assignee and inventor countries as well as their distribution by EU regions. In addition, this section also contains findings from the reputation assessment exercise and an analysis of EU project collaboration in the area of nanotechnologies.

Before presenting the data in detail, it should be noted that for both publications and patents field assignments made by setting a sum of keyword weights >= 20, which is generally the equivalent of two keywords with a maximum weighting (of 10) or four keywords with a medium weighting (of 5). Keywords may appear in title, abstract or, in the case of publications, author keywords. It should be noted that though there is always a title, abstract and author keyword data is not always available. Table 2 summarises the basic data analysed in this study.

TABLE 2. BASIC DATA FOR PAPERS AND PATENTS

| | N of papers in 2000 | N of cited papers 1996-2000 | N of patents 1996-2000 |
|---|---|---|---|
| **Field 1: Micro-nano-technology for interacting, sensing, actuating and Microsystems** | 329 | 2059 | 50 |
| **Field 2: Nanobiotechnology** | 177 | 1784 | 48 |
| **Field 3: Nanotechnology for information processing, storage and transmission** | 323 | 2551 | 38 |
| **Field 4: Nanotechnology for materials and surface science** | 1311 | 8461 | 179 |

## PUBLICATIONS

European institutions were amongst the most frequently cited ones worldwide, in particular groups at

- TU Delft in the Netherlands (in fields 1, 3, and 4)
- Inst Charles Sadron in France (in fields 1 and 4)

Tables 3A-3D and the attached plots give more detail about cited papers by European departments. The tables provide information about the departmental affiliation of those papers that were most frequently cited in a field (column 1). In addition, the tables also contain the total number of citations the paper received from all papers in our database of year 2000 nano-papers (column 2 in Tables 3A-D).

The plots attached to the tables inform about which type of organization produces highly cited nano-science. Each data point in the plots represents an individual paper. The x-axis of a plot indicates where a paper was written in terms of the number of papers by the department that has been cited, which is an approximate indication of the size of research activity. The y-axis indicates how many times a given publication has been cited.

For instance, data point (30/20) in plot 3A, refers to a paper that was written in a department, which contributed 30 papers to the field, and is cited 20 times. Data point (1/26) marks a single publication that was cited 26 times – it received more recognition than the paper in (30/20). It was written in a department which contributed only this paper (x=1) to the area of micro-nanotechnology. This way excellence can be tracked (as measured by citations received) independent of size. This particular example illustrated that departments with high output in the area do not necessarily produce highly cited science and departments with a low publication output in the area are not bound to generate papers that are to be ignored by the scientific community.

The plots appear to confirm this observation for all the fields. Not only that large departments (with a large numbers of papers) produce highly cited science in the area of nanotechnologies but also that excellence (in terms of citations received per paper) can be found in small departments as well. While the plots differ in distributions from field to field, the overall tendency remains unchanged.

In the APPENDIX 5 another listing of most cited papers by department is presented. The citing side is our four fields. The threshold used is that a paper must have a total citation frequency of 10 or more for fields 1, 3 and 4. Given the much smaller size of field 2, the threshold is 5. These listings include some departments with only one cited paper above the threshold, and that is good, but it also takes the number of highly cited papers into consideration.

TABLE 3A. EUROPEAN DEPARTMENTS PRODUCING THE HIGHLY CITED PAPERS IN FIELD 1

| Field 1 | All | At least 10 citations |
|---|---|---|
| Citations | Citations | Department |
| 38 | 165 | Inst Charles Sadron, , France |
| 26 | 117 | Off Natl Etud & Rech Aerosp, Lps, France |
| 26 | 117 | Univ Nantes, Imn, France |
| 26 | 117 | Univ Montpellier 2, Dynam Phases Condensees Grp/France |
| 25 | 83 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| 20 | 95 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| 20 | 95 | Delft Univ Technol, Dimes, Netherlands |
| 19 | 88 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| 19 | 88 | Delft Univ Technol, Dimes, Netherlands |
| 11 | 24 | Ecole Polytech Fed Lausanne, Dept Phys, Switzerland |
| 11 | 24 | Univ Oxford, Dept Mat, Uk |

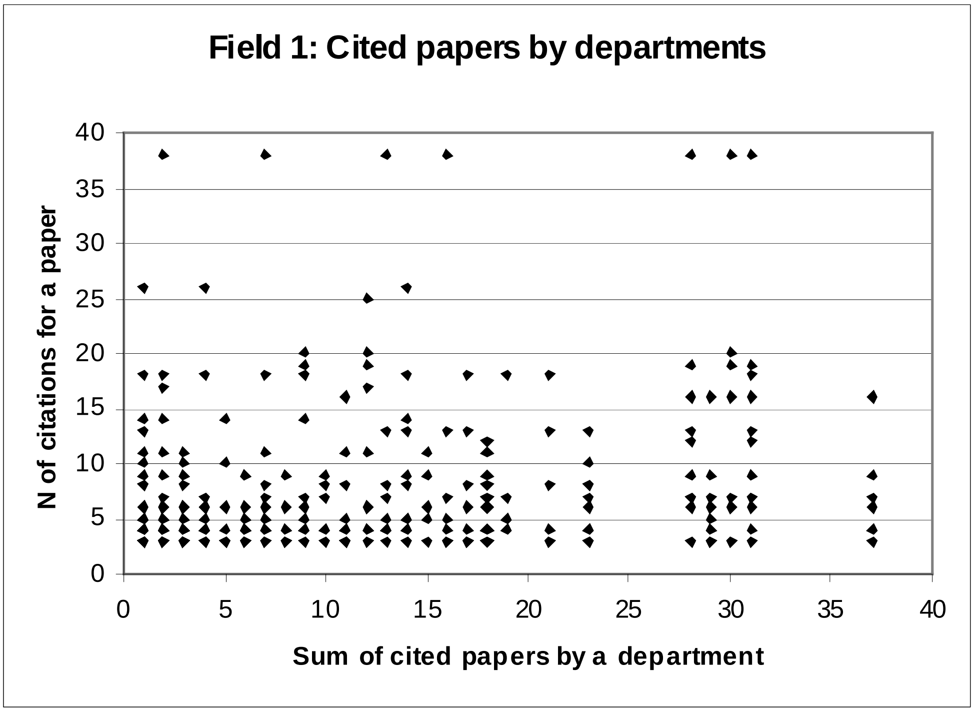


TABLE 3B. EUROPEAN DEPARTMENTS PRODUCING THE HIGHLY CITED PAPERS IN FIELD 2

| Field 2 | All | At least 3 citations |
|---|---|---|
| **Citations** | **Citations** | **Department** |
| 4 | 13 | European Molec Biol Lab, Prot & Peptide Grp, Germany |
| 3 | 3 | Biol Bundesanstalt Land & Forstwirtschaft, Inst Biochem & Pflanzenvirol, Germany |
| 3 | 3 | Cnrs, Inst Sci Vegetales, France |
| 3 | 3 | Univ London, Sch Pharm, Uk |
| 3 | 5 | Ctr Etud Pharmaceut, Cnrs, France |
| 3 | 19 | Inst Charles Sadron, Cnrs, France |
| 3 | 19 | Univ Strasbourg 1, France |
| 3 | 3 | Univ London Kings Coll, Randall Inst, Uk |
| 3 | 3 | Univ Turin, Dipartimento Anat Farmacol & Med Legale, Italy |
| 3 | 3 | Univ Turin, Dipartimento Fisiopatol Clin, Italy |
| 3 | 3 | Univ Turin, Dipartimento Sci & Tecnol Farm, Italy |
| 3 | 9 | Univ Geneva, Sch Pharm, Switzerland |
| 3 | 3 | Cnrs, Inst Sci Vegetales, France |
| 3 | 5 | Univ Dublin Trinity Coll, Dept Chem, Ireland |
| 3 | 4 | Univ Glasgow, Ctr Cell Engn, Uk |
| 3 | 3 | Natl Inst Biol Stand & Controls, Div Hematol, Uk |

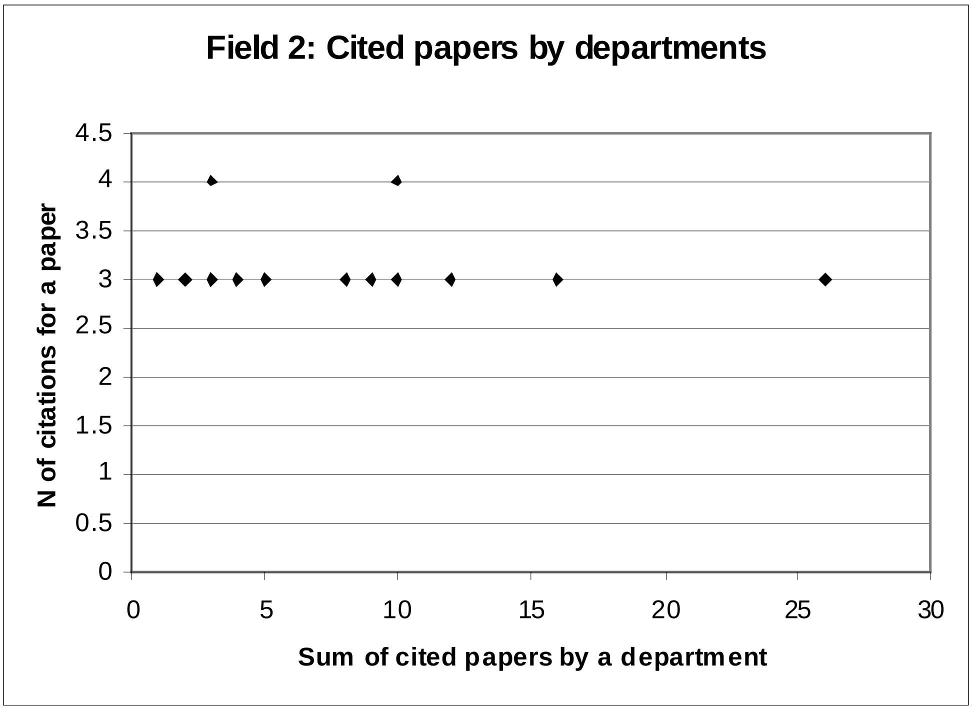


TABLE 3C. EUROPEAN DEPARTMENTS PRODUCING THE HIGHLY CITED PAPERS IN FIELD 3

| Field 3 | All | At least 10 citations |
|---|---|---|
| Citations | citations | Department |
| **34** | 88 | Delft Univ Technol, Dimes, Netherlands |
| **34** | 88 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| **23** | 95 | Delft Univ Technol, Dimes, Netherlands |
| **23** | 95 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| **22** | 83 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| **18** | 165 | Inst Charles Sadron, , France |
| **17** | 33 | Csic, Inst Ciencia Mat, Spain |
| **13** | 31 | Delft Univ Technol, Delft Inst Microelect & Submicron Technol, Netherlands |
| **12** | 29 | Delft Univ Technol, Dept Appl Sci, Netherlands |
| **12** | 29 | Delft Univ Technol, Dimes, Netherlands |

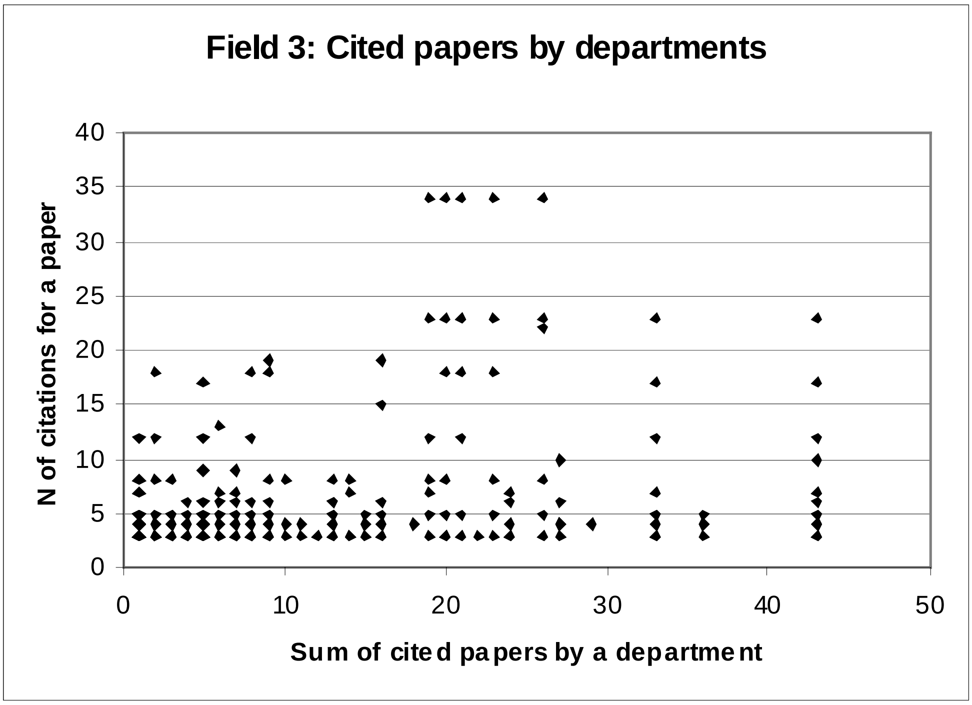
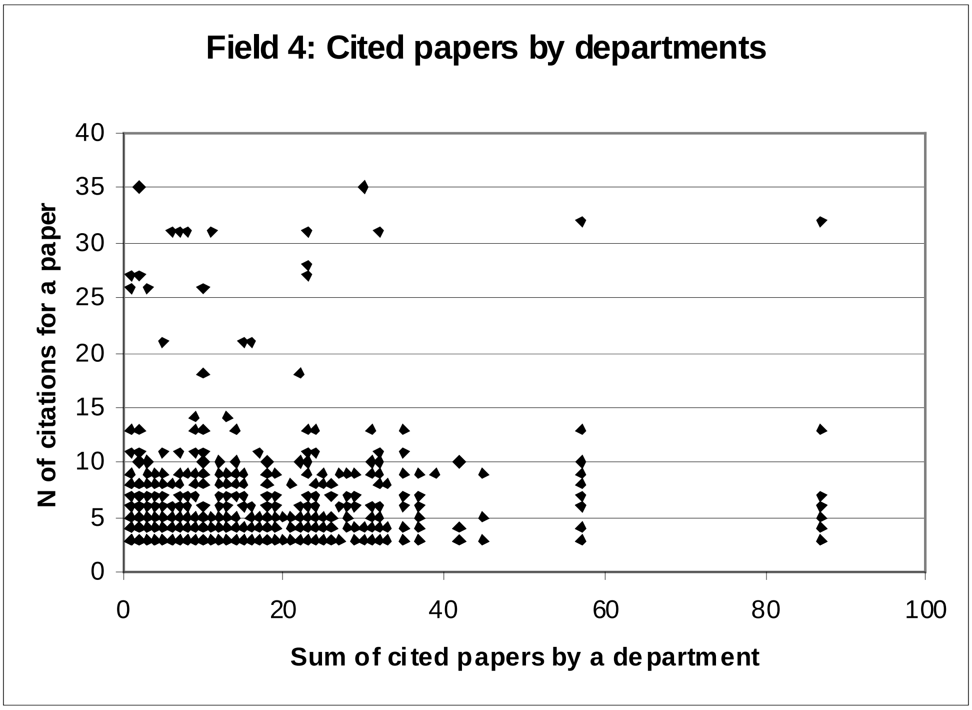


TABLE 3D. EUROPEAN DEPARTMENTS PRODUCING THE HIGHLY CITED PAPERS IN FIELD 4

| Field 4 | All | At least 10 citations |
|---|---|---|
| Citations | Citations | Department |
| 31 | 165 | Inst Charles Sadron, , France |
| 26 | 117 | Univ Montpellier 2, Dynam Phases Condensees Grp, France |
| 26 | 117 | Univ Nantes, Imn, France |
| 26 | 117 | Off Natl Etud & Rech Aerosp, Lps, France |
| 21 | 41 | Univ Sussex, Sch Chem Phys & Environm Sci, Uk |
| 18 | 83 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| 13 | 95 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| 13 | 95 | Delft Univ Technol, Dimes, Netherlands |
| 11 | 88 | Delft Univ Technol, Dept Appl Phys, Netherlands |
| 11 | 88 | Delft Univ Technol, Dimes, Netherlands |
| 11 | 30 | Univ Sheffield, Dept Elect & Elect Engn, Uk |
| 11 | 30 | Def Res Agcy, , Uk |
| 10 | 22 | Univ Paris 06, Lab Srsi, France |
| 10 | 22 | Ecole Polytech Fed Lausanne, Inst Chim Phys, Switzerland |
| 10 | 22 | Cea, Dsm, France |
| 10 | 19 | Inst Charles Sadron, Cnrs, France |
| 10 | 22 | Univ London Imperial Coll Sci Technol & Med, Ctr Photomol Sci, Uk |
| 10 | 19 | Univ Strasbourg 1, 6 Rue Boussingault, France |



# PATENTS

This section of the report gives an overview of patenting activity in nanotechnologies. First, it gives an overview of how the four fields in nanotechnology vary in terms of technological specialization. Then, various country and regional comparisons are presented. The data are compared with respect to patent assignations, patent inventor distributions, and potential locations of excellence. An evaluation of the technological relevance and the commercial potential of these patents cannot be made in this study due to lack of access to relevant data sources, such as patent citation databases.

A total of 2108 patent documents following our *'nano'* search strategy were retrieved for the period 1996-2000, 1301 of which were deemed relevant by at least one expert. Field 4 (nanotechnology for materials and surface science) was also the strongest sub-field in terms of nano-patenting with a total of 755 documents, followed by field 2 (nanobiotechnology) with 431, field 3 (nanotechnology for information processing, etc.) with 244 and field 1 (micro-nanotechnology) with 237 documents.

The keyword-weighting approach results in a much smaller number of documents. Only 315 of the 2108 records have a keyword-weight sum of 20 or more. However, field 4 is still the most active sub-area of nano-patenting. Applying this method, however, leads to a change in ranking between fields 1, 2, and 3. Nanobiotechnology patents are not the second-largest group anymore; they follow micro-nano-patents on rank 3. Field 3 (nanotechnology for information processing, etc.) is the least active patenting area. As the keyword weighting approach was employed in dealing with scientific papers, this approach was also applied to the patent data.[9]

Table 4 gives an overview of the distribution of patents by fields and names the patenting focus of each sub-field. There is a clear difference in emphasis between the fields. For instance, most of the patents in micro-nanotechnology (field 1) are to be located in section G – physics of the International Patent Classification (IPC), while nanobiotechnology is highly focused on 'section A- Human necessities' and nanotechnology for information processing, storage and transmission relates mostly to the electricity-section H. As the largest area of activity, field 4 is also the most diverse. It is the only field in which no single IPC section accounts for 50 % or more of the patents in the area. However, a strong concentration towards chemistry/metallurgy is still found. More than 40% of field-4 patents belong to this category.

TABLE 4. PATENTING IN THE FOUR SUB-FIELDS

| Fields | Number of patents | Strongest IPC section and its share of sub-field patenting |
|---|---|---|
| **Field 1: Micro-nano-technology for interacting, sensing, actuating and Microsystems** | 50 | G – Physics (50% of the relevant patenting) |
| **Field 2: Nanobiotechnology** | 48 | A – Human necessities (more than 60%) |
| **Field 3: Nanotechnology for information processing, storage and transmission** | 38 | H – Electricity (more than 50%) |
| **Field 4: Nanotechnology for materials and surface science** | 179 | C – Chemistry/metallurgy (more than 40%) |

The patent document offers us information on a number of actors. It lists inventors with their home addresses; it also lists assignees with their respective address information. Both categories were utilised to generate rankings of inventors and assignees by country and field. Table 5 lists inventor distributions, table 6 does the same for assignees. As indicated earlier, patents can be seen as a

[9] Another reason for not choosing the one-by-one approach was the low degree of agreement among the experts. While 61,7% of the nano-patents were considered relevant by at least one expert, only 12,5% of them, or 263, were deemed relevant by two or more experts. See the Appendix for details.

representation of potential excellence insofar as they point to a technological artefact or process for whose exclusive right of use substantial financial resources are spent. In this sense, Tables 7A-D, which summarise regional distributions of EU inventors in the four fields, point to geographical concentrations of person-embodied knowledge in nanotechnologies. It should be noted that all tables reflect only limited patent data. However, in emerging and dynamic fields, such as nanotechnology, one should therefore be careful to draw strong conclusions about national strengths and weaknesses.

