

Relation of seminal nanotechnology document production to total nanotechnology document production – South Korea

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This study evaluates trends in quality of nanotechnology and nanoscience papers produced by South Korean authors. The metric used to gauge quality is ratio of highly cited nanotechnology papers to total nanotechnology papers produced in sequential time frames. In the first part of this paper, citations (and publications) for nanotechnology documents published by major producing nations and major producing global institutions in four uneven time frames are examined. All nanotechnology documents in the Science Citation Index [SCI, 2006] for 1998, 1999–2000, 2001–2002, 2003 were retrieved and analyzed in March 2007.

In the second part of this paper, all the nanotechnology documents produced by South Korean institutions were retrieved and examined. All nanotechnology documents produced in South Korea (each document had at least one author with a South Korea address) in each of the above time frames were retrieved and analyzed. The South Korean institutions were extracted, and their fraction of total highly cited documents was compared to their fraction of total published documents. Non-Korean institutions that co-authored papers were included as well, to offer some perspective on the value of collaboration.

Disclaimer

(The views in this paper are solely those of the authors, and do not represent the views of the Department of the Navy or any of its components