TABLE 5. PATENT INVENTORS BY COUNTRY AND FIELD

| Inv country | Field 1 | Field 2 | Field 3 | Field 4 | Total |
|---|---|---|---|---|---|
| **US** | 26 | 38 | 25 | 128 | 217 |
| **JP** | 2 | 5 | 29 | 74 | 110 |
| **DE** | 16 | 24 | 11 | 55 | 106 |
| **GB** | 6 | | 8 | 28 | 42 |
| **AU** | 3 | 8 | 8 | 20 | 39 |
| **RU** | 6 | 1 | 10 | 18 | 35 |
| **FR** | 7 | | 2 | 14 | 23 |
| **KR** | | | 2 | 17 | 19 |
| **CH** | 1 | 9 | | 6 | 16 |
| **BE** | | 4 | | 10 | 14 |
| **IL** | 10 | 4 | | | 14 |
| **SE** | | | | 9 | 9 |
| **ES** | | 4 | | 4 | 8 |
| **NL** | 5 | 1 | 1 | 1 | 8 |
| **AT** | 4 | 1 | | 1 | 6 |
| **CN** | | 2 | 2 | 2 | 6 |
| **CA** | 2 | | | 3 | 5 |
| **IT** | | 5 | | | 5 |
| **IE** | | 4 | | | 4 |
| **IN** | | 4 | | | 4 |
| **SI** | 2 | | 2 | | 4 |
| **LU** | | | | 3 | 3 |
| **AR** | | | 1 | 1 | 2 |
| **NZ** | | | | 2 | 2 |
| **FI** | 1 | | | | 1 |

TABLE 6. PATENT ASSIGNEES BY COUNTRY AND FIELD

| Country | Field 1 | Field 2 | Field 3 | Field 4 | Total |
|---|---|---|---|---|---|
| **US** | 39 | 56 | 26 | 188 | 309 |
| **DE** | 17 | 27 | 13 | 54 | 111 |
| **AU** | 4 | 11 | 11 | 27 | 53 |
| **JP** | 1 | 1 | 11 | 40 | 53 |
| **GB** | 10 | | 7 | 31 | 48 |
| **RU** | 6 | 1 | 7 | 18 | 32 |
| **FR** | 8 | | 1 | 12 | 21 |
| **KR** | | | 2 | 18 | 20 |
| **CH** | 1 | 10 | | 5 | 16 |
| **NL** | 7 | 1 | 1 | 2 | 11 |
| **SE** | | | | 9 | 9 |
| **CA** | 3 | | 1 | 4 | 8 |
| **BE** | | 1 | | 6 | 7 |
| **IE** | | 7 | | | 7 |
| **CN** | | 2 | 2 | 2 | 6 |
| **SI** | 3 | | 3 | | 6 |
| **IL** | 1 | 4 | | | 5 |
| **IT** | | 5 | | | 5 |
| **IN** | | 4 | | | 4 |
| **AT** | 1 | 1 | | 1 | 3 |
| **NZ** | | | | 3 | 3 |
| **AR** | | | 1 | 1 | 2 |
| **ES** | | 1 | | 1 | 2 |
| **FI** | 1 | | | | 1 |

TABLE 7A. REGIONAL DISTRIBUTION OF EU INVENTORS IN FIELD 1[10]

| Count | EU Region | Country |
|---|---|---|
| 3 | Wien | AT |
| 3 | Rems-Murr-Kreis | DE |
| 3 | London (South West) | GB |
| 2 | Goslar | DE |
| 2 | Saarpfalz-Kreis | DE |
| 2 | Bas-Rhin | FR |
| 2 | Cambridge | GB |
| 2 | Ultrecht | NL |
| 2 | Delft en Westland | NL |
| 1 | Östliche Obersteiermark | AT |
| 1 | Karlsruhe, Stadtkreis | DE |
| 1 | München, Kreisfreie Stadt | DE |
| 1 | Bayreuth, Landkreis | DE |
| 1 | Offenbach, Landkreis | DE |
| 1 | Vogelsbergkreis | DE |
| 1 | Fulda | DE |
| 1 | Köln, Kreisfreie Stadt | DE |
| 1 | Dresden, Kreisfreie Stadt | DE |
| 1 | Sächsische Schweiz | DE |
| 1 | Keski-Suomi | FI |
| 1 | Paris | FR |
| 1 | Essonne | FR |
| 1 | Hauts-de-Seine | FR |
| 1 | Isère | FR |
| 1 | Rhône | FR |
| 1 | Coventry | GB |
| 1 | Zuidoost-Zuid-Holland | NL |

[10] This and the following tables, which summarize regional distributions, are based on the NUTS3 classification and GB Postcodes.

TABLE 7B. REGIONAL DISTRIBUTION OF EU INVENTORS IN FIELD 2

| Count | EU Region | Country |
|---|---|---|
| 5 | Stadtverband Saarbrücken | DE |
| 4 | La Coruna | ES |
| 2 | Liège (Arrondissement) | BE |
| 2 | Berlin | DE |
| 2 | Potsdam-Mittelmark | DE |
| 2 | Hamburg | DE |
| 2 | Aachen, Kreisfreie Stadt | DE |
| 2 | Mainz-Bingen | DE |
| 2 | Bologna | IT |
| 1 | Östliche Obersteiermark | AT |
| 1 | Verviers | BE |
| 1 | Stuttgart, Stadtkreis | DE |
| 1 | Breisgau-Hochschwarzwald | DE |
| 1 | Lörrach | DE |
| 1 | Havelland | DE |
| 1 | Oder-Spree | DE |
| 1 | Frankfurt am Main, Kreisfreie Stadt | DE |
| 1 | Main-Kinzig-Kreis | DE |
| 1 | Main-Taunus-Kreis | DE |
| 1 | Saalkreis | DE |
| 1 | Torino | IT |
| 1 | Forlì-Cesena | IT |
| 1 | Roma | IT |
| 1 | Zuid-Limburg | NL |

TABLE 7C. REGIONAL DISTRIBUTION OF EU INVENTORS IN FIELD 3

| Count | EU Region | Country |
|---|---|---|
| 6 | Cambridge | GB |
| 3 | München, Kreisfreie Stadt | DE |
| 2 | Frankfurt am Main, Kreisfreie Stadt | DE |
| 2 | Darmstadt-Dieburg | DE |
| 2 | Liverpool | GB |
| 1 | München, Landkreis | DE |
| 1 | Bayreuth, Kreisfreie Stadt | DE |
| 1 | Darmstadt, Kreisfreie Stadt | DE |
| 1 | Wetteraukreis | DE |
| 1 | Essonne | FR |
| 1 | Rhône | FR |
| 1 | Ultrecht | NL |

TABLE 7D. REGIONAL DISTRIBUTION OF EU INVENTORS IN FIELD 4 (MIN =2)

| Count | EU Region | Country |
|---|---|---|
| 12 | Soltau-Fallingbostel | DE |
| 8 | Stadtverband Saarbrücken | DE |
| 7 | Berlin | DE |
| 7 | Cambridge | GB |
| 7 | Uppsala län | SE |
| 4 | Antwerpen (Arrondissement) | BE |
| 4 | La Coruna | ES |
| 4 | Val-d'Oise | FR |
| 4 | Sheffield | GB |
| 4 | London (South West) | GB |
| 3 | Würzburg, Kreisfreie Stadt | DE |
| 3 | Paris | FR |
| 3 | Milton Keynes | GB |
| 2 | Brugge | BE |
| 2 | Leverkusen, Kreisfreie Stadt | DE |
| 2 | Saarlouis | DE |
| 2 | Rhône | FR |
| 2 | Glasgow | GB |
| 2 | Liverpool | GB |

# REPUTATION ASSESSMENT EXERCISE

Reputation reflects the outside worldview of reality; peoples' impressions are sometimes more important than reality. Therefore the exercise of measuring reputation is very important.

In addition to analysis of publication and patent data, the Commission services carried out a reputation assessment exercise. Based on this analysis, co-mentions were analyzed at country and departmental levels. The co-mention metrics is interesting judgments can be compared with other results.

A total of 115 questionnaires originating from the following countries were used for this analysis:

TABLE 8: NUMBER OF QUESTIONNAIRES RECEIVED BY COUNTRY

| Country | Number of questionnaires |
|---|---|
| **AT** | 5 |
| **BE** | 6 |
| **CZ** | 5 |
| **DK** | 4 |
| **EE** | 2 |
| **ES** | 21 |
| **FI** | 12 |
| **GR** | 2 |
| **IE** | 4 |
| **IL** | 12 |
| **IS** | 2 |
| **IT** | 3 |
| **LT** | 11 |
| **LV** | 6 |
| **MT** | 1 |
| **NL** | 2 |
| **PL** | 1 |
| **PT** | 5 |
| **RO** | 4 |
| **RU** | 1 |
| **SE** | 3 |
| **SI** | 1 |
| **UK** | 2 |

Most of the questionnaires were been filled in by experts in more than one field, and, as the different fields chosen in nanotechnologies are not really disjoined, as explained previously, a vast majority of the entities from different fields were cited.

For the analysis, the entities cited were considered as competent in the same field as the expert filling the questionnaire. Due the imbalance in the geographical coverage, only citations to entities in European countries outside the expert's home country were analysed.

Table 9 shows the number of times the entities from different countries were cited: it gives a measure of the reputation of a country in the different fields. The ranking of the countries for each field and overall is identical except for some minor differences.

TABLE 9: NUMBER OF ENTITIES CITED IN QUESTIONNAIRES

| Country | All fields | Field 1 | Field 2 | Field 3 | Field 4 |
|---|---|---|---|---|---|
| **AT** | 9 | 5 | 3 | 5 | 7 |
| **BE** | 21 | 6 | 3 | 9 | 16 |
| **BG** | 1 | | | | 1 |
| **BY** | 1 | 1 | | | 1 |

TABLE 9: NUMBER OF ENTITIES CITED IN QUESTIONNAIRES

| Country | All fields | Field 1 | Field 2 | Field 3 | Field 4 |
|---|---|---|---|---|---|
| **CH** | 41 | 21 | 12 | 17 | 32 |
| **CZ** | 7 | 5 | 2 | 1 | 7 |
| **DE** | 173 | 74 | 33 | 45 | 142 |
| **DK** | 17 | 10 | 1 | 4 | 12 |
| **EE** | 3 | 1 | | 1 | 3 |
| **ES** | 15 | 7 | 3 | 2 | 13 |
| **FI** | 7 | 5 | 1 | 3 | 5 |
| **FR** | 102 | 29 | 17 | 37 | 80 |
| **GR** | 4 | 2 | 1 | | 2 |
| **HU** | 6 | | | 1 | 5 |
| **IE** | 11 | 3 | 2 | 6 | 7 |
| **IL** | 3 | 3 | 1 | 1 | 2 |
| **IT** | 37 | 14 | 4 | 14 | 32 |
| **LT** | 3 | 1 | | 1 | 3 |
| **LV** | 3 | | | | 3 |
| **NL** | 60 | 21 | 15 | 18 | 48 |
| **NO** | 1 | | | | 1 |
| **PL** | 7 | 2 | | 1 | 7 |
| **PT** | 5 | | 1 | 4 | 4 |
| **RO** | 2 | | | | 2 |
| **RU** | 8 | 2 | | 3 | 7 |
| **SE** | 34 | 15 | 5 | 11 | 24 |
| **SI** | 2 | 1 | | 1 | 2 |
| **SL** | 2 | | | | 2 |
| **UA** | 6 | 3 | | | 6 |
| **UK** | 77 | 26 | 17 | 32 | 65 |
| | | | | | |
| **Total** | 668 | 257 | 121 | 217 | 541 |

The experts of the group have normalised the entities names. A small proportion of entities were not recognised because the institution was not clearly identified. The normalisation of the department was impossible because the departments were cited from memory and not really accurate. Some were also cited as “Group of Professor X”.

Fig. 2A includes a map showing the country relationships in the assessment exercise. The links indicate the number of reciprocal referrals - there is no directionality included. The circle area indicates the number of times a country is "cited" in the assessment survey. The countries with grey labels and circles are the citing ones, and those with grey labels but with no circle are those that only "cite" but never get "cited". All country "self-citations" are excluded. Figure 2B provides the same information at the department level.

FIGURE 2A: CO-MENTION MAP FOR MEMBER AND ASSOCIATED STATES

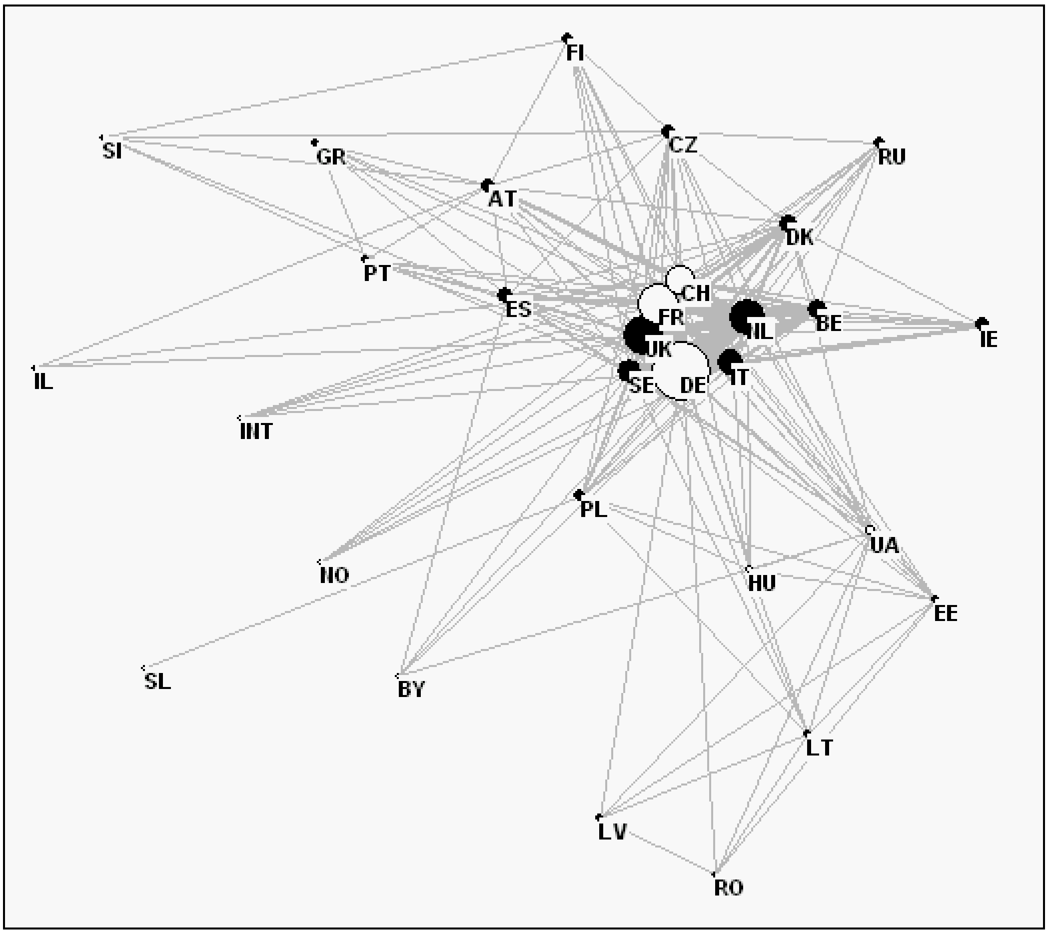
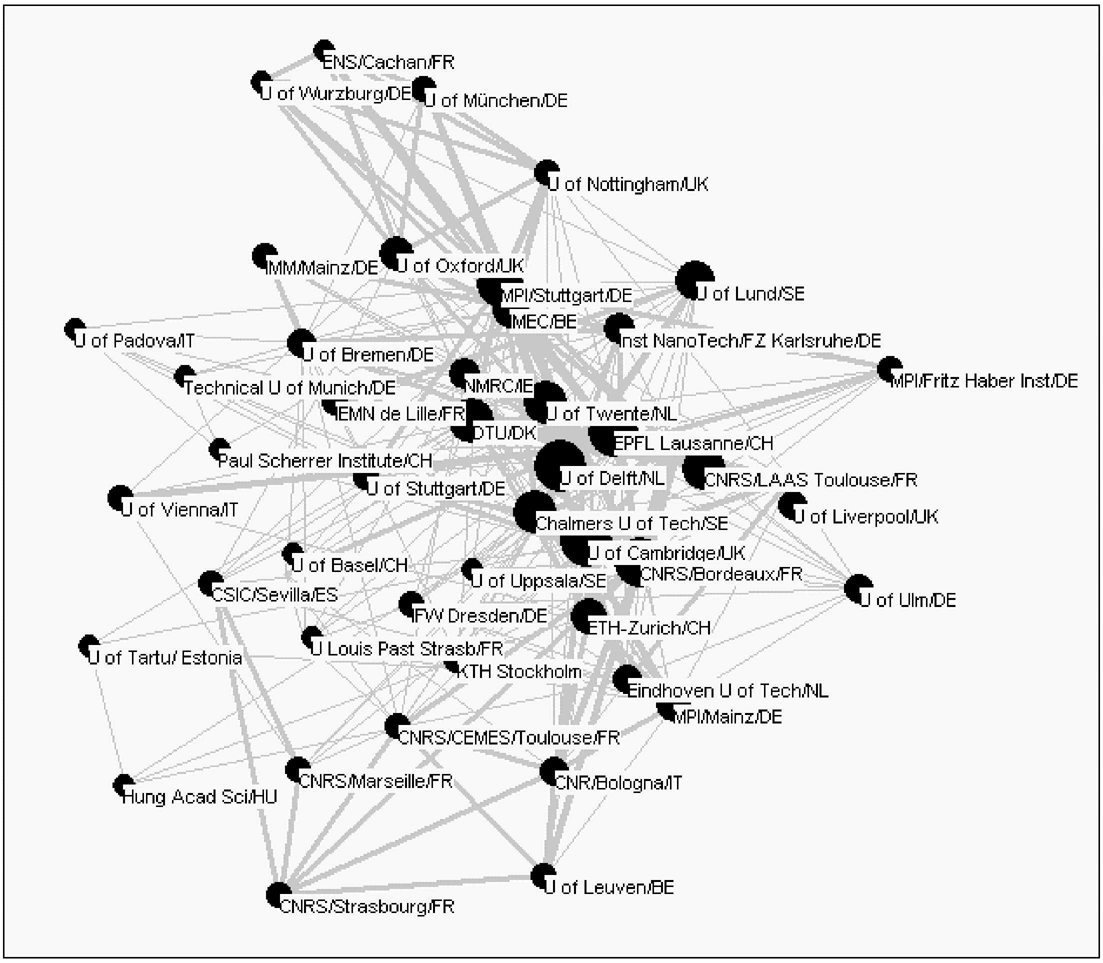


FIGURE 2B: CO-MENTION MAP AT THE DEPARTMENT LEVEL




The most frequently cited entities are shown in tables 10, 11A to 11 D. The cut-off points, chosen by considering, the number of cited entities, were 4 citations for the total of the citations for all fields and for field 4, 3 citations for the fields 1 and 3 and 2 citations for field 2.

TABLE 10: MOST CITED ENTITIES FOR THE TOTAL OF THE 4 FIELDS TO BE MAPPED

| Entity | Country | Number of European citations in reputation assessment |
|---|---|---|
| **University of Cambridge** | UK | 19 |
| **EPFL Lausanne** | CH | 18 |
| **CNRS / Bordeaux / Laboratoire IXL** | FR | 18 |
| **University of Delft** | NL | 18 |
| **CNRS / LAAS Toulouse /Groupe Microstructures et Microsystemes Integres** | FR | 16 |
| **MPI / Stuttgart** | DE | 13 |
| **DTU** | DK | 12 |
| **University of Twente** | NL | 11 |
| **Chalmers University of Technology** | SE | 11 |
| **University of Lund** | SE | 11 |
| **University of Oxford** | UK | 11 |
| **Institute of Nanotechnology / Forschungzentrum Karlsruhe** | DE | 9 |
| **IMEC** | BE | 8 |
| **ETH / Zurich** | CH | 8 |
| **Eindhoven University of Technology** | NL | 8 |
| **MPI / Mainz** | DE | 7 |
| **University of Hamburg** | DE | 7 |
| **University of Ulm** | DE | 7 |
| **University of Leuven** | BE | 6 |
| **University of Munchen** | DE | 6 |
| **NMRC** | IE | 6 |
| **IFW Dresden** | DE | 5 |
| **University of Bremen** | DE | 5 |
| **University of Stuttgart** | DE | 5 |
| **ENS / Cachan** | FR | 5 |
| **Universite Louis Pasteur de Strasbourg / ISIS** | FR | 5 |
| **CNR / Bologna / Institute of Molecular Spectroscopy** | IT | 5 |
| **University of Liverpool** | UK | 5 |
| **University of Vienna** | AT | 4 |
| **IMM / Mainz** | DE | 4 |
| **MPI / Fritz Haber Institute / Berlin** | DE | 4 |
| **University of Wurzburg** | DE | 4 |
| **CSIC / Sevilla / Instituto de Ciencia de Materiales** | ES | 4 |
| **CNRS / Strasbourg** | FR | 4 |
| **CNRS / CEMES / Toulouse** | FR | 4 |
| **IEMN de Lille** | FR | 4 |
| **CNRS / Marseille** | FR | 4 |
| **KTH Stockholm** | SE | 4 |
| **University of Nottingham** | UK | 4 |

TABLE 11A: MOST CITED ENTITIES FOR THE FIELD 1

| Entity | Country | Number of European citations in reputation assessment |
|---|---|---|
| **EPFL Lausanne** | CH | 12 |
| **CNRS / LAAS Toulouse /Groupe Microstructures et Microsystemes Integres** | FR | 9 |
| **CNRS / Bordeaux / Laboratoire IXL** | FR | 8 |
| **University of Lund** | SE | 7 |
| **Institute of Nanotechnology / Forschungzentrum Karlsruhe** | DE | 6 |
| **DTU** | DK | 6 |
| **University of Cambridge** | UK | 6 |
| **University of Delft** | NL | 5 |
| **University of Twente** | NL | 5 |
| **University of Oxford** | UK | 5 |
| **University of Vienna** | AT | 4 |
| **IMEC** | BE | 4 |
| **ETH-Zurich** | CH | 3 |
| **IMM / Mainz** | DE | 3 |
| **University of Bremen** | DE | 3 |
| **University of Munchen** | DE | 3 |

TABLE 11B: MOST CITED ENTITIES FOR THE FIELD 2

| Entity | Country | Number of European citations in reputation assessment |
|---|---|---|
| **University of Delft** | NL | 5 |
| **University of Oxford** | UK | 5 |
| **EPFL Lausanne** | CH | 4 |
| **Institute of Nanotechnology / Forschungzentrum Karlsruhe** | DE | 4 |
| **University of Cambridge** | UK | 4 |
| **ETH-Zurich** | CH | 3 |
| **CNRS / LAAS Toulouse /Groupe Microstructures et Microsystemes Integres** | FR | 3 |
| **Paul Scherrer Institute** | CH | 2 |
| **University of Basel** | CH | 2 |
| **University of Kiel** | DE | 2 |
| **University of Munchen** | DE | 2 |
| **CNRS / Bordeaux / Laboratoire IXL** | FR | 2 |
| **CNRS / CEMES / Toulouse** | FR | 2 |
| **Philips Research Center / Eindhoven** | NL | 2 |
| **University of Twente** | NL | 2 |
| **Chalmers University of Technology** | SE | 2 |
| **University of Lund** | SE | 2 |
| **University of Leeds** | UK | 2 |

TABLE 11C: MOST CITED ENTITIES FOR THE FIELD 3

| Entity | Country | Number of European citations in reputation assessment |
|---|---|---|
| **University of Cambridge** | UK | 7 |
| **EPFL Lausanne** | CH | 6 |
| **CNRS / Bordeaux / Laboratoire IXL** | FR | 6 |
| **University of Delft** | NL | 6 |
| **University of Leuven** | BE | 5 |
| **CNRS / LAAS Toulouse /Groupe Microstructures et Microsystemes Integres** | FR | 5 |
| **CNR / Bologna / Institute of Molecular Spectroscopy** | IT | 5 |
| **University of Oxford** | UK | 5 |
| **IMEC** | BE | 4 |
| **ETH-Zurich** | CH | 4 |
| **MPI / Stuttgart** | DE | 4 |
| **University of Munchen University of Munchen** | DE | 4 |
| **University of Nottingham** | UK | 4 |
| **Institute of Nanotechnology / Forschungzentrum Karlsruhe** | DE | 3 |
| **University of Wurzburg** | DE | 3 |
| **DTU** | DK | 3 |
| **CNRS / Strasbourg** | FR | 3 |
| **NMRC** | IE | 3 |
| **University of Twente** | NL | 3 |
| **Chalmers University of Technology** | SE | 3 |
| **University of Lund** | SE | 3 |

TABLE 11D: MOST CITED ENTITIES FOR THE FIELD 4

| Entity | Country | Number of European citations in reputation assessment |
|---|---|---|
| **University of Cambridge** | UK | 16 |
| **EPFL Lausanne** | CH | 15 |
| **University of Delft** | NL | 15 |
| **MPI / Stuttgart** | DE | 11 |
| **CNRS / LAAS Toulouse /Groupe Microstructures et Microsystemes Integres** | FR | 11 |
| **CNRS / Bordeaux / Laboratoire IXL** | FR | 10 |
| **University of Oxford** | UK | 10 |
| **Institute of Nanotechnology / Forschungzentrum Karlsruhe** | DE | 8 |
| **DTU** | DK | 8 |
| **Eindhoven University of Technology** | NL | 8 |
| **University of Twente** | NL | 8 |
| **Chalmers University of Technology** | SE | 8 |
| **University of Ulm** | DE | 7 |
| **ETH-Zurich** | CH | 6 |
| **IMEC** | BE | 5 |
| **IFW Dresden** | DE | 5 |
| **MPI / Mainz** | DE | 5 |
| **University of Stuttgart** | DE | 5 |
| **University of Lund** | SE | 5 |
| **University of Liverpool** | UK | 5 |
| **University of Leuven** | BE | 4 |
| **MPI / Fritz Haber Institute / Berlin** | DE | 4 |
| **University of Hamburg** | DE | 4 |
| **University of Munchen** | DE | 4 |
| **CSIC / Sevilla / Instituto de Ciencia de Materiales** | ES | 4 |
| **CNRS / Strasbourg** | FR | 4 |
| **Universite Louis Pasteur de Strasbourg / ISIS** | FR | 4 |
| **CNRS / Marseille** | FR | 4 |
| **NMRC** | IE | 4 |
| **CNR / Bologna / Institute of Molecular Spectroscopy** | IT | 4 |
| **University of Linkoping** | SE | 4 |

## Questions arising from the analysis

Some Member States did not participate in the survey and it introduces a bias in the results. The important participation of others, like Spain for example, introduce a high citation of entities located close to the frontier, like CNRS of Toulouse and Bordeaux in the case of Spain. Moreover, the basis of 115 questionnaires is probably a little weak to rely on the results and while field 4 is well covered (541 cited entities), field 2 was only covered by 121 cited entities.

The only way to pursue this type of survey up to the department level would be to ask the citation of the names of the scientists. This would bring precision in the cited departments but the management of that information would be very heavy difficult and would require the interrogation of the Web in order to find the exact affiliation of the cited scientists for every cited entity.

Uncertainty in defining the four nanotechnology fields may have been a reason for the low response-rates to the questionnaires. Providing more detailed specifications of the areas relevant to the individual fields (including the respective keywords) could help national coordinators to find proper experts and the national experts to manage the reputation assessment

The fact to consider that the cited entities have the same specialisation as the citing experts is not a very rigorous assumption: in some cases the competence of the citing expert is complementary to the competence of the cited entities.

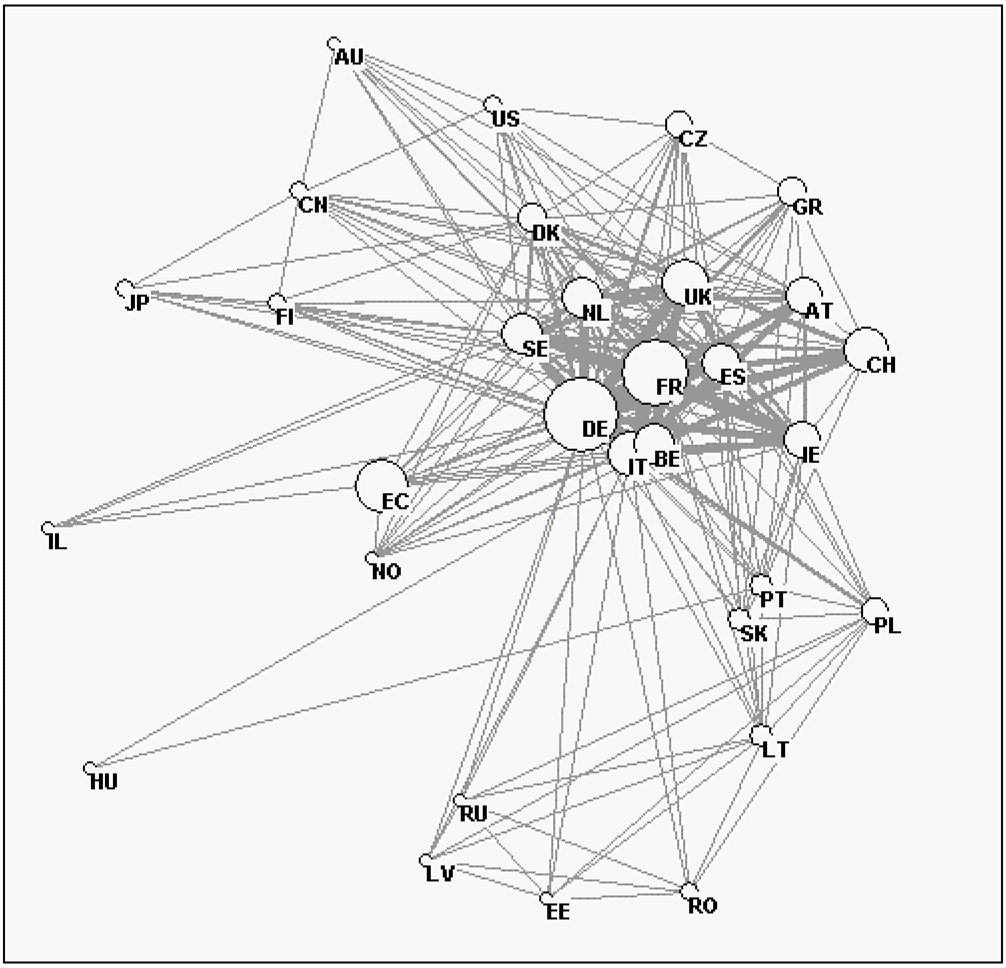
## PROJECT COLLABORATION

Table 12 gives an overview of the extent to which countries collaborate with other Member and Associated States. The listing covers all fields of nanotechnologies and is based on an analysis of the networks in nanotechnology database located on Cordis (www.cordis.lu/nanotechnology). Figure 3 illustrates which Member States collaborate in EU projects.

TABLE 12. EUROPEAN PROJECT COLLABORATION BY COUNTRY

| Projects | Country |
|---|---|
| 31 | DE |
| 25 | FR |
| 16 | EC |
| 13 | UK |
| 12 | CH |
| 11 | IT |
| 10 | NL |
| 10 | BE |
| 10 | SE |
| 9 | ES |
| 8 | AT |
| 8 | IE |
| 5 | GR |
| 5 | DK |
| 4 | CZ |
| 4 | PL |
| 3 | LT |
| 3 | PT |
| 3 | SK |
| 2 | CN |
| 2 | RO |
| 2 | JP |
| 2 | US |
| 2 | FI |
| 1 | SI |
| 1 | RU |
| 1 | HU |
| 1 | EE |
| 1 | AU |
| 1 | IL |
| 1 | NO |
| 1 | LV |
| 1 | LU |

FIGURE 3. MAP OF EUROPEAN PROJECT COOPERATIONS.



# RECOMMENDATIONS

## CONCLUSIONS FROM THIS PILOT STUDY

This study has to be seen primarily as an exploratory methodological exercise. Policy-makers should be careful in drawing strong conclusions from it in terms of distributing RTD resources or reorganising RTD programs. The central recommendation of this study is to embed informetric evaluations in emerging fields in a broader set of activities, including also more qualitative methods. A full-scale study should cover various perspectives. Both field and bibliometric experts stressed the need to find additional indicators of excellence and to go beyond informetric evaluations.

This study cannot give comprehensive and detailed recommendations as to what other indicators should be applied. Yet, some experts suggested a few points that could start a discussion about appropriate indicators in future studies. For instance, one recommendation was to trace the number of research-based spin-offs as a sign of excellence in the field. Commercial spin-offs cannot be measured appropriately through patents and publications.

Taking a multi-method approach is particularly important because there is no consensus amongst experts as to what exactly nanotechnology is. As a result, it is problematic to devise a bibliometric search strategy that would find the approval of most experts in the field. The prefix *'nano'* was used to define the general area in bibliometric terms and later refined the keyword strategy using expert judgements. This is a justifiable approach when starting to explore a new area in a pilot study. Experts remarked with respect to a full-scale study that the exclusive use of '*nano*' to select the original set of publications is unsatisfactory. This is so because the word '*nano*' itself does not appear in many of the publications experts considered as being related to nanotechnology while they found that '*nano*' did appear in many unrelated publications. Keywords have to be more specific in order not to produce too many records that are irrelevant.

Experts considered the original division into four fields of nanotechnology artificial. A considerable number of publications are related to more than one subfield. Therefore, a future study may follow an approach of 'self-organizing maps'.

Finally, the study also indicated that excellence defined as the capability to produce highly cited scientific publications is not exclusively a domain of large institutions or research groups. Also small units can produce high-impact papers – a point decision makers in RTD policy should be aware of.

## BIBLIOMETRIC STUDY

1) The field of Nanotechnology for Biotechnology requires special consideration in terms of redefinition of the field and keywords.

2) More experts are needed to come to a consensus on the area of nanotechnology, the fields within it and how best to approach mapping them.

3) Given the difficulties with unstandardised address data and some specific problems such as that posed by the CNRS in France and duplicate city names in the same country, collaboration with national representatives to standardise and interpret address and geographical data would improve the reliability of the study.

# PUBLICATIONS

## SUGGESTIONS FOR REFINEMENT OF CURRENT METHODOLOGY

Nanotechnologies are a challenging area to be studied with bibliometric methods. This is due to the emerging character of the area that brings about uncertainties in terms of definitions, which makes devising an adequate search strategy a challenge.

This study is only a starting point; it covers publications for one year only and is based on mostly unstandardised address data. Further, abstract and keyword data for many publications had not yet been entered into the SCI database at the time of the study, reducing the volume of citing side publications found through the keyword approach. Full-scale studies cannot afford to have these methodological limitations.

Given the recall and precision problematique, it seemed more reasonable to carry out institutional analyses of the papers cited in the nanopublications. In order to avoid bias favouring departments with high publication rates in the area, an approach that is based on highly cited papers was used in the excellence mapping, rather than departmental citation counts. This way excellence in nanotechnology-related research can also be traced in units that are small or publish little in the area yet make recognized contributions to the field.

The following are some recommendations for the full-scale study:

1) Given the low degree of agreement among experts in the area, the *'nano'* keyword search seemed to be the only reasonable approach to address the area in bibliometric terms. However a number of experts noticed that this technique skewed results in favour of some fields, such as polymers; other fields, such as nanobiotechnology seemed poorly covered.

   It was therefore suggested that more keywords indicative of nanotechnology be used in the initial search for papers. Such keywords might include:
   - single molecule
   - biomolecular
   - macromolecular
   - self assembly
   - NEMS

2) Use review articles in highly cited scientific journals such as Nature and Science for both refinement and validation of nanotechnology fields, and the improvement of the keywords. Monitoring the high impact journals could also help recognize new important discoveries and trends timely. One must bear in mind that the most cited publications in bibliometric analysis reflect frequently a state several years old due to time periods determined by writing an article, its publication, writing a citing article and its publication.

3) Analyse also relevant non-SCI journals. The SCI does not cover all the important nano-journals. For instance, one expert remarked that '*Nano*letters' should be added to the list of relevant journals.

4) Produce sets of results including and excluding self-citation.

5) Study the trend over a period of years, both the numbers of publications and cited publications.

6) The SCI does not cover all nano-papers. Inspec, for instance, contains several times as many '*nano*' publications as SCI. SCI mostly covers the English-language journals that have an international reach, while journals published in other languages are overlooked to a large extent. Therefore the choice of databases and the focus on SCI may be a point that is to be re-considered in terms of a full-scale study.

7) Clearly, the mapping process could be made more cost effective, flexible and streamlined if the whole of the used database (the Science Citation Index from ISI) were to be brought in-house. It should be noted, however, that the quality of SCI address data for Europe is not considered to be as good as for the US; further that the quality varies between countries, with generally less good quality outside the UK.

## ALTERNATIVE APPROACHES

1) An alternative approach to a full scale project is to rank and study highly cited nano papers. The advantages of such an approach are:

   - It will not discriminate small units
   - The citations will come from any part of the whole database as an overall indication of excellence and thus not biased by the citing side.
   - The cited time period will be held constant since ranks can be made year by year.
   - The fact that the most cited papers by the nano-papers in our study have *'nano'* in title is a strong support for such a strategy.
   - The highly cited papers can also be assigned to the four fields as defined by our keyword-approach.

   Examples of highly cited paper ranks by department are given in APPENDIX 6.

2) Start by identifying the characteristics of publications from some well-known excellent departments, and use this to develop a strategy.

3) Give a spectrum of measures:

   - Papers from highly cited general journals, with and without weighting by the Journal Impact Factor
   - Papers from more specialised journals, with and without weighting by the Journal Impact Factor
   - Papers from specifically nanotechnology journals, with and without weighting by the Journal Impact Factor

4) Treat publications in a similar way to patents in this study, mapping the number of papers by geographical location (NUTS 3 or city where this is not possible).

## PATENTS

1) With respect to patents, our recommendation is that it is necessary to get access to relevant data sources, in particular, both EPO and US patent data should be utilized.

2) Various types of citation analyses should be applied, e.g. patent-to-patent and patent-to-science formats.

3) Drawing on citations as measures of technological relevance and potential economic value, one could also produce rankings of highly cited patents for various technological fields and examine data on inventor country and municipality of residence as well as assignee. Further analysis should also pay attention to renewal fees and licensing information.

4) Receiving data from a patent database in text format and then reformatting into database format appears to be inefficient. A more direct access would seem more suitable.

5) Abstracts and keywords were missing from much of the patent data. Retrieval of this information from other Family members, though more expensive, would allow a fairer analysis of patents.

# APPENDIX 1: KEYWORDS AND THEIR WEIGHTS FOR FIELD ASSIGNMENTS OF NANO-PAPERS AND PATENTS

## KEY

### FIELDS

Field 1: Nanotechnology for  interacting, sensing, actuating and microsystems
Field 2: Nanotechnology for biotechnology
Field 3: Nanotechnology for information processing, storage and transmission
Field 4: Nanotechnology for materials and surface science

### SEARCH

1 normal instring search
2 word on its own
3 at the beginning of a word
4 beginning, end of a word, or word on its own
5 normal instring search for two versions of word

? refers to any character

Note: many words are truncated (e.g. machin) in order to cover variants

KEYWORDS AND KEYWORD WEIGHTS FOR FIELD ASSIGNMENTS OF NANO-PAPERS AND PATENTS

| Field | Keyword | Alternative Keyword | Weighting | Search Type |
|---|---|---|---|---|
| **1** | actuator | | 10 | 1 |
| **1** | chip | | 5 | 1 |
| **1** | contact | | 3 | 1 |
| **1** | fluidics | | 10 | 1 |
| **1** | gmr | | 5 | 1 |
| **1** | machin | | 7 | 1 |
| **1** | mechani | | 5 | 1 |
| **1** | metrology | | 5 | 1 |
| **1** | optical | | 4 | 1 |
| **1** | optics | | 4 | 1 |
| **1** | patterning | | 7 | 1 |
| **1** | receptor | | 5 | 1 |
| **1** | transducer | | 9 | 1 |
| **1** | sensor | | 10 | 1 |
| **1** | sensing | | 10 | 1 |
| **1** | motor | | 7 | 1 |
| **1** | NEMS | | 10 | 2 |
| **1** | tube | | 6 | 1 |
| **2** | antibod | | 9 | 1 |
| **2** | antigene | | 9 | 1 |
| **2** | bio | | 10 | 3 |
| **2** | capillarity | | 5 | 1 |

KEYWORDS AND KEYWORD WEIGHTS FOR FIELD ASSIGNMENTS OF NANO-PAPERS AND PATENTS

| Field | Keyword | Alternative Keyword | Weighting | Search Type |
|---|---|---|---|---|
| **2** | capsul | | 5 | 1 |
| **2** | cell | | 7 | 1 |
| **2** | colloid | | 5 | 1 |
| **2** | drug | | 8 | 1 |
| **2** | enzyme | | 8 | 1 |
| **2** | fiber | | 6 | 1 |
| **2** | filtration | | 3 | 1 |
| **2** | Langmuir?Blodgett | | 7 | 1 |
| **2** | liposome | | 9 | 1 |
| **2** | membrane | | 8 | 1 |
| **2** | molecular?manipulation | | 10 | 1 |
| **2** | multilayer | multi?layer | 8 | 5 |
| **2** | neurochip | | 9 | 1 |
| **2** | neuron | | 9 | 1 |
| **2** | nucleic | | 7 | 1 |
| **2** | nucleo | | 6 | 1 |
| **2** | peptide | | 7 | 1 |
| **2** | pharmaceutical | | 6 | 1 |
| **2** | positional?assembl | | 4 | 1 |
| **2** | protein | | 7 | 1 |
| **2** | scaffold | | 5 | 1 |
| **2** | selfassembl | self?assembl | 5 | 5 |
| **2** | spatial?positioning | | 9 | 1 |
| **2** | template | | 9 | 1 |
| **2** | texture | | 6 | 1 |
| **2** | therap | | 6 | 1 |
| **2** | tissue | | 5 | 1 |
| **2** | tubule | | 8 | 1 |
| **2** | virus | | 5 | 1 |
| **2** | chip | | 6 | 1 |
| **2** | patterning | | 5 | 1 |
| **2** | RNA | | 9 | 4 |
| **2** | DNA | | 9 | 4 |
| **2** | selforgan | self?organ | 5 | 5 |
| **2** | mimetic | | 8 | 1 |
| **2** | bilayer | | 9 | 1 |
| **2** | tether | | 9 | 1 |
| **2** | motor | | 9 | 1 |
| **2** | nanosphere | nano?sphere | 8 | 5 |
| **3** | architecture | | 5 | 1 |
| **3** | bandwidth | | 8 | 1 |
| **3** | bit | | 7 | 4 |
| **3** | byte | | 7 | 1 |

KEYWORDS AND KEYWORD WEIGHTS FOR FIELD ASSIGNMENTS OF NANO-PAPERS AND PATENTS

| Field | Keyword | Alternative Keyword | Weighting | Search Type |
|---|---|---|---|---|
| **3** | channel | | 6 | 1 |
| **3** | circuit | | 8 | 1 |
| **3** | computer | | 5 | 1 |
| **3** | Coulomb?blockade | | 9 | 1 |
| **3** | embedded | | 4 | 1 |
| **3** | emit | | 6 | 1 |
| **3** | etching | | 7 | 1 |
| **3** | information | | 7 | 1 |
| **3** | integrat | | 7 | 1 |
| **3** | interconnect | | 8 | 1 |
| **3** | junction | | 9 | 1 |
| **3** | layer | | 9 | 1 |
| **3** | logic | | 6 | 4 |
| **3** | magnet | | 8 | 1 |
| **3** | memor | | 8 | 1 |
| **3** | molecular?electronics | | 10 | 1 |
| **3** | MRAM | | 8 | 1 |
| **3** | network | | 8 | 1 |
| **3** | optoelectronic | opto?electronic | 8 | 5 |
| **3** | photonics | | 9 | 1 |
| **3** | processing | | 8 | 1 |
| **3** | processor | | 8 | 1 |
| **3** | quantum | | 6 | 1 |
| **3** | retriev | | 5 | 1 |
| **3** | routing | | 5 | 1 |
| **3** | semiconduct | semi?conduct | 7 | 5 |
| **3** | storage | | 8 | 1 |
| **3** | superconduct | | 8 | 1 |
| **3** | switching | | 7 | 1 |
| **3** | transistor | | 8 | 1 |
| **3** | transmi | | 6 | 1 |
| **3** | tube | | 8 | 1 |
| **3** | tunnel | | 3 | 1 |
| **3** | wire | | 8 | 1 |
| **3** | chip | | 8 | 1 |
| **3** | contact | | 8 | 1 |
| **3** | electronic | | 10 | 1 |
| **3** | gmr | | 10 | 1 |
| **3** | optical | | 6 | 1 |
| **3** | optics | | 6 | 1 |
| **3** | patterning | | 7 | 1 |
| **3** | selfassembl | self?assembl | 5 | 5 |
| **3** | selforgan | self?organ | 5 | 5 |

KEYWORDS AND KEYWORD WEIGHTS FOR FIELD ASSIGNMENTS OF NANO-PAPERS AND PATENTS

| Field | Keyword | Alternative Keyword | Weighting | Search Type |
|---|---|---|---|---|
| **3** | computing | | 9 | 1 |
| **3** | insulat | | 5 | 1 |
| **3** | dots | | 9 | 2 |
| **3** | quantum?well | | 9 | 1 |
| **3** | SET | | 10 | 2 |
| **4** | adlayer | ad?layer | 8 | 1 |
| **4** | adhesion | | 7 | 1 |
| **4** | Aggregate | | 7 | 1 |
| **4** | atomic?force?microscop | | 10 | 1 |
| **4** | carbon | | 8 | 1 |
| **4** | cataly | | 6 | 1 |
| **4** | ceramic | | 5 | 1 |
| **4** | characterisation | characterization | 5 | 5 |
| **4** | composit | | 8 | 1 |
| **4** | confocal | | 8 | 1 |
| **4** | crystal | | 4 | 1 |
| **4** | dipole | | 6 | 1 |
| **4** | droplet | | 6 | 1 |
| **4** | film | | 8 | 1 |
| **4** | hardness | | 7 | 1 |
| **4** | hybrid | | 6 | 1 |
| **4** | interfac | | 8 | 1 |
| **4** | laser?trapping | | 8 | 1 |
| **4** | magnet | | 5 | 1 |
| **4** | manipul | | 10 | 1 |
| **4** | near?field?microscopy | | 10 | 1 |
| **4** | organoclay | organo?clay | 7 | 1 |
| **4** | particle | | 8 | 1 |
| **4** | polymer | | 4 | 1 |
| **4** | porous | | 8 | 1 |
| **4** | powder | | 5 | 1 |
| **4** | scanning?probe?microscop | | 10 | 1 |
| **4** | silicate | | 3 | 1 |
| **4** | spacing | | 7 | 1 |
| **4** | substrate | | 10 | 1 |
| **4** | supramolecular | supra?molecular | 7 | 5 |
| **4** | surface | | 7 | 1 |
| **4** | toughness | | 6 | 1 |
| **4** | optical | | 7 | 1 |
| **4** | optics | | 7 | 1 |
| **4** | patterning | | 7 | 1 |
| **4** | selfassembl | self?assembl | 8 | 5 |
| **4** | selforgan | self?organ | 8 | 5 |

### KEYWORDS AND KEYWORD WEIGHTS FOR FIELD ASSIGNMENTS OF NANO-PAPERS AND PATENTS

| Field | Keyword | Alternative Keyword | Weighting | Search Type |
|---|---|---|---|---|
| **4** | template | | 6 | 1 |
| **4** | etching | | 6 | 1 |
| **4** | dots | | 7 | 2 |
| **4** | morphol | | 6 | 1 |
| **4** | roughness | | 7 | 1 |
| **4** | indentation | | 7 | 1 |
| **4** | nanocluster | nano?cluster | 7 | 5 |

### NANOWORDS THAT WERE EXCLUDED WHERE THEY APPEARED ON THEIR OWN

| |
|---|
| nano s |
| nano-second |
| nano2 |
| nano3 |
| nanoarcsecond |
| nanogram |
| nanograms |
| nanoliter |
| nanoliters |
| nanomolar |
| nanomolarlevels |
| nanomole |
| nanos |
| nanosatellite |
| nanosatellites |
| nanosatetlites |
| nanosats |
| nanosec |
| nanosecond |
| nanoseconds |
| subnanomolar |
| subnanosecond |

# APPENDIX 2: EXPERT EVALUATIONS: FULLERENES AND PATENTS

In order to test the recall structure of our keyword approach, a test in an area that is widely recognized as a field of nanotechnology was carried out. It is understood that fullerene is a form of carbon which is composed of 60 carbon atoms bonded together in a polyhedral structure of pentagons and hexagons.

It is possible e.g. to produce novel enclosure compounds by trapping metal irons within the C60 cage, some of which have semiconducting properties. Similarly, one can also produce forms of carbon in which the atoms are linked in a cylindrical, rather than spherical, framework with a diameter of a few nanometres. Therefore, it seems reasonable to think that research on fullerenes is relevant to nanoscience and technology.

The fullerene paper study was based on 480 papers from year 2000 that had fulleren* somewhere in title, abstarct or keywords. The experts were asked to judge the relevance of these papers. The results are as follows.

1. Recall: Among the papers judged as relevant for nano science and technology the recall ratio using *'nano'* as search term varies between 12.5 to 13.1 percent. This is a consistent pattern meaning that regardless of the expert used a maximum 15 percent of the relevant papers using *'nano'* as search term will be retrieved.

2. Precision: The percentage of papers considered as relevant varies considerably between the experts 10-62 percent for all fullerene papers and 8-53 percent for those containing *'nano'*. This means that one cannot expect experts to agree on which papers are relevant. When compare pairs of experts are compared in terms of identifying the same paper as relevant, Expert 1 and 2 agreed on 34 out of 40 maximum, Expert 1 and 3 on 65 out of 108 , and Expert 2 and 3 on 13 of 40.

TABLE 1: FULLERENE PAPERS

| **Overlaps** | | | |
|---|---|---|---|
| | **Exp 1** | **Exp 2** | **Exp 3** |
| **Exp 1** | *252* | 34 | 65 |
| **Exp 2** | 34 | *40* | 13 |
| **Exp 3** | 65 | 13 | *108* |

| **Precision and recall** | | | | | |
|---|---|---|---|---|---|
| | **Precision all %** | **Precision with *'nano'* %** | **Recall % with *'nano'*** | **Relevant** | **With nano** |
| **Exp 1** | 61.8 | 53.2 | 13.1 | 252 | 33 |
| **Exp 2** | 9.8 | 8.1 | 12.5 | 40 | 5 |
| **Exp 3** | 26.5 | 22.6 | 13.0 | 108 | 14 |
| | | | | | |
| **Total n of papers** | **408** | | | | |
| **Total with *'nano'*** | **62** | | | | |

TABLE 2: OVERVIEW OF PATENTS

| **Field** | **Number of records judged relevant by at least one expert *** | **Number of records judged relevant by at least two experts *** | **Number of records calculated to be relevant by weighted keywords, with weighted keyword weighting >= 15 +** | **Number of records judged relevant by at least one expert and calculated to be relevant** | **Number of records judged relevant by at least two experts and calculated to be relevant** |
|---|---|---|---|---|---|
| ***1*** | 237 | 65 | 139 | 60 | 24 |
| ***2*** | 431 | 59 | 58 | 37 | 7 |
| ***3*** | 244 | 76 | 70 | 29 | 9 |
| ***4*** | 755 | 105 | 520 | 325 | 46 |
| **Total records** | 1301 | 263 | 787 | 451 | 86 |
| | | | | | |
| **Total Patents:** | | 2108 | | | |

* some records duplicated in more than one field
+ no records duplicated in more than one Field

# Appendix 3: Number of Papers By Field

## Number of year 2000 nano-papers by department and field.

| Note: Keyword weightsum >=20 | |
|---|---|
| **Field** | **N of papers** |
| **Field 1** | |
| Weizmann Inst Sci, Dept Mat & Interfaces, Israel | 8 |
| Univ Sussex, Sch Chem Phys & Environm Sci, UK | 5 |
| Delft Univ Technol, Dept Appl Phys, Netherlands | 4 |
| Delft Univ Technol, Dimes, Netherlands | 4 |
| Hebrew Univ Jerusalem, Inst Chem, Israel | 4 |
| Univ Munich, Sekt Phys, Germany | 4 |
| Univ Munich, Ctr Nanosci, Germany | 4 |
| Univ London Imperial Coll Sci Technol & Med, Dept Chem, UK | 4 |
| **Field 2** | |
| Univ Paris 11, Fac Pharm, France | 10 |
| Univ Turin, Dipartimento Sci & Tecnol Farm, Italy | 7 |
| Cnrs, Inst Sci Vegetales, France | 4 |
| Max Planck Inst Colloids & Interfaces, , Germany | 3 |
| Free Univ Berlin, Dept Pharmaceut Biopharmaceut & Biotechnol, Germany | 3 |
| Univ Marburg, Dept Pharmaceut & Biopharm, Germany | 3 |
| Univ Frankfurt, Inst Pharmazeut Technol, Germany | 3 |
| **Field 3** | |
| Univ Munster, Inst Phys, Germany | 4 |
| Univ Sussex, Sch Chem Phys & Environm Sci, UK | 3 |
| Delft Univ Technol, Dimes, Netherlands | 3 |
| Univ Montpellier 2, Dynam Phases Condensees Grp, France | 3 |
| Univ Montpellier 2, Cnrs, France | 3 |
| Fac Univ Notre Dame Paix, Lab Phys Solide, Belgium | 3 |
| Ecole Polytech Fed Lausanne, Inst Phys Expt, Switzerland | 3 |
| **Field 4** | |
| Bar Ilan Univ, Dept Chem, Israel | 8 |
| Univ Oxford, Dept Mat, UK | 7 |
| Max Planck Inst Colloids & Interfaces, , Germany | 7 |
| Univ Paris 06, Ura Cnrs 1662, France | 7 |
| Univ Cambridge, Cavendish Lab, UK | 6 |
| Univ Liverpool, Dept Chem, UK | 6 |
| Max Planck Inst Festkorperforsch, , Germany | 6 |
| Univ Oxford, Inorgan Chem Lab, UK | 6 |
| Univ Grenoble 1, Cnrs, France | 6 |
| Univ London Imperial Coll Sci Technol & Med, Ctr Photomol Sci, UK | 6 |

# APPENDIX 4: PAPERS BY JOURNAL SUBJECT CATEGORY

TABLE X1. SUBJECT CATEGORY OF CITED JOURNALS BY FIELD

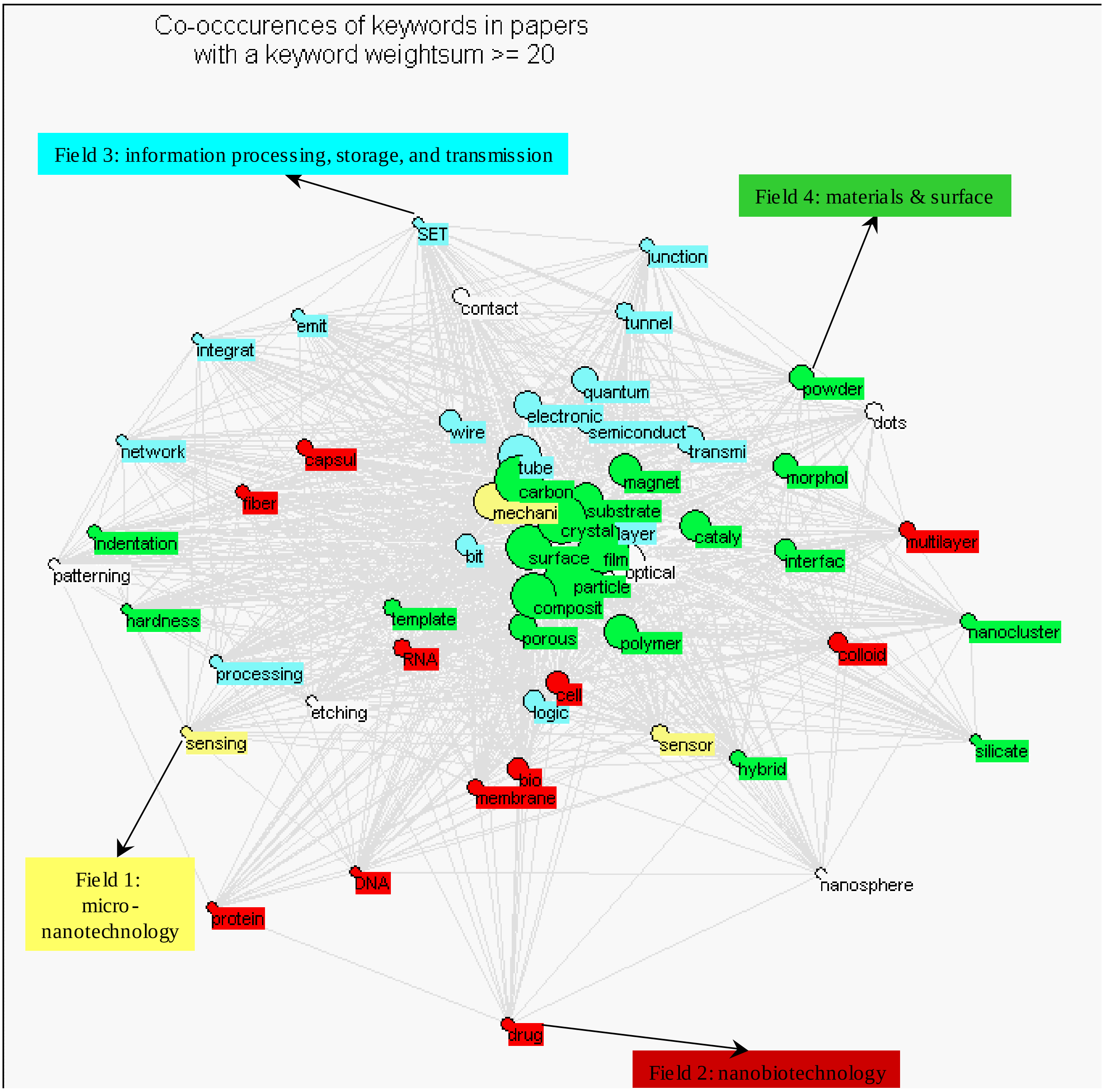
| Journal subject category | Citations |
|---|---|
| **Field 1** | |
| Applied physics/condensed matter/materials science | 516 |
| Physical chemistry/chemical physics | 268 |
| Applied physics/condensed matter/materials science; materials science & engineering | 250 |
| Multidisciplinary | 185 |
| Physics | 167 |
| Chemistry; chemistry & analysis | 77 |
| Instrumentation & measurement; spectroscopy/instrumentation/analytical sciences | 47 |
| Chemistry | 46 |
| Biochemistry & biophysics | 43 |
| Spectroscopy/instrumentation/analytical sciences | 43 |
| Chemistry & analysis; spectroscopy/instrumentation/analytical sciences | 41 |
| Materials science & engineering; multidisciplinary | 40 |
| Organic chemistry/polymer science | 23 |
| Applied physics/condensed matter/materials science; optics & acoustics | 21 |
| Electrical & electronics engineering | 21 |
| Materials science & engineering | 19 |
| Cell & developmental biology | 10 |
| Materials science & engineering; physical chemistry/chemical physics | 10 |
| Biotechnology & applied microbiology; microbiology | 9 |
| Inorganic & nuclear chemistry | 8 |
| Molecular biology & genetics | 8 |
| Multidisciplinary; spectroscopy/instrumentation/analytical sciences | 8 |
| Applied physics/condensed matter/materials science; metallurgy | 5 |
| Gastroenterology and hepatology; medical research, organs & systems | 5 |
| Instrumentation & measurement | 5 |
| Mechanical engineering | 5 |
| Metallurgy | 5 |
| **Field 2** | |
| Multidisciplinary | 237 |
| Pharmacology & toxicology | 176 |
| Biochemistry & biophysics | 134 |
| Physical chemistry/chemical physics | 123 |
| Applied physics/condensed matter/materials science; materials science & engineering | 96 |
| Cell & developmental biology | 71 |
| Chemistry & analysis; spectroscopy/instrumentation/analytical sciences | 70 |
| Chemistry; chemistry & analysis | 67 |
| Applied physics/condensed matter/materials science | 66 |

TABLE X1. SUBJECT CATEGORY OF CITED JOURNALS BY FIELD

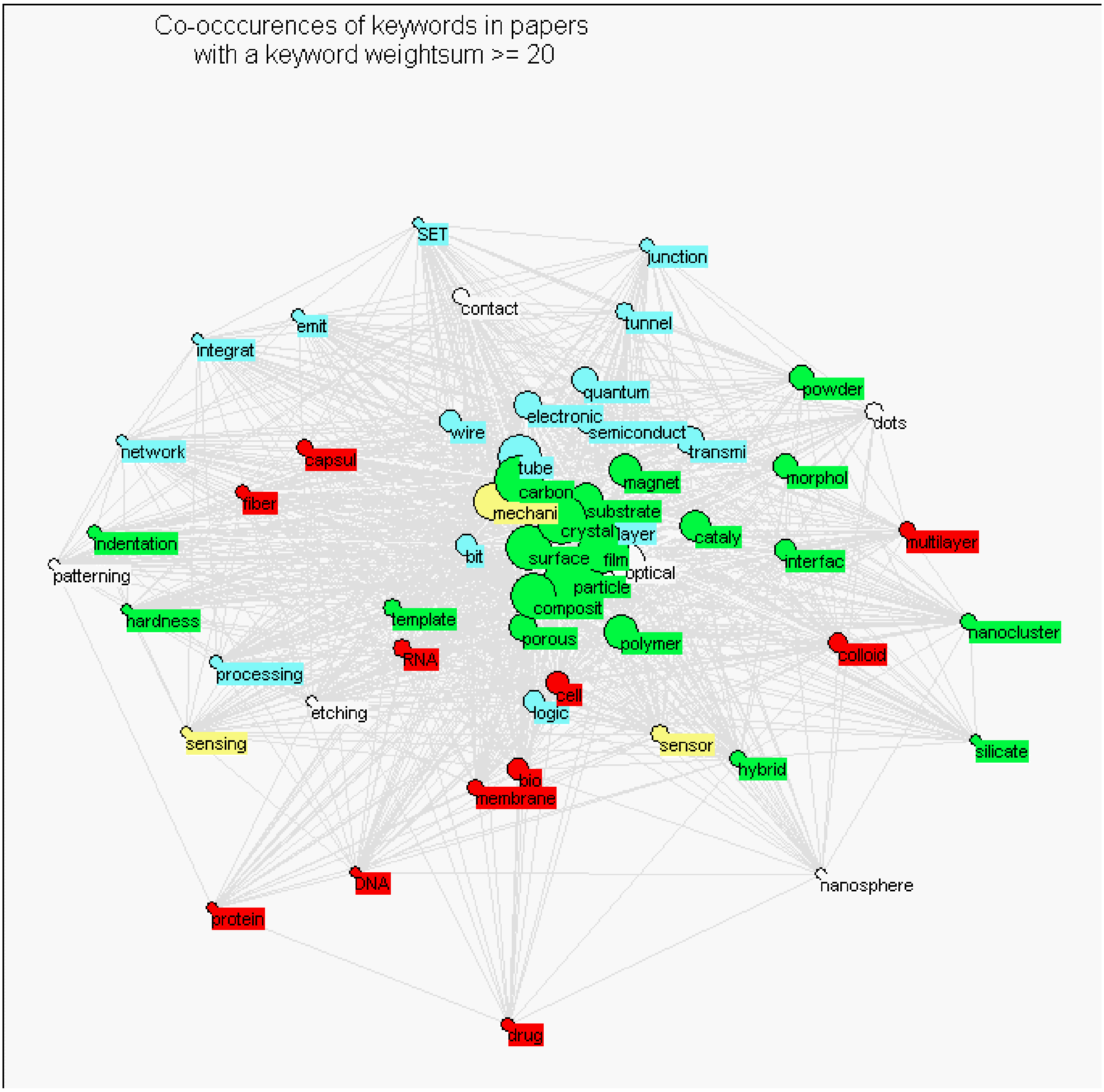
| Journal subject category | Citations |
|---|---|
| Organic chemistry/polymer science | 47 |
| Microbiology | 45 |
| Molecular biology & genetics | 45 |
| Chemistry | 38 |
| Biotechnology & applied microbiology; microbiology | 34 |
| Chemistry & analysis | 31 |
| Experimental biology | 21 |
| Spectroscopy/instrumentation/analytical sciences | 21 |
| Chemical engineering; chemistry | 17 |
| Medical research, diagnosis & treatment | 17 |
| Neurosciences & behavior | 17 |
| Oncogenesis & cancer research | 17 |
| Materials science & engineering; multidisciplinary | 16 |
| Physics | 16 |
| Dentistry/oral surgery & medicine | 14 |
| Chemical engineering | 11 |
| Animal & plant sciences; plant sciences | 10 |
| Biotechnology & applied microbiology | 9 |
| **Field 3** | |
| Applied physics/condensed matter/materials science | 1077 |
| Physics | 306 |
| Physical chemistry/chemical physics | 257 |
| Multidisciplinary | 227 |
| Applied physics/condensed matter/materials science; materials science & engineering | 185 |
| Electrical & electronics engineering | 60 |
| Chemistry; chemistry & analysis | 49 |
| Materials science & engineering; multidisciplinary | 42 |
| Chemistry & analysis; spectroscopy/instrumentation/analytical sciences | 32 |
| Spectroscopy/instrumentation/analytical sciences | 28 |
| Applied physics/condensed matter/materials science; optics & acoustics | 22 |
| Materials science & engineering; physical chemistry/chemical physics | 19 |
| Chemistry | 17 |
| Instrumentation & measurement; spectroscopy/instrumentation/analytical sciences | 17 |
| Organic chemistry/polymer science | 17 |
| Chemical engineering; physical chemistry/chemical physics | 13 |
| Materials science & engineering | 10 |
| Applied physics/condensed matter/materials science; electrical & electronics engineering | 7 |
| Chemistry & analysis | 6 |
| Inorganic & nuclear chemistry | 6 |
| Computer science & engineering; multidisciplinary | 5 |
| Multidisciplinary; spectroscopy/instrumentation/analytical sciences | 5 |
| Pharmacology & toxicology | 5 |

TABLE X1. SUBJECT CATEGORY OF CITED JOURNALS BY FIELD

| **Journal subject category** | **Citations** |
|---|---|
| Physiology | 5 |
| Biochemistry & biophysics | 4 |
| Environment/ecology | 4 |
| Instrumentation & measurement | 3 |
| **Field 4** | |
| Applied physics/condensed matter/materials science | 1898 |
| Physical chemistry/chemical physics | 1376 |
| Applied physics/condensed matter/materials science; materials science & engineering | 1260 |
| Physics | 427 |
| Multidisciplinary | 423 |
| Organic chemistry/polymer science | 319 |
| Chemistry; chemistry & analysis | 299 |
| Chemistry | 250 |
| Materials science & engineering; multidisciplinary | 158 |
| Chemical engineering; physical chemistry/chemical physics | 146 |
| Materials science & engineering | 146 |
| Materials science & engineering; physical chemistry/chemical physics | 121 |
| Instrumentation & measurement; spectroscopy/instrumentation/analytical sciences | 102 |
| Spectroscopy/instrumentation/analytical sciences | 102 |
| Pharmacology & toxicology | 91 |
| Applied physics/condensed matter/materials science; metallurgy | 75 |
| Biochemistry & biophysics | 75 |
| Chemistry & analysis; spectroscopy/instrumentation/analytical sciences | 74 |
| Inorganic & nuclear chemistry | 62 |
| Chemical engineering | 60 |
| Applied physics/condensed matter/materials science; optics & acoustics | 50 |
| Materials science & engineering; organic chemistry/polymer science | 49 |
| Electrical & electronics engineering | 46 |
| Chemical engineering; chemistry | 35 |
| Mechanical engineering | 25 |
| Environmental engineering & energy; physical chemistry/chemical physics | 23 |
| Cell & developmental biology | 21 |



Co-occcurences of keywords in papers with a keyword weightsum >= 20
Field 3: information processing, storage, and transmission
Field 4: materials & surface
Field 1: micro-nanotechnology
Field 2: nanobiotechnology
SET
junction
contact
tunnel
emit
integrat
powder
quantum
electronic
dots
wire
semiconduct
transmi
network
capsul
tube
magnet
morphol
carbon
fiber
mechani
substrate
crystal
layer
cataly
multilayer
indentation
bit
surface
film
interfac
patterning
optical
particle
composit
hardness
template
nanocluster
porous
polymer
RNA
colloid
processing
cell
etching
logic
sensing
sensor
silicate
hybrid
bio
membrane
DNA
nanosphere
protein
drug


Co-occcurences of keywords in papers
with a keyword weightsum >= 20
SET
junction
contact
tunnel
emit
integrat
powder
quantum
electronic
dots
wire
semiconduct
transmi
network
capsul
tube
magnet
morphol
carbon
fiber
mechani
substrate
crystal
layer
cataly
multilayer
indentation
bit
surface
film
interfac
patterning
optical
particle
composit
hardness
template
nanocluster
porous
polymer
RNA
colloid
processing
cell
etching
logic
sensing
sensor
silicate
hybrid
bio
membrane
DNA
nanosphere
protein
drug

# APPENDIX 5: MOST CITED DEPARTMENTS

**FIELD 1: CITED DEPARTMENTS WITH PAPERS HAVING >=10 CITATIONS FROM ALL NANO-PAPERS**

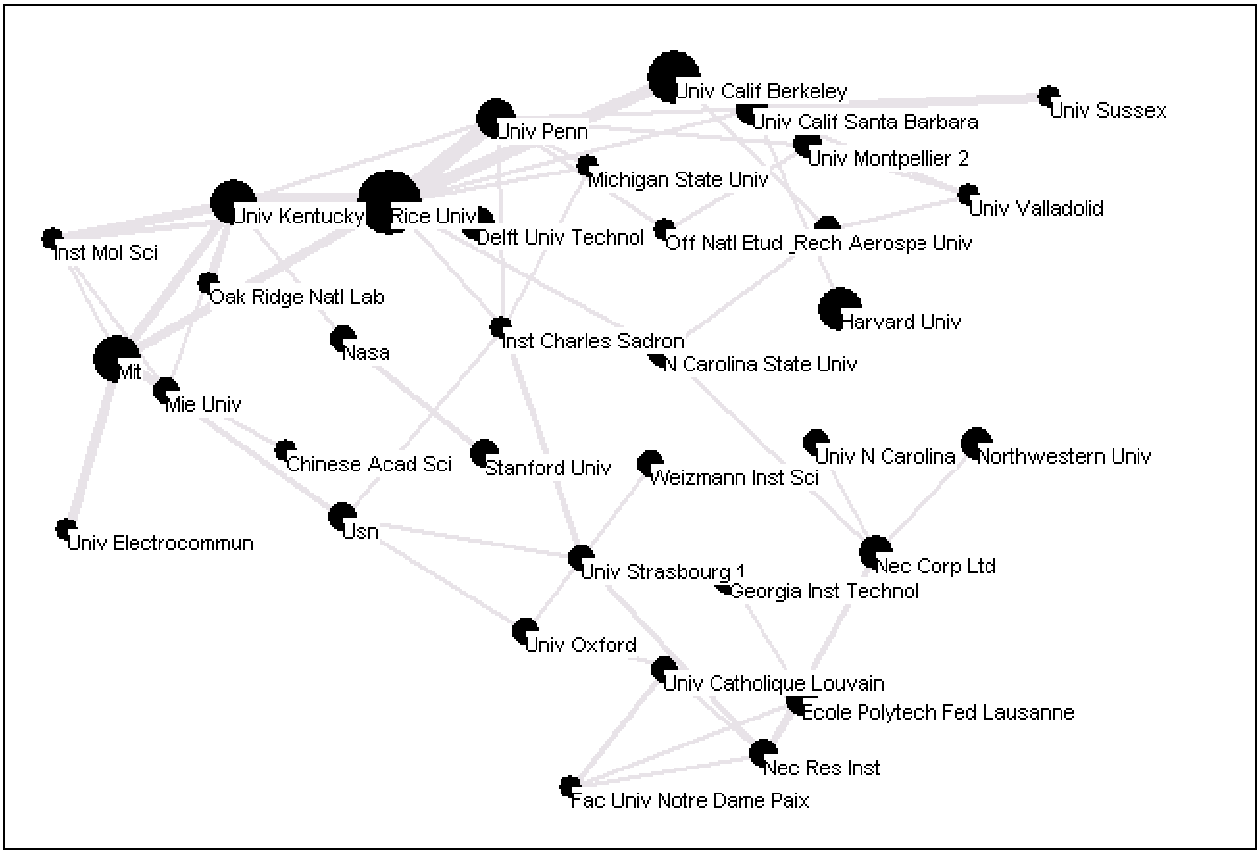
| Department | Sum Citations | Sum Cited Papers |
|---|---|---|
| Univ Delft Technol/Dept Appl Phys//Netherlands | 305 | 5 |
| Univ Delft Technol/Dimes//Netherlands | 251 | 5 |
| Inst Charles Sadron/Cnrs//France | 171 | 4 |
| Univ Montpellier 2/Dynam Phases Condensees Grp//France | 165 | 1 |
| Onera/Lps//France | 117 | 1 |
| Univ Nantes/Imn//France | 117 | 1 |
| Univ Valladolid/Dept Fis Teor//Spain | 58 | 3 |
| Univ Oxford/Dept Mat//Uk | 57 | 4 |
| Univ Sussex/Sch Chem Phys & Environm Sci//Uk | 44 | 2 |
| Weizmann Inst Sci/Dept Mat & Interfaces//Israel | 41 | 1 |
| Univ Paris 11/Phys Solides Lab//France | 40 | 4 |
| Ecole Polytech Fed Lausanne/Inst Genie Atom//Switzerland | 38 | 2 |
| Univ Basel/Inst Phys//Switzerland | 36 | 2 |
| Csic/Inst Ciencia Mat//Spain | 36 | 2 |
| Univ Delft Technol/Delft Inst Microelect & Submicron Technol//Netherlands | 36 | 3 |
| Univ Liverpool/Dept Chem//Uk | 33 | 1 |
| Dera///Uk | 31 | 1 |
| Univ Sheffield/Dept Elect & Elect Engn//Uk | 30 | 1 |
| Univ Delft Technol/Dept Appl Sci//Netherlands | 30 | 2 |
| Univ Fac Notre Dame Paix/Dept Phys//Belgium | 30 | 1 |
| Univ Strasbourg 1/Isis//France | 30 | 2 |
| Univ Sussex/Sch Chem & Mol Sci//Uk | 29 | 1 |
| Ecole Polytech Fed Lausanne/Dept Phys//Switzerland | 27 | 2 |
| Univ Catholique Louvain/Unite Physicochim & Phys Mat//Belgium | 25 | 2 |
| Cea/Dsm//France | 25 | 2 |
| Univ Paris 06/Lab Srsi//France | 23 | 2 |
| Cea/Rech Met Phys Sect//France | 22 | 1 |
| Ecole Polytech/Solides Irradies Lab//France | 22 | 1 |
| Inst Angew Photovoltaik///Germany | 20 | 1 |
| Univ Catholic Leuven/Vaste Stof Fys Magnetisme Lab//Belgium | 20 | 1 |
| Lab Aimee Cotton/Upr 3321//France | 20 | 1 |
| Onera/Phys Solides Lab//France | 20 | 1 |
| Univ Catholique Louvain/Unite Phys Chim & Phys Mat//Belgium | 20 | 1 |
| Cea/Rech Met Phys Sect//France | 20 | 1 |
| Ecole Polytech/Cnrs//France | 19 | 1 |
| Inst Charles Sadron/Cnrs//France | 19 | 1 |
| Onera/Cnrs//France | 19 | 1 |
| Onera/Phys Solide Lab//France | 19 | 1 |
| Micrion Europe Gmbh///Germany | 18 | 1 |

**FIELD 1: CITED DEPARTMENTS WITH PAPERS HAVING >=10 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum Citations | Sum Cited Papers |
|---|---|---|
| Coll France/Phys Mat Condensee Lab//France | 17 | 1 |
| Hahn Meitner Inst Berlin Gmbh/Abt Kleinteilchenforsch//Germany | 17 | 1 |
| Consejo Super Invest Cient/Inst Ciencia Mat Madrid//Spain | 16 | 1 |
| Max Planck Inst Festkorperforsch///Germany | 16 | 1 |
| Swiss Fed Inst Technol/Inst Phys Chem//Switzerland | 16 | 1 |
| Univ Pisa/Ctr E Piaggio//Italy | 16 | 1 |
| Univ Tubingen/Abt Angew Phys//Germany | 16 | 1 |
| Univ Munich/Lehrstuhl Photon & Optoelektr//Germany | 15 | 1 |
| Ifw Dresden///Germany | 14 | 1 |
| Univ Lorand Eotvos/Dept Biol Phys//Hungary | 14 | 1 |
| Univ Vienna/Inst Mat Phys//Austria | 14 | 1 |
| Univ Vienna Tech/Inst Theoret Phys//Austria | 14 | 1 |
| Csic/Inst Carboquim//Spain | 13 | 1 |
| Embl/Prot & Peptide Grp//Germany | 13 | 1 |
| Univ Barcelona/Serv Cientifico Tecn//Spain | 13 | 1 |
| Univ Montpellier 2/Gdpc//France | 13 | 1 |
| Univ Zaragoza/Csic//Spain | 13 | 1 |
| Ill///France | 12 | 1 |
| Niels Bohr Inst/Oersted Lab//Denmark | 12 | 1 |
| Phb Ecublens/Inst Romand Rech Numer Phys Mat//Switzerland | 12 | 1 |
| Univ Freiburg/Fak Phys//Germany | 12 | 1 |
| Univ London Imperial Coll Sci Technol & Med/Dept Math//Uk | 12 | 1 |
| Univ Lyon 1/Dept Phys Mat//France | 12 | 1 |
| Univ Politecn Madrid/Escuela Tecn Ingn Aeronaut//Spain | 12 | 1 |
| Coll France/Lab Chim Interact Mol//France | 11 | 1 |
| Hahn Meitner Inst Berlin Gmbh/Abt Kleinteilchen Forsch//Germany | 11 | 1 |
| Inst Elect & Microelect N/Dept Inst Super Elect N//France | 11 | 1 |
| Max Planck Inst Met Res/Inst Werkstoffwissensch//Germany | 11 | 1 |
| Univ Mainz/Inst Phys Chem//Germany | 11 | 1 |
| Univ Strasbourg 1///France | 11 | 1 |
| Univ Toulouse 3/Esa Cnrs 5070//France | 11 | 1 |
| Univ Vigo/Dept Quim Fis//Spain | 11 | 1 |
| Ctr Technol Educ Holon/Dept Mech & Control//Israel | 10 | 1 |
| Ecole Polytech Fed Lausanne/Inst Romand Rech Numer Phys Mat//Switzerland | 10 | 1 |
| Univ Fac Notre Dame Paix/Inst Studies Interface Sci//Belgium | 10 | 1 |
| Univ Tech Denmark/Ctr Atom Scale Mat Phys//Denmark | 10 | 1 |
| Univ Tech Denmark/Dept Phys//Denmark | 10 | 1 |
| Univ Liverpool/Dept Elect & Electr Engn//Uk | 10 | 1 |
| Univ Oxford/Dept Inorgan Chem//Uk | 10 | 1 |
| Univ Surrey/Dept Electr & Elect Engn//Uk | 10 | 1 |
| Weizmann Inst Sci/Chem Serv Unit//Israel | 10 | 1 |
| Weizmann Inst Sci/Dept Chem Serv//Israel | 10 | 1 |

**Field 1: Excellence and collaboration.**

Note: Based on co-authorships among organizations (not departments) in papers cited by papers in Field 1 and which have received at least 10 citations from all year 2000 *'nano'* papers. Circle area equal to number of cited papers. See also Table 3A.



**FIELD 2: CITED DEPARTMENTS WITH PAPERS HAVING >=5 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum citations | Sum cited papers |
|---|---|---|
| Inst Charles Sadron/Cnrs//France | 184 | 2 |
| Univ Delft Technol/Dept Appl Phys//Netherlands | 171 | 2 |
| Univ Montpellier 2/Dynam Phases Condensees Grp//France | 126 | 2 |
| Onera/Lps//France | 117 | 1 |
| Univ Nantes/Imn//France | 117 | 1 |
| Univ Delft Technol/Dimes//Netherlands | 88 | 1 |
| Max Planck Inst Colloids & Interfaces///Germany | 57 | 8 |
| Univ Delft Technol/Delft Inst Microelect & Submicron Technol//Netherlands | 31 | 1 |
| Univ Paris 06/Lab Srsi//France | 30 | 2 |
| Cea/Dsm//France | 28 | 2 |
| Ecole Polytech Fed Lausanne/Inst Genie Atom//Switzerland | 23 | 1 |
| Univ Basel/Inst Phys//Switzerland | 23 | 1 |
| Weizmann Inst Sci/Dept Mat & Interfaces//Israel | 20 | 2 |
| Univ Strasbourg 1/6 Rue Boussingault//France | 19 | 1 |
| Embl/Prot & Peptide Grp//Germany | 18 | 2 |
| Univ Essen Gesamthsch/Inst Anorgan Chem//Germany | 15 | 2 |
| Univ Munich/Lehrstuhl Photon & Optoelektr//Germany | 15 | 1 |
| Ecole Polytech Fed Lausanne/Inst Phys Expt//Switzerland | 12 | 2 |
| Technion Israel Inst Technol/Dept Chem//Israel | 11 | 1 |
| Technion Israel Inst Technol/Dept Phys//Israel | 11 | 1 |
| Technion Israel Inst Technol/Inst Solid State//Israel | 11 | 1 |
| Ctr Technol Educ Holon/Dept Mech & Control//Israel | 10 | 1 |
| Max Planck Inst Polymer Res///Germany | 10 | 2 |
| Univ Politecn Valencia/Csic//Spain | 10 | 1 |
| Weizmann Inst Sci/Chem Serv Unit//Israel | 10 | 1 |
| Weizmann Inst Sci/Dept Chem Serv//Israel | 10 | 1 |
| Ipcms/23 Rue Loess//France | 9 | 1 |
| Max Planck Inst///Germany | 9 | 1 |
| Thomson Csf/Cnrs//France | 9 | 1 |
| Univ Catholique Louvain/Dept Mat Sci & Procedes//Belgium | 9 | 1 |
| Univ Geneva/Sch Pharm//Switzerland | 9 | 1 |
| Univ Paris 11/Cnrs//France | 9 | 1 |
| Cea/Cea//France | 8 | 1 |
| Univ Marburg/Fachbereich Phys Chem//Germany | 8 | 1 |
| Univ Munster/Inst Phys//Germany | 7 | 1 |
| Cnrs/Crtbt//France | 6 | 1 |
| Cnrs/Lab Louis Neel//France | 6 | 1 |
| Cnrs/Lpn//France | 6 | 1 |
| Cnrs/Microstruct & Microelect Lab//France | 6 | 1 |
| Inst Phys & Chim Mat Strasbourg///France | 6 | 1 |
| Inst Phys & Chim Mat Strasbourg/23 Rue Loess//France | 6 | 1 |
| Univ Paris 06/Ura Cnrs 1662//France | 6 | 1 |

**FIELD 2: CITED DEPARTMENTS WITH PAPERS HAVING >=5 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum citations | Sum cited papers |
|---|---|---|
| Univ Paris 11/Inst Electr Fondamentale//France | 6 | 1 |
| Univ Tech Berlin/Dept Phys//Germany | 6 | 1 |
| Univ Tech Berlin/Inst Anorgan & Analyt Chem//Germany | 6 | 1 |
| Cnrs/Cemes//France | 5 | 1 |
| Ctr Etud Pharmaceut/Cnrs//France | 5 | 1 |
| Desy/Embl//Germany | 5 | 1 |
| Erwin Schrodinger Inst Nanostrukturforsch///Austria | 5 | 1 |
| Hahn Meitner Inst Berlin Gmbh///Germany | 5 | 1 |
| Trinity Coll Dublin/Dept Chem//Ireland | 5 | 1 |
| Univ Alcala De Henares/Dept Pharm & Pharmaceut Technol//Spain | 5 | 1 |
| Univ Bielefeld/Fak Chem//Germany | 5 | 1 |
| Univ Bielefeld/Lehrstuhl Anorgan Chem 1//Germany | 5 | 1 |
| Univ Bourgogne/Phys Lab//France | 5 | 1 |
| Univ Catholique Louvain/Unite Phys & Chim Hauts Polymeres//Belgium | 5 | 1 |
| Univ Heidelberg/Childrens Hosp//Germany | 5 | 1 |
| Univ Jena/Inst Pharm//Germany | 5 | 1 |
| Univ Karl Franzens Graz/Inst Expt Phys//Austria | 5 | 1 |
| Univ Karl Franzens Graz/Inst Phys Expt//Austria | 5 | 1 |
| Univ Rostock/Kim//Germany | 5 | 1 |
| Whatman Sa///Belgium | 5 | 1 |

**FIELD 3: CITED DEPARTMENTS WITH PAPERS HAVING >=10 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum Citations | Sum Cited Papers |
|---|---|---|
| Univ Delft Technol/Dept Appl Phys//Netherlands | 305 | 5 |
| Univ Delft Technol/Dimes//Netherlands | 251 | 5 |
| Inst Charles Sadron/Cnrs//France | 184 | 2 |
| Univ Montpellier 2/Dynam Phases Condensees Grp//France | 157 | 3 |
| Univ Nantes/Imn//France | 117 | 1 |
| Onera/Lps//France | 117 | 1 |
| Univ Valladolid/Dept Fis Teor//Spain | 58 | 3 |
| Univ Oxford/Dept Mat//Uk | 47 | 3 |
| Univ Sussex/Sch Chem Phys & Environm Sci//Uk | 41 | 1 |
| Weizmann Inst Sci/Dept Mat & Interfaces//Israel | 40 | 4 |
| Onera/Phys Solides Lab//France | 39 | 2 |
| Univ Paris 11/Phys Solides Lab//France | 38 | 2 |
| Univ Basel/Inst Phys//Switzerland | 36 | 2 |
| Ecole Polytech Fed Lausanne/Inst Genie Atom//Switzerland | 36 | 2 |
| Univ Catholique Louvain/Unite Phys Chim & Phys Mat//Belgium | 34 | 2 |
| Csic/Inst Ciencia Mat//Spain | 33 | 1 |
| Univ Liverpool/Dept Mat Sci & Engn//Uk | 32 | 2 |
| Univ Liverpool/Dept Chem//Uk | 31 | 2 |
| Univ Delft Technol/Delft Inst Microelect & Submicron Technol//Netherlands | 31 | 1 |
| Univ Sheffield/Dept Elect & Elect Engn//Uk | 30 | 1 |
| Dera///Uk | 30 | 1 |
| Univ Delft Technol/Dept Appl Sci//Netherlands | 29 | 1 |
| Hahn Meitner Inst Berlin Gmbh/Abt Kleinteilchenforsch//Germany | 28 | 2 |
| Univ Fac Notre Dame Paix/Dept Phys//Belgium | 27 | 2 |
| Univ Sussex/Sch Chem & Mol Sci//Uk | 25 | 2 |
| Univ Strasbourg 1/Isis//France | 25 | 2 |
| Univ Catholique Louvain/Unite Physicochim & Phys Mat//Belgium | 24 | 2 |
| Ecole Polytech Fed Lausanne/Dept Phys//Switzerland | 24 | 1 |
| Univ Paris 06/Lab Srsi//France | 22 | 1 |
| Cea/Dsm//France | 22 | 1 |
| Weizmann Inst Sci/Dept Chem Serv//Israel | 20 | 2 |
| Univ Catholic Leuven/Vaste Stof Fys Magnetisme Lab//Belgium | 20 | 1 |
| Univ Bath/Dept Chem//Uk | 20 | 2 |
| Lab Aimee Cotton/Upr 3321//France | 20 | 1 |
| Inst Angew Photovoltaik///Germany | 20 | 2 |
| Ecole Polytech/Solides Irradies Lab//France | 20 | 1 |
| Cea/Rech Met Phys Sect//France | 20 | 1 |
| Univ Strasbourg 1/6 Rue Boussingault//France | 19 | 1 |
| Onera/Cnrs//France | 19 | 1 |
| Ecole Polytech/Cnrs//France | 19 | 1 |
| Cea/Rech Met Phys Sect//France | 19 | 1 |
| Micrion Europe Gmbh///Germany | 18 | 1 |

**FIELD 3: CITED DEPARTMENTS WITH PAPERS HAVING >=10 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum Citations | Sum Cited Papers |
|---|---|---|
| Coll France/Phys Mat Condensee Lab//France | 17 | 1 |
| Univ Tubingen/Abt Angew Phys//Germany | 16 | 1 |
| Univ Pisa/Ctr E Piaggio//Italy | 16 | 1 |
| Swiss Fed Inst Technol/Inst Phys Chem//Switzerland | 16 | 1 |
| Max Planck Inst Festkorperforsch///Germany | 16 | 1 |
| Consejo Super Invest Cient/Inst Ciencia Mat Madrid//Spain | 16 | 1 |
| Univ Munich/Lehrstuhl Photon & Optoelektr//Germany | 15 | 1 |
| Univ Vienna/Inst Mat Phys//Austria | 14 | 1 |
| Univ Vienna Tech/Inst Theoret Phys//Austria | 14 | 1 |
| Univ Versailles/Cnrs//France | 14 | 1 |
| Univ Paris 06/Lcmc//France | 14 | 1 |
| Univ Lyon 1/Dept Phys Mat//France | 14 | 1 |
| Univ Lorand Eotvos/Dept Biol Phys//Hungary | 14 | 1 |
| Max Planck Inst Met Res///Germany | 14 | 1 |
| Inst Romand Rech Numer Phys Mat///Switzerland | 14 | 1 |
| Ifw Dresden///Germany | 14 | 1 |
| Cnr/Ist Chim Mat//Italy | 14 | 1 |
| Univ Zaragoza/Csic//Spain | 13 | 1 |
| Univ Montpellier 2/Gdpc//France | 13 | 1 |
| Univ Barcelona/Serv Cientifico Tecn//Spain | 13 | 1 |
| Ecole Polytech Fed Lausanne/Inst Chim Phys//Switzerland | 13 | 1 |
| Csic/Inst Carboquim//Spain | 13 | 1 |
| Univ Politecn Madrid/Escuela Tecn Ingn Aeronaut//Spain | 12 | 1 |
| Univ London Imperial Coll Sci Technol & Med/Dept Math//Uk | 12 | 1 |
| Univ Freiburg/Fak Phys//Germany | 12 | 1 |
| Niels Bohr Inst/Oersted Lab//Denmark | 12 | 1 |
| Ill///France | 12 | 1 |
| Ecole Polytech/Phys Mat Condensee Lab//France | 12 | 1 |
| Univ Vigo/Dept Quim Fis//Spain | 11 | 1 |
| Technion Israel Inst Technol/Inst Solid State//Israel | 11 | 1 |
| Technion Israel Inst Technol/Dept Phys//Israel | 11 | 1 |
| Technion Israel Inst Technol/Dept Chem//Israel | 11 | 1 |
| Swiss Fed Inst Technol/Inst Photon & Interfaces//Switzerland | 11 | 1 |
| Max Planck Inst Polymer Res///Germany | 11 | 1 |
| Inst Elect & Microelect N/Dept Inst Super Elect N//France | 11 | 1 |
| Iemn/Dept Inst Super Elect Nord//France | 11 | 1 |
| Hoechst Res & Technol Deutschland Gmbh & Co Kg///Germany | 11 | 1 |
| Coll France/Lab Chim Interact Mol//France | 11 | 1 |
| Univ Fac Notre Dame Paix/Inst Studies Interface Sci//Belgium | 10 | 1 |
| Ecole Polytech Fed Lausanne/Inst Romand Rech Numer Phys Mat//Switzerland | 10 | 1 |
| Ctr Technol Educ Holon/Dept Mech & Control//Israel | 10 | 1 |
| Cnrs/Phys Solides Bellevue Lab//France | 10 | 1 |

**FIELD 4: CITED DEPARTMENTS WITH PAPERS HAVING >=10 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum citations | Sum cited papers |
|---|---|---|
| Univ Delft Technol/Dept Appl Phys//Netherlands | 290 | 4 |
| Univ Delft Technol/Dimes//Netherlands | 236 | 4 |
| Inst Charles Sadron/Cnrs//France | 195 | 3 |
| Univ Montpellier 2/Dynam Phases Condensees Grp//France | 159 | 3 |
| Univ Nantes/Imn//France | 117 | 1 |
| Onera/Lps//France | 117 | 1 |
| Univ Catholique Louvain/Unite Physicochim & Phys Mat//Belgium | 60 | 4 |
| Univ Valladolid/Dept Fis Teor//Spain | 46 | 2 |
| Univ Oxford/Dept Mat//Uk | 44 | 3 |
| Ecole Polytech Fed Lausanne/Dept Phys//Switzerland | 44 | 2 |
| Univ Sussex/Sch Chem Phys & Environm Sci//Uk | 41 | 1 |
| Weizmann Inst Sci/Dept Mat & Interfaces//Israel | 40 | 4 |
| Onera/Phys Solides Lab//France | 39 | 2 |
| Univ Paris 11/Phys Solides Lab//France | 38 | 2 |
| Univ Basel/Inst Phys//Switzerland | 36 | 2 |
| Ecole Polytech Fed Lausanne/Inst Genie Atom//Switzerland | 36 | 2 |
| Ecole Polytech Fed Lausanne/Inst Chim Phys//Switzerland | 35 | 2 |
| Csic/Inst Ciencia Mat//Spain | 33 | 1 |
| Univ Liverpool/Dept Chem//Uk | 31 | 2 |
| Univ Delft Technol/Delft Inst Microelect & Submicron Technol//Netherlands | 31 | 1 |
| Univ Strasbourg 1/6 Rue Boussingault//France | 30 | 2 |
| Univ Sheffield/Dept Elect & Elect Engn//Uk | 30 | 1 |
| Ecole Polytech/Cnrs//France | 30 | 2 |
| Dera///Uk | 30 | 1 |
| Univ Delft Technol/Dept Appl Sci//Netherlands | 29 | 1 |
| Univ Fac Notre Dame Paix/Dept Phys//Belgium | 27 | 2 |
| Univ Lyon 1/Dept Phys Mat//France | 26 | 2 |
| Univ Sussex/Sch Chem & Mol Sci//Uk | 25 | 2 |
| Univ Fribourg/Dept Phys//Switzerland | 23 | 2 |
| Univ Paris 06/Lab Srsi//France | 22 | 1 |
| Univ London Imperial Coll Sci Technol & Med/Ctr Photomol Sci//Uk | 22 | 1 |
| Cea/Dsm//France | 22 | 1 |
| Univ Catholic Leuven/Vaste Stof Fys Magnetisme Lab//Belgium | 20 | 1 |
| Univ Bath/Dept Chem//Uk | 20 | 2 |
| Max Planck Inst Colloids & Interfaces///Germany | 20 | 2 |
| Lab Aimee Cotton/Upr 3321//France | 20 | 1 |
| Inst Angew Photovoltaik///Germany | 20 | 2 |
| Ecole Polytech/Solides Irradies Lab//France | 20 | 1 |
| Cea/Rech Met Phys Sect//France | 20 | 1 |
| Onera/Cnrs//France | 19 | 1 |
| Hahn Meitner Inst Berlin Gmbh///Germany | 19 | 1 |
| Fritz Haber Inst///Germany | 19 | 1 |

**FIELD 4: CITED DEPARTMENTS WITH PAPERS HAVING >=10 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum citations | Sum cited papers |
|---|---|---|
| Cea/Rech Met Phys Sect//France | 19 | 1 |
| Univ Liverpool/Dept Mat Sci & Engn//Uk | 18 | 1 |
| Micrion Europe Gmbh///Germany | 18 | 1 |
| Hahn Meitner Inst Berlin Gmbh/Abt Kleinteilchenforsch//Germany | 17 | 1 |
| Coll France/Phys Mat Condensee Lab//France | 17 | 1 |
| Univ Tubingen/Abt Angew Phys//Germany | 16 | 1 |
| Univ Pisa/Ctr E Piaggio//Italy | 16 | 1 |
| Swiss Fed Inst Technol/Inst Phys Chem//Switzerland | 16 | 1 |
| Max Planck Inst Festkorperforsch///Germany | 16 | 1 |
| Univ Munich/Lehrstuhl Photon & Optoelektr//Germany | 15 | 1 |
| Univ Vienna/Inst Mat Phys//Austria | 14 | 1 |
| Univ Vienna Tech/Inst Theoret Phys//Austria | 14 | 1 |
| Univ Versailles/Cnrs//France | 14 | 1 |
| Univ Strasbourg 1/Isis//France | 14 | 1 |
| Univ Paris 06/Lcmc//France | 14 | 1 |
| Univ Lorand Eotvos/Dept Biol Phys//Hungary | 14 | 1 |
| Max Planck Inst Met Res///Germany | 14 | 1 |
| Inst Romand Rech Numer Phys Mat///Switzerland | 14 | 1 |
| Cnr/Ist Chim Mat//Italy | 14 | 1 |
| Univ Liverpool/Dept Mat Sci & Engn//Uk | 13 | 1 |
| Embl/Prot & Peptide Grp//Germany | 13 | 1 |
| Univ Politecn Madrid/Escuela Tecn Ingn Aeronaut//Spain | 12 | 1 |
| Univ London Imperial Coll Sci Technol & Med/Dept Math//Uk | 12 | 1 |
| Univ Freiburg/Fak Phys//Germany | 12 | 1 |
| Phb Ecublens/Inst Romand Rech Numer Phys Mat//Switzerland | 12 | 1 |
| Niels Bohr Inst/Oersted Lab//Denmark | 12 | 1 |
| Ecole Polytech/Phys Mat Condensee Lab//France | 12 | 1 |
| Univ Vigo/Dept Quim Fis//Spain | 11 | 1 |
| Univ Toulouse 3/Esa Cnrs 5070//France | 11 | 1 |
| Univ Strasbourg 1///France | 11 | 1 |
| Univ Mainz/Inst Phys Chem//Germany | 11 | 1 |
| Technion Israel Inst Technol/Inst Solid State//Israel | 11 | 1 |
| Technion Israel Inst Technol/Dept Phys//Israel | 11 | 1 |
| Technion Israel Inst Technol/Dept Chem//Israel | 11 | 1 |
| Swiss Fed Inst Technol/Inst Photon & Interfaces//Switzerland | 11 | 1 |
| Onera/Om//France | 11 | 1 |
| Max Planck Inst Polymer Res///Germany | 11 | 1 |
| Max Planck Inst Met Res/Inst Werkstoffwissensch//Germany | 11 | 1 |
| Inst Elect & Microelect N/Dept Inst Super Elect N//France | 11 | 1 |
| Iemn/Dept Inst Super Elect Nord//France | 11 | 1 |
| Hoechst Res & Technol Deutschland Gmbh & Co Kg///Germany | 11 | 1 |
| Hahn Meitner Inst Berlin Gmbh/Abt Kleinteilchen Forsch//Germany | 11 | 1 |
| Cnrs/Microstruct & Microelect Lab//France | 11 | 1 |

**FIELD 4: CITED DEPARTMENTS WITH PAPERS HAVING >=10 CITATIONS FROM ALL NANO-PAPERS**

| Department | Sum citations | Sum cited papers |
|---|---|---|
| Cnrs/Lab Louis Neel//France | 11 | 1 |
| Cnrs/Crtbt//France | 11 | 1 |
| Weizmann Inst Sci/Dept Chem Serv//Israel | 10 | 1 |
| Weizmann Inst Sci/Chem Serv Unit//Israel | 10 | 1 |
| Univ Tech Denmark/Dept Phys//Denmark | 10 | 1 |
| Univ Tech Denmark/Ctr Atom Scale Mat Phys//Denmark | 10 | 1 |
| Univ Surrey/Dept Electr & Elect Engn//Uk | 10 | 1 |
| Univ Politecn Valencia/Csic//Spain | 10 | 1 |
| Univ Pavia/Dipartimento Fis A Volta//Italy | 10 | 1 |
| Univ Oxford/Dept Inorgan Chem//Uk | 10 | 1 |
| Univ Nice/Phys Mat Condensee Lab//France | 10 | 1 |
| Univ Munich/Sekt Phys//Germany | 10 | 1 |
| Univ London Imperial Coll Sci Technol & Med/Dept Chem//Uk | 10 | 1 |
| Univ London Imperial Coll Sci Technol & Med/Dept Biochem//Uk | 10 | 1 |
| Univ Liverpool/Dept Elect & Electr Engn//Uk | 10 | 1 |
| Politecn Milan/Dipartimento Fis//Italy | 10 | 1 |
| Inst Neue Mat///Germany | 10 | 1 |
| Ctr Technol Educ Holon/Dept Mech & Control//Israel | 10 | 1 |
| Cnrs/Phys Solides Bellevue Lab//France | 10 | 1 |

# APPENDIX 6: EXCELLENCE: MOST CITED PAPERS

| | Title | Journal | Cit | WoS cit | Year | Addresses |
|---|---|---|---|---|---|---|
| **Field 1** | Crystalline Ropes Of Metallic Carbon Nanotubes/ | Science | 38 | 823 | 1996 | Inst Charles Sadron//France;Michigan State Univ/Dept Phys & Astron/Us;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us;Univ Penn/Dept Mat Sci & Engn/Us;Univ Penn/Res Struct Matter Lab/Us; |
| **Field 1** | Large-Scale Production Of Single-Walled Carbon Nanotubes By The Electric-Arc Technique/ | Nature | 26 | 385 | 1997 | Off Natl Etud & Rech Aerosp/Lps/France;Univ Montpellier 2/Dynam Phases Condensees Grp/France;Univ Nantes/Imn/France;Univ Penn/Lrsm/Us; |
| **Field 1** | Room-Temperature Transistor Based On A Single Carbon Nanotube/ | Nature | 25 | 326 | 1998 | Delft Univ Technol/Dept Appl Phys/Netherlands; |
| **Field 1** | Electronic-Structure Of Atomically Resolved Carbon Nanotubes/ | Nature | 20 | 421 | 1998 | Delft Univ Technol/Dept Appl Phys/Netherlands;Delft Univ Technol/Dimes/Netherlands;Rice Univ/Rice Quantum Inst/Us; |
| **Field 1** | Individual Single-Wall Carbon Nanotubes As Quantum Wires/ | Nature | 19 | 515 | 1997 | Delft Univ Technol/Dept Appl Phys/Netherlands;Delft Univ Technol/Dimes/Netherlands;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us; |
| **Field 1** | Nanobeam Mechanics - Elasticity, Strength, And Toughness Of Nanorods And Nanotubes/ | Science | 18 | 217 | 1997 | Harvard Univ/Dept Chem/Us;Harvard Univ/Div Engn & Appl Sci/Us; |
| **Field 1** | Diameter-Selective Raman-Scattering From Vibrational-Modes In Carbon Nanotubes/ | Science | 18 | 306 | 1997 | Dupont Co Inc/Expt Stn/Us;Inst Mol Sci/Instrument Ctr/Japan;Mit/Dept Elect Engn & Comp Sci/Us;Mit/Dept Phys/Us;Mit/Francis Bitter Natl Magnet Lab/Us;Rice Univ/Dept Chem/Us;Univ Kentucky/Ctr Appl Energy Res/Us;Univ Kentucky/Ctr Computat Sci/Us;Univ Kentucky/Dept Phys & Astron/Us; |
| **Field 1** | Large-Scale Synthesis Of Aligned Carbon Nanotubes/ | Science | 17 | 279 | 1996 | Cent Univ Nationalities/Dept Phys/Peoples R China;Chinese Acad Sci/Inst Phys/Peoples R China; |
| **Field 1** | Single-Electron Transport In Ropes Of Carbon Nanotubes/ | Science | 16 | 283 | 1997 | Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us;Univ Calif Berkeley/Dept Phys/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 1** | Self-Oriented Regular Arrays Of Carbon Nanotubes And Their Field-Emission Properties/ | Science | 16 | 238 | 1999 | Stanford Univ/Dept Chem/Us; |
| **Field 1** | Atomic-Structure And Electronic-Properties Of Single-Walled Carbon Nanotubes/ | Nature | 14 | | 1998 | Harvard Univ/Dept Chem & Chem Biol/Us;Harvard Univ/Div Engn & Appl Sci/Us; |
| **Field 1** | Synthesis Of Large Arrays Of Well-Aligned Carbon Nanotubes On Glass/ | Science | 14 | | 1998 | Sandia Natl Labs//Us;Suny Buffalo/Ctr Adv Photon & Elect Mat/Us;Suny Buffalo/Instrumentat Ctr/Us;Suny Buffalo/Mat Synth Lab/Us; |

| | Title | Journal | Cit | WoS cit | Year | Addresses |
|---|---|---|---|---|---|---|
| **Field 1** | Large-Scale Purification Of Single-Wall Carbon Nanotubes - Process, Product, And Characterization/ | Appl Phys A | 13 | | 1998 | Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Univ Kentucky/Ctr Appl Energy Res/Us;Univ Kentucky/Dept Phys & Astron/Us;Univ Penn/Dept Mat Sci & Engn/Us;Univ Penn/Lab Res Struct Matter/Us; |
| **Field 1** | Exceptionally High Youngs Modulus Observed For Individual Carbon Nanotubes/ | Nature | 13 | | 1996 | Nec Res Inst Inc/4 Independence Way/Us;Univ Illinois/Dept Phys/Us; |
| **Field 1** | Structural Flexibility Of Carbon Nanotubes/ | J Chem Phys | 13 | | 1996 | N Carolina State Univ/Dept Phys/Us;Nec Corp Ltd/Fundamental Res Labs/Japan; |
| **Field 1** | Nanotubes As Nanoprobes In Scanning Probe Microscopy/ | Nature | 12 | | 1996 | Rice Univ/Ctr Nanoscale Sci & Technol/Us;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us; |
| **Field 1** | Electrostatic Deflections And Electromechanical Resonances Of Carbon Nanotubes/ | Science | 11 | | 1999 | Georgia Inst Technol/Sch Mat Sci & Engn/Us;Georgia Inst Technol/Sch Phys/Us;Lab Natl Luz Sincrotron//Brazil; |
| **Field 1** | Storage Of Hydrogen In Single-Walled Carbon Nanotubes/ | Nature | 11 | | 1997 | Ibm Corp/Almaden Res Ctr/Us;Natl Renewable Energy Lab//Us;Natl Renewable Energy Lab/1617 Cole Blvd/Us; |
| **Field 1** | Elastic And Shear Moduli Of Single-Walled Carbon Nanotube Ropes/ | Phys Rev L | 11 | | 1999 | Ecole Polytech Fed Lausanne/Dept Phys/Switzerland;Univ Oxford/Dept Mat/Uk; |
| **Field 1** | Nanomechanics Of Carbon Tubes - Instabilities Beyond Linear-Response/ | Phys Rev L | 10 | | 1996 | N Carolina State Univ/Dept Phys/Us; |
| **Field 1** | Solution Properties Of Single-Walled Carbon Nanotubes/ | Science | 10 | | 1998 | Univ Kentucky/Adv Carbon Mat Ctr/Us;Univ Kentucky/Dept Chem/Us;Univ Kentucky/Dept Phys/Us; |
| **Field 2** | Analytical Properties Of The Nanoelectrospray Ion-Source/ | Analyt Chem | 4 | 427 | 1996 | European Molec Biol Lab/Prot & Peptide Grp/Germany; |
| **Field 2** | A Dna-Based Method For Rationally Assembling Nanoparticles Into Macroscopic Materials/ | Nature | 4 | 321 | 1996 | Northwestern Univ/Dept Chem/Us; |
| **Field 2** | 10 Distinct Circular Ssdna Components, 4 Of Which Encode Putative Replication-Associated Proteins, Are Associated With The Faba Bean Necrotic Yellows Virus Genome/ | J Gen Virol | 3 | 15 | 1998 | Biol Bundesanstalt Land & Forstwirtschaft/Inst Biochem & Pflanzenvirol/Germany;Cnrs/Inst Sci Vegetales/France; |
| **Field 2** | The Oral Absorption Of Microparticulates And Nanoparticulates - Neither Exceptional Nor Unusual/ | Pharm Res | 3 | 60 | 1997 | Univ London/Sch Pharm/Uk; |
| **Field 2** | Influence Of Colloidal Subphase Ph On The Deposition Of Multilayer Langmuir-Blodgett-Films Of Gold Clusters/ | J Chem S F | 3 | 16 | 1997 | Natl Chem Lab/Mat Chem Div/India; |
| **Field 2** | Reversion Of Multidrug-Resistance With Polyalkylcyanoacrylate Nanoparticles - Towards | Br J Canc | 3 | 9 | 1997 | Ctr Etud Pharmaceut/Cnrs/France; |

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|---|---|---|---|---|---|---|
| | A Mechanism Of Action/ | | | | | |
| **Field 2** | Microsecond Time-Scale Discrimination Among Polycytidylic Acid, Polyadenylic-Acid, And Polyuridylic Acid As Homopolymers Or As Segments Within Single Rna Molecules/ | Biophys J | 3 | 28 | 1999 | Harvard Univ/Dept Mol & Cellular Biol/Us;Natl Inst Stand & Technol/Div Biotechnol/Us;Univ Calif Santa Cruz/Dept Chem/Us;Univ Calif Santa Cruz/Dept Chem & Biochem/Us; |
| **Field 2** | Semiconductor Nanocrystals As Fluorescent Biological Labels/ | Science | 3 | 149 | 1998 | Univ Calif Berkeley/Dept Chem/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 2** | Selective Colorimetric Detection Of Polynucleotides Based On The Distance-Dependent Optical-Properties Of Gold Nanoparticles/ | Science | 3 | 187 | 1997 | Northwestern Univ/Dept Chem/Us; |
| **Field 2** | Semiconductor Clusters, Nanocrystals, And Quantum Dots/ | Science | 3 | 641 | 1996 | Univ Calif Berkeley/Dept Chem/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 2** | A General Template-Based Method For The Preparation Of Nanomaterials/ | J Mat Chem | 3 | 62 | 1997 | Colorado State Univ/Dept Chem/Us; |
| **Field 2** | Application Of Central Composite Designs To The Preparation Of Polycaprolactone Nanoparticles By Solvent Displacement/ | J Pharm Sci | 3 | 19 | 1996 | Univ Alcala De Henares/Dept Farm & Tecnol Farmaceut/Spain; |
| **Field 2** | Biologically Erodable Microsphere As Potential Oral-Drug Delivery System/ | Nature | 3 | | 1997 | Brown Univ/Dept Mol Pharmacol Physiol & Biotechnol/Us; |
| **Field 2** | In-Vitro Characterization Of A Novel, Tissue-Targeted Ultrasonic Contrast System With Acoustic Microscopy/ | J Acoust So | 3 | | 1998 | Iowa State Univ Sci & Technol/Ames Lab/Us;Iowa State Univ Sci & Technol/Dept Phys & Astron/Us;Natl Inst Biol Stand & Controls/Div Hematol/Uk;Washington Univ/Barnes Jewish Hosp/Us;Washington Univ/Dept Phys/Us; |
| **Field 2** | Fuzzy Nanoassemblies - Toward Layered Polymeric Multicomposites/ | Science | 3 | | 1997 | Inst Charles Sadron/Cnrs/France;Univ Strasbourg 1/6 Rue Boussingault/France; |
| **Field 2** | Pressure/Temperature Phase-Diagrams And Superlattices Of Organically Functionalized Metal Nanocrystal Monolayers - The Influence Of Particle-Size, Size Distribution, And Surface Passivant/ | J Phys Ch B | 3 | | 1997 | Univ Calif Los Angeles/Dept Chem & Biochem/Us; |
| **Field 2** | Single-Molecule Biomechanics With Optical Methods/ | Science | 3 | | 1999 | Stanford Univ/Dept Biochem B400/Us;Univ London Kings Coll/Randall Inst/Uk; |
| **Field 2** | Pharmacokinetics Of Doxorubicin | Pharmac Res | 3 | | 1999 | Univ Turin/Dipartimento Anat Farmacol & Med Legale/Italy;Univ Turin/Dipartimento |

| | Title | Journal | Cit | WoS cit | Year | Addresses |
|---|---|---|---|---|---|---|
| | Incorporated In Solid Lipid Nanospheres %Sln</ | | | | | Fisiopatol Clin/Italy;Univ Turin/Dipartimento Sci & Tecnol Farm/Italy; |
| **Field 2** | Biodegradable Nanoparticles - From Sustained-Release Formulations To Improved Site-Specific Drug-Delivery/ | J Contr Rel | 3 | | 1996 | Univ Geneva/Sch Pharm/Switzerland; |
| **Field 2** | Nanotechnology For Biomaterials Engineering - Structural Characterization Of Amphiphilic Polymeric Nanoparticles By H-1-Nmr Spectroscopy/ | Biomaterial | 3 | | 1997 | Mit/Dept Chem Engn/Us; |
| **Field 2** | A Single Rep Protein Initiates Replication Of Multiple Genome Components Of Faba Bean Necrotic Yellows Virus, A Single-Stranded-Dna Virus Of Plants/ | J Virology | 3 | | 1999 | Biol Bundesanstalt Land & Forstwirtschaft/Inst Pflanzenvirol Mikrobiol & Biol Sicherheit/Germany;Cnrs/Inst Sci Vegetales/France; |
| **Field 2** | Time-Resolved Small-Angle X-Ray-Scattering Studies Of Nanocrystal Superlattice Self-Assembly/ | J Am Chem S | 3 | | 1998 | Univ Dublin Trinity Coll/Dept Chem/Ireland; |
| **Field 2** | Topographical Control Of Cells/ | Biomaterial | 3 | | 1997 | Univ Glasgow/Ctr Cell Engn/Uk; |
| **Field 2** | Chemical And Physical Aspects Of Natural Organic-Matter %Nom< Fouling Of Nanofiltration Membranes/ | J Membr Sci | 3 | | 1997 | Univ Calif Los Angeles/Sch Engn & Appl Sci/Us; |
| **Field 2** | Electrodynamics Of Noble-Metal Nanoparticles And Nanoparticle Clusters/ | J Clust Sci | 3 | | 1999 | Northwestern Univ/Dept Chem/Us; |
| **Field 2** | Characterization Of Individual Polynucleotide Molecules Using A Membrane Channel/ | P Nas Us | 3 | | 1996 | Harvard Univ/Dept Mol & Cellular Biol/Us;Nist/Div Biotechnol/Us;Univ Calif Santa Cruz/Dept Chem & Biochem/Us; |
| **Field 2** | A Novel Site-Targeted Ultrasonic Contrast Agent With Broad Biomedical Application/ | Circulation | 3 | | 1996 | Hemagen Pfc Inc//Us;Natl Inst Biol Stand & Controls/Div Hematol/Uk;Washington Univ/Dept Phys/Us;Washington Univ/Med Ctr/Us;Washington Univ/Sch Med/Us; |
| **Field 2** | Structure Of Staphylococcal Alpha-Hemolysin, A Heptameric Transmembrane Pore/ | Science | 3 | | 1996 | Univ Chicago/Dept Biochem & Mol Biol/Us;Worcester Fdn Biomed Res//Us; |
| **Field 2** | Diblock Copolymer Nanoparticles For Drug-Delivery/ | Cr R Ther | 3 | | 1998 | Univ Wisconsin/Sch Pharm/Us; |
| **Field 3** | Individual Single-Wall Carbon Nanotubes As Quantum Wires/ | Nature | 34 | 510 | 1997 | Delft Univ Technol/Dept Appl Phys/Netherlands;Delft Univ Technol/Dimes/Netherlands;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us; |
| **Field 3** | Electronic-Structure Of Atomically Resolved | Nature | 23 | 412 | 1998 | Delft Univ Technol/Dept Appl Phys/Netherlands;Delft Univ |

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|---|---|---|---|---|---|---|
| | Carbon Nanotubes/ | | | | | Technol/Dimes/Netherlands;Rice Univ/Rice Quantum Inst/Us; |
| **Field 3** | Single-Electron Transport In Ropes Of Carbon Nanotubes/ | Science | 23 | 280 | 1997 | Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us;Univ Calif Berkeley/Dept Phys/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 3** | Room-Temperature Transistor Based On A Single Carbon Nanotube/ | Nature | 22 | 355 | 1998 | Delft Univ Technol/Dept Appl Phys/Netherlands; |
| **Field 3** | Atomic-Structure And Electronic-Properties Of Single-Walled Carbon Nanotubes/ | Nature | 19 | 330 | 1998 | Harvard Univ/Dept Chem & Chem Biol/Us;Harvard Univ/Div Engn & Appl Sci/Us; |
| **Field 3** | Crystalline Ropes Of Metallic Carbon Nanotubes/ | Science | 18 | 823 | 1996 | Inst Charles Sadron//France;Michigan State Univ/Dept Phys & Astron/Us;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us;Univ Penn/Dept Mat Sci & Engn/Us;Univ Penn/Res Struct Matter Lab/Us; |
| **Field 3** | Pure Carbon Nanoscale Devices - Nanotube Heterojunctions/ | Phys Rev L | 17 | 209 | 1996 | Csic/Inst Ciencia Mat/Spain;Univ Calif Berkeley/Dept Phys/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 3** | Single-Wall And Multi-Wall Carbon Nanotube Field-Effect Transistors/ | Appl Phys L | 15 | 130 | 1998 | Ibm Corp/Div Res/Us; |
| **Field 3** | Carbon Nanotubes As Molecular Quantum Wires/ | Phys Today | 13 | 120 | 1999 | Delft Univ Technol/Delft Inst Microelect & Submicron Technol/Netherlands; |
| **Field 3** | Carbon Nanotube Intramolecular Junctions/ | Nature | 12 | 115 | 1999 | Bell Labs/Lucent Technol/Us;Delft Univ Technol/Dept Appl Sci/Netherlands;Delft Univ Technol/Dimes/Netherlands; |
| **Field 3** | Luttinger-Liquid Behavior In Carbon Nanotubes/ | Nature | 12 | | 1999 | Rice Univ/Dept Chem & Phys/Us;Rice Univ/Rice Quantum Inst/Us;Univ Calif Berkeley/Dept Phys/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us;Univ Calif Santa Barbara/Inst Theoret Phys/Us; |
| **Field 3** | Semiconductor Clusters, Nanocrystals, And Quantum Dots/ | Science | 10 | | 1996 | Univ Calif Berkeley/Dept Chem/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 3** | Aharonov-Bohm Oscillations In Carbon Nanotubes/ | Nature | 9 | | 1999 | Ecole Polytech Fed Lausanne/Inst Genie Atom/Switzerland;Univ Basel/Inst Phys/Switzerland; |
| **Field 3** | Quantum Transport In A Multiwalled Carbon Nanotube/ | Phys Rev L | 8 | | 1996 | Gm Corp/Res/Us;Katholieke Univ Leuven/Vaste Stof Fys Magnetisme Lab/Belgium;Univ Catholique Louvain/Unite Phys Chim & Phys Mat/Belgium; |
| **Field 3** | Multiprobe Transport Experiments On Individual Single-Wall Carbon Nanotubes/ | Phys Rev L | 8 | | 1998 | Delft Univ Technol/Dept Appl Phys/Netherlands;Delft Univ Technol/Dimes/Netherlands; |
| **Field 3** | Tunneling Conductance Of Connected Carbon Nanotubes/ | Phys Rev B | 8 | | 1996 | Mit/Dept Elect Engn & Comp Sci/Us;Mit/Dept Phys/Us;Mit/Francis Bitter Natl Magnet Lab/Us;Univ Electrocommun/Dept Electr Engn/Japan; |
| **Field 3** | Diameter-Selective Raman-Scattering From Vibrational-Modes In Carbon Nanotubes/ | Science | 8 | | 1997 | Dupont Co Inc/Expt Stn/Us;Inst Mol Sci/Instrument Ctr/Japan;Mit/Dept Elect Engn & Comp Sci/Us;Mit/Dept Phys/Us;Mit/Francis Bitter Natl Magnet Lab/Us;Rice Univ/Dept Chem/Us;Univ Kentucky/Ctr Appl Energy Res/Us;Univ Kentucky/Ctr Computat Sci/Us;Univ |

| | Title | Journal | Cit | WoS cit | Year | Addresses |
|---|---|---|---|---|---|---|
| | | | | | | Kentucky/Dept Phys & Astron/Us; |
| **Field 3** | A Single-Electron Transistor Made From A Cadmium Selenide Nanocrystal/ | Nature | 7 | | 1997 | Univ Calif Berkeley/Dept Phys/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 3** | Structural Flexibility Of Carbon Nanotubes/ | J Chem Phys | 7 | | 1996 | N Carolina State Univ/Dept Phys/Us;Nec Corp Ltd/Fundamental Res Labs/Japan; |
| **Field 3** | Brittle And Ductile Behavior In Carbon Nanotubes/ | Phys Rev L | 7 | | 1998 | N Carolina State Univ/Dept Phys/Us; |
| **Field 3** | Conductance Of Carbon Nanotubes With Disorder - A Numerical Study/ | Phys Rev B | 7 | | 1998 | Appl Res Lab//Us;Nasa/Ames Res Ctr/Us; |
| **Field 3** | Carbon Nanotube Quantum Resistors/ | Science | 7 | | 1998 | Georgia Inst Technol/Sch Mat Sci & Engn/Us;Georgia Inst Technol/Sch Phys/Us; |
| **Field 3** | Size, Shape, And Low-Energy Electronic-Structure Of Carbon Nanotubes/ | Phys Rev L | 7 | | 1997 | Univ Penn/Dept Phys/Us; |
| **Field 3** | Quantum Conductance Of Carbon Nanotubes With Defects/ | Phys Rev B | 7 | | 1996 | Consejo Super Invest Cient/Inst Ciencia Mat Madrid/Spain;Univ Calif Berkeley/Dept Phys/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 4** | Large-Scale Synthesis Of Aligned Carbon Nanotubes/ | Science | 35 | 272 | 1996 | Cent Univ Nationalities/Dept Phys/Peoples R China;Chinese Acad Sci/Inst Phys/Peoples R China; |
| **Field 4** | Semiconductor Clusters, Nanocrystals, And Quantum Dots/ | Science | 32 | 629 | 1996 | Univ Calif Berkeley/Dept Chem/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 4** | Crystalline Ropes Of Metallic Carbon Nanotubes/ | Science | 31 | 823 | 1996 | Inst Charles Sadron//France;Michigan State Univ/Dept Phys & Astron/Us;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us;Univ Penn/Dept Mat Sci & Engn/Us;Univ Penn/Res Struct Matter Lab/Us; |
| **Field 4** | Self-Oriented Regular Arrays Of Carbon Nanotubes And Their Field-Emission Properties/ | Science | 28 | 238 | 1999 | Stanford Univ/Dept Chem/Us; |
| **Field 4** | Synthesis Of Large Arrays Of Well-Aligned Carbon Nanotubes On Glass/ | Science | 27 | 213 | 1998 | Sandia Natl Labs//Us;Suny Buffalo/Ctr Adv Photon & Elect Mat/Us;Suny Buffalo/Instrumentat Ctr/Us;Suny Buffalo/Mat Synth Lab/Us; |
| **Field 4** | Large-Scale Production Of Single-Walled Carbon Nanotubes By The Electric-Arc Technique/ | Nature | 26 | 390 | 1997 | Off Natl Etud & Rech Aerosp/Lps/France;Univ Montpellier 2/Dynam Phases Condensees Grp/France;Univ Nantes/Imn/France;Univ Penn/Lrsm/Us; |
| **Field 4** | Controlled Production Of Aligned-Nanotube Bundles/ | Nature | 21 | 152 | 1997 | Unam/Inst Fis/Mexico;Univ Calif Santa Barbara/Mat Res Lab/Us;Univ Sussex/Sch Chem Phys & Environm Sci/Uk; |
| **Field 4** | Room-Temperature Transistor Based On A Single Carbon Nanotube/ | Nature | 18 | 335 | 1998 | Delft Univ Technol/Dept Appl Phys/Netherlands; |
| **Field 4** | Polymer Layered Silicate Nanocomposites/ | Advan Mater | 18 | 212 | 1996 | Cornell Univ/Dept Mat Sci & Engn/Us; |
| **Field 4** | Self-Assembly Of A 2-Dimensional Superlattice Of Molecularly Linked Metal-Clusters/ | Science | 14 | 299 | 1996 | Purdue Univ/Dept Chem/Us;Purdue Univ/Sch Chem Engn/Us;Purdue Univ/Sch Elect & Comp Engn/Us; |

| | Title | Journal | Cit | WoS cit | Year | Addresses |
|---|---|---|---|---|---|---|
| **Field 4** | Nanocrystal Gold Molecules/ | Advan Mater | 13 | | 1996 | Georgia Inst Technol/Ctr Comp Mat Sci/Us;Georgia Inst Technol/Microelectr Res Ctr/Us;Georgia Inst Technol/Sch Chem/Us;Georgia Inst Technol/Sch Mat Sci & Engn/Us;Georgia Inst Technol/Sch Phys/Us;Suny Stony Brook/Dept Phys/Us; |
| **Field 4** | Electronic-Structure Of Atomically Resolved Carbon Nanotubes/ | Nature | 13 | | 1998 | Delft Univ Technol/Dept Appl Phys/Netherlands;Delft Univ Technol/Dimes/Netherlands;Rice Univ/Rice Quantum Inst/Us; |
| **Field 4** | Selective Colorimetric Detection Of Polynucleotides Based On The Distance-Dependent Optical-Properties Of Gold Nanoparticles/ | Science | 13 | | 1997 | Northwestern Univ/Dept Chem/Us; |
| **Field 4** | Semiconductor Nanocrystals As Fluorescent Biological Labels/ | Science | 13 | | 1998 | Univ Calif Berkeley/Dept Chem/Us;Univ Calif Berkeley/Lawrence Berkeley Lab/Us; |
| **Field 4** | Nanobeam Mechanics - Elasticity, Strength, And Toughness Of Nanorods And Nanotubes/ | Science | 13 | | 1997 | Harvard Univ/Dept Chem/Us;Harvard Univ/Div Engn & Appl Sci/Us; |
| **Field 4** | Alkanethiolate Gold Cluster Molecules With Core Diameters From 1.5 To 5.2 Nm - Core And Monolayer Properties As A Function Of Core Size/ | Langmuir | 11 | | 1998 | Iowa State Univ/Dept Chem/Us;Oak Ridge Inst Sci & Educ//Us;Oak Ridge Natl Lab//Us;Univ N Carolina/Kenan Labs Chem/Us; |
| **Field 4** | Surface-Plasmon Spectroscopy Of Nanosized Metal Particles/ | Langmuir | 11 | | 1996 | Univ Melbourne/Sch Chem/Australia; |
| **Field 4** | Kinetic Control Of Interparticle Spacing In Au Colloid-Based Surfaces - Rational Nanometer-Scale Architecture/ | J Am Chem S | 11 | | 1996 | Penn State Univ/Dept Chem/Us; |
| **Field 4** | A Dna-Based Method For Rationally Assembling Nanoparticles Into Macroscopic Materials/ | Nature | 11 | | 1996 | Northwestern Univ/Dept Chem/Us; |
| **Field 4** | Individual Single-Wall Carbon Nanotubes As Quantum Wires/ | Nature | 11 | | 1997 | Delft Univ Technol/Dept Appl Phys/Netherlands;Delft Univ Technol/Dimes/Netherlands;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us;Rice Univ/Rice Quantum Inst/Us; |
| **Field 4** | The Structural And Luminescence Properties Of Porous Silicon/ | J Appl Phys | 11 | | 1997 | Def Res Agcy//Uk;Univ Sheffield/Dept Elect & Elect Engn/Uk; |
| **Field 4** | Subpicosecond Interfacial Charge Separation In Dye-Sensitized Nanocrystalline Titanium-Dioxide Films/ | J Phys Chem | 10 | | 1996 | Ecole Polytech Fed Lausanne/Inst Chim Phys/Switzerland;Univ London Imperial Coll Sci Technol & Med/Ctr Photomol Sci/Uk; |
| **Field 4** | Quantum-Dot Bioconjugates For Ultrasensitive | Science | 10 | | 1998 | Indiana Univ/Dept Chem/Us; |

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| | Nonisotopic Detection/ | | | | | |
| **Field 4** | Pressure/Temperature Phase-Diagrams And Superlattices Of Organically Functionalized Metal Nanocrystal Monolayers - The Influence Of Particle-Size, Size Distribution, And Surface Passivant/ | J Phys Ch B | 10 | | 1997 | Univ Calif Los Angeles/Dept Chem & Biochem/Us; |
| **Field 4** | Isolation Of Smaller Nanocrystal Au Molecules - Robust Quantum Effects In Optical-Spectra/ | J Phys Ch B | 10 | | 1997 | Georgia Inst Technol/Sch Chem/Us;Georgia Inst Technol/Sch Phys/Us;Inin//Mexico;Unam/Inst Phys/Mexico; |
| **Field 4** | Nanotubes As Nanoprobes In Scanning Probe Microscopy/ | Nature | 10 | | 1996 | Rice Univ/Ctr Nanoscale Sci & Technol/Us;Rice Univ/Dept Chem/Us;Rice Univ/Dept Phys/Us; |
| **Field 4** | Synthesis Of Individual Single-Walled Carbon Nanotubes On Patterned Silicon-Wafers/ | Nature | 10 | | 1998 | Stanford Univ/Dept Chem/Us;Stanford Univ/Dept Elect Engn/Us; |
| **Field 4** | Nanocomposite Materials For Optical Applications/ | Chem Mater | 10 | | 1997 | Cornell Univ/Dept Mat Sci & Engn/Us; |
| **Field 4** | Reversible Tuning Of Silver Quantum-Dot Monolayers Through The Metal-Insulator-Transition/ | Science | 10 | | 1997 | Univ Calif Berkeley/Dept Chem/Us;Univ Calif Los Angeles/Dept Chem & Biochem/Us; |
| **Field 4** | Nanosized Particles Made In Colloidal Assemblies/ | Langmuir | 10 | | 1997 | Cea/Dsm/France;Univ Paris 06/Lab Srsi/France; |
| **Field 4** | Fuzzy Nanoassemblies - Toward Layered Polymeric Multicomposites/ | Science | 10 | | 1997 | Inst Charles Sadron/Cnrs/France;Univ Strasbourg 1/6 Rue Boussingault/France; |

# APPENDIX 7: HIGHLY CITED NANO-PAPERS

TABLE 1. HIGHLY CITED EU '*NANO*' PAPERS 1991-1992 FROM WEB OF SCIENCE

Note: Search commands: Title='*nano*'; Address=sweden or finland or denmark or germany or netherlands or belgium or france or spain or portugal or italy or austria or ireland or scotland or wales or "north ireland" or england or luxemburg or greece

| Citations | Doc nr | Address |
|---|---|---|
| 533 | 11 | Philips Res Labs, 5600 Ja Eindhoven, Netherlands |
| 181 | 21 | Vacuumschmelze Gmbh, Dept Res & Dev, Gruner Weg 37, W-6450 Hanau, Germany |
| 120 | 35 | Dipartimento Chim Inorgan Chim Fis & Chim Mat, Via P Giuria 7, I-10125 Turin, Italy |
| 120 | 35 | Enichem, Anic, Ctr Ric Bollate, I-20021 Bollate, Italy |
| 120 | 18 | Tech Univ Munich, Lehrstuhl Biophys E22, W-8046 Garching, Germany |
| 120 | 35 | Uib, Dept Quim, E-07071 Palma De Mallorca, Spain |
| 111 | 16 | Max Planck Inst Entwicklungsbiol, Tubingen, Germany |
| 108 | 19 | Fraunhofer Inst Silicatforsch, W-8700 Wurzburg, Germany |
| 108 | 19 | Univ Wurzburg, Inst Anorgan Chem, Hubland, W-8700 Wurzburg, Germany |
| 103 | 33 | Vacuumschmelze Gmbh, Gruner Weg 37, W-6450 Hanau 1, Germany |
| 102 | 22 | Univ Dortmund, Dept Chem Engn, W-4600 Dortmund, Germany |
| 98 | 39 | Univ Saarland, Fachbereich 15, Gebaude 43, W-6600 Saarbrucken, Germany |
| 98 | 39 | Univ Saarland, Inst Neue Mat, W-6600 Saarbrucken, Germany |
| 91 | 44 | Univ Twente, Fac Chem Technol, Inorgan Chem Mat Sci & Catalysis Lab, 7500 Ae Enschede, Netherlands |
| 77 | 50 | Univ Orleans, Ufr Sci, Cnrs, Ura 831, Rech Energet Milieux Ionises Grp, Bp 6759, F-45067 Orleans 02, France |
| 74 | 46 | Museum Natl Hist Nat, Biophys Lab, Cnrs, Ura 481, Inserm, U201, 43 Rue Cuvier, F-75231 Paris 05, France |
| 74 | 46 | Univ Paris Sud, Cnrs, Ura 1218, Physico Chim Surfaces & Innovat Pharmacotech Lab, F-92296 Chatenay Malabry, France |
| 71 | 49 | Cent Inst Solid State Phys & Mat Res, Helmholtzstr 20, O-8027 Dresden, Germany |
| 70 | 30 | Janssen Pharmaceut, Res Fdn, Dept Cellular Biol & Pathol, B- 2340 Beerse, Belgium |
| 70 | 30 | Janssen Pharmaceut, Res Fdn, Dept Life Sci, B-2340 Beerse, Belgium |
| 70 | 30 | Janssen Pharmaceut, Res Fdn, Dept Physiol, B-2340 Beerse, Belgium |
| 70 | 45 | Laser Lab Gottingen, Hassel 21, W-3400 Gottingen, Germany |
| 69 | 15 | Univ Munich, Sekt Phys, W-8000 Munich 2, Germany |
| 68 | 32 | Cea Saclay, Serv Phys Etat Condense, F-91191 Gif Sur Yvette, France |
| 68 | 28 | Univ Constance, Inst Limnol, Pob 5560, W-7750 Constance, Germany |
| 68 | 14 | Univ Frankfurt, Inst Pharmazeut Technol, Georg Voigt Str 16, Postfach 111932, W-6000 Frankfurt, Germany |
| 64 | 43 | Ecole Natl Super Chim, Cnrs, Ua 1381, Chim Bioorgan & Organ Phys Lab, 11 Rue Pierre & Marie Curie, F-75231 Paris 05, France |
| 64 | 43 | Ecole Norm Super, Cnrs, Ua 311, Biomembranes & Surfaces Cellulaires Vegetales Lab, F-75230 Paris 05, France |
| 64 | 43 | Univ Mainz, Inst Allgemeine Bot, W-6500 Mainz, Germany |
| 62 | 24 | Univ Saarland, Fachbereich Werkstoffwissensch 15, Gebaude 43, W-6600 Saarbrucken, Germany |
| 60 | 23 | Univ Saarland, Inst Neue Mat, Gebaude 43, W-6600 Saarbrucken, Germany |
| 59 | 47 | Siemens Ag, Res Labs, W-8520 Erlangen, Germany |
| 57 | 37 | Ecole Mines, Cnrs, Sci & Genie Mat Met Lab, Ura 159, F-54042 Nancy, France |

## TABLE 1. HIGHLY CITED EU *'NANO'* PAPERS 1991-1992 FROM WEB OF SCIENCE

Note: Search commands: Title=*'nano'*; Address=sweden or finland or denmark or germany or netherlands or belgium or france or spain or portugal or italy or austria or ireland or scotland or wales or "north ireland" or england or luxemburg or greece

| **Citations** | **Doc nr** | **Address** |
|---|---|---|
| 57 | 13 | Univ Paris 11, Pharmacie Galen & Biopharmacie Lab, Cnrs, Ura 1218, F-92290 Chatenay Malabry, France |
| 57 | 37 | Univ Udine, Dipartimento Sci & Tecnol Chim, I-33100 Udine, Italy |
| 53 | 31 | Chim Coordinat Lab, Cnrs, Toulouse, France |
| 53 | 31 | Exxon Res & Engn Co, Rt 22e, Annandale, Nj 08801 |
| 53 | 25 | Max Planck Inst Met Res, Inst Werkstoffwissensch, Seestr 92, W- 7000 Stuttgart 80, Germany |
| 53 | 17 | Philips Res Labs, Pob 80000, Eindhoven, Netherlands |
| 53 | 25 | Univ Stuttgart, Inst Theoret & Angew Phys, W-7000 Stuttgart 80, Germany |
| 50 | 20 | Univ Erlangen Nurnberg, Inst Pharmaceut Technol, W-8520 Erlangen, Germany |
| 50 | 20 | Univ Erlangen Nurnberg, Max Planck Soc, Clin Res Units Rheumatol, Schwabachanlage 10, W-8520 Erlangen, Germany |
| 50 | 20 | Univ Frankfurt, Inst Pharmaceut Technol, W-6000 Frankfurt, Germany |

TABLE 2. HIGHLY CITED NETHERLANDS *'NANO'* PAPERS IN 1998 FROM WEB OF SCIENCE

Note: Title=*'nano'*; Address=netherlands; DocType=All document types; Language=All languages; Databases= SCI-EXPANDED; Timespan=1998

| Citations | Doc nr | Address |
|---|---|---|
| 421 | 59 | Delft Univ Technol, Dept Appl Phys, Lorentzweg 1, Nl-2628 Cj Delft, Netherlands |
| 421 | 59 | Delft Univ Technol, Dept Appl Phys, Nl-2628 Cj Delft, Netherlands |
| 421 | 59 | Delft Univ Technol, Dimes, Nl-2628 Cj Delft, Netherlands |
| 335 | 44 | Delft Univ Technol, Dept Appl Phys, Lorentzweg 1, Nl-2628 Cj Delft, Netherlands |
| 335 | 44 | Delft Univ Technol, Dept Appl Phys, Nl-2628 Cj Delft, Netherlands |
| 90 | 40 | Delft Univ Technol, Dept Appl Phys, Lorentzweg 1, Nl-2628 Cj Delft, Netherlands |
| 90 | 40 | Delft Univ Technol, Dept Appl Phys, Nl-2628 Cj Delft, Netherlands |
| 90 | 40 | Delft Univ Technol, Dimes, Nl-2628 Cj Delft, Netherlands |
| 78 | 46 | European Synchrotron Radiat Facil, F-38043 Grenoble, France |
| 78 | 46 | Univ Amsterdam, Ec Slater Inst Biochem Res, Microbiol Lab, Nl-1018 Ws Amsterdam, Netherlands |
| 78 | 46 | Univ Lund, Ctr Chem, S-22100 Lund, Sweden |
| 49 | 25 | Cea Saclay, Serv Phys Etat Condense, F-91191 Gif Sur Yvette, France |
| 49 | 25 | Delft Univ Technol, Dept Appl Phys, Lorentzweg 1, Nl-2628 Cj Delft, Netherlands |
| 49 | 25 | Delft Univ Technol, Dept Appl Phys, Nl-2628 Cj Delft, Netherlands |
| 49 | 25 | Delft Univ Technol, Dimes, Nl-2628 Cj Delft, Netherlands |
| 44 | 54 | Delft Univ Technol, Interfac Reactor Inst, Mekelweg 15, Nl-2629 Jb Delft, Netherlands |
| 44 | 54 | Delft Univ Technol, Interfac Reactor Inst, Nl-2629 Jb Delft, Netherlands |
| 44 | 54 | Max Planck Inst Polymerforsch, D-55128 Mainz, Germany |
| 36 | 41 | Fom, Inst Atom & Mol Phys, Kruislaan 407, Nl-1098 Sj Amsterdam, Netherlands |
| 36 | 41 | Fom, Inst Atom & Mol Phys, Nl-1098 Sj Amsterdam, Netherlands |
| 34 | 45 | Delft Univ Technol, Dept Appl Phys, Nl-2628 Cj Delft, Netherlands |
| 34 | 45 | Delft Univ Technol, Dimes, Nl-2628 Cj Delft, Netherlands |
| 34 | 45 | Ulp, Cnrs, Inst Charles Sadron, F-67000 Strasbourg, France |
| 23 | 32 | Philips Res Labs, Nl-5656 Aa Eindhoven, Netherlands |
| 23 | 32 | Philips Res Labs, Wa 13, Prof Holstlaan 4, Nl-5656 Aa Eindhoven, Netherlands |
| 21 | 24 | Univ Groningen Hosp, Dept Gynecol, Nl-9700 Rb Groningen, Netherlands |
| 21 | 24 | Univ Groningen Hosp, Dept Gynecol, Pob 30001, Nl-9700 Rb Groningen, Netherlands |
| 21 | 24 | Univ Groningen Hosp, Dept Nucl Med, Nl-9700 Rb Groningen, Netherlands |
| 21 | 24 | Univ Groningen Hosp, Dept Pathol, Nl-9700 Rb Groningen, Netherlands |
| 21 | 24 | Univ Groningen Hosp, Dept Surg Oncol, Nl-9700 Rb Groningen, Netherlands |

# APPENDIX 8: PATENTS BY IPC CLASSIFICATION

| **Description of IPC class** | **Field 1 (in %)** | **Field 2 (in %)** | **Field 3 (in %)** | **Field 4 (in %)** |
|---|---|---|---|---|
| *SECTION A – Human Necessities* | 2 | 60,4 | 2,6 | 6,1 |
| *SECTION B – Performing Operations; Transporting* | 6 | 16,7 | 7,9 | 16,2 |
| *SECTION C – Chemistry; Metallurgy* | 20 | 18,8 | 10,5 | 42,5 |
| *SECTION F – Mechanical Engineering; Lighting; Heating; Weapons; Blasting* | 6 | 0 | 5,3 | 1,7 |
| *SECTION G – Physics* | 50 | 4,2 | 21,1 | 7,8 |
| *SECTION H – Electricity* | 16 | 0 | 52,6 | 25,7 |
| | **50** | **48** | **38** | **179** |

# APPENDIX 9: DEVELOPMENT OF REVIEW PAPERS OVER TIME

Table 1: Review papers over time by field

| Year / Field | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Biology & Biochemistry | | | | 1 | 3 | 1 | 1 | 6 | 6 | | 18 |
| Chemistry | | | 9 | 9 | 19 | 28 | 38 | 28 | 37 | | 168 |
| Clinical Medicine | | | 5 | 1 | 3 | 3 | 3 | 2 | 12 | | 29 |
| Computer Sciences | | | | | | | 1 | | | | 1 |
| Engineering | | | 3 | 3 | 3 | 1 | 3 | 2 | 4 | 1 | 20 |
| Geosciences | | | | | | 1 | 1 | 3 | | | 5 |
| Materials Science | | 1 | 5 | 39 | 20 | 13 | 10 | 8 | 30 | | 126 |
| Microbiology | | | | | | | | 1 | | | 1 |
| Molecular Biology & Genetics | | | 1 | | | 1 | 1 | | 1 | | 4 |
| Multidisciplinary | | | 1 | 2 | 3 | 3 | 4 | 7 | 6 | | 26 |
| Neurosciences | | | | | | | 1 | | | | 1 |
| Not found | 1 | 3 | 12 | 6 | 16 | 8 | 11 | 18 | 30 | | 105 |
| Physics | | | 5 | 7 | 8 | 15 | 12 | 24 | 17 | | 88 |
| Plant & Animal Sciences | | | | 1 | | | | | | | 1 |
| Grand Total | 1 | 4 | 41 | 69 | 75 | 74 | 86 | 99 | 143 | 1 | 593 |

Table 2: Review papers over time by field (in % of annual publications)

| Year / Field | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Biology & Biochemistry | | | | 1% | 4% | 1% | 1% | 6% | 4% | |
| Chemistry | | | 22% | 13% | 25% | 38% | 44% | 28% | 26% | |
| Clinical Medicine | | | 12% | 1% | 4% | 4% | 3% | 2% | 8% | |
| Computer Sciences | | | | | | | 1% | | | |
| Engineering | | | 7% | 4% | 4% | 1% | 3% | 2% | 3% | 100% |
| Geosciences | | | | | | 1% | 1% | 3% | 0% | |
| Materials Science | | 25% | 12% | 57% | 27% | 18% | 12% | 8% | 21% | |
| Microbiology | | | | | | | | 1% | | |
| Molecular Biology & Genetics | | | 2% | | | 1% | 1% | | 1% | |
| Multidisciplinary | | | 2% | 3% | 4% | 4% | 5% | 7% | 4% | |
| Neurosciences | | | | | | | 1% | | | |
| Not found | 100% | 75% | 29% | 9% | 21% | 11% | 13% | 18% | 21% | |
| Physics | | | 12% | 10% | 11% | 20% | 14% | 24% | 12% | |
| Plant & Animal Sciences | | | | 1% | | | | | | |

Figure 1: Review papers - Development of fields over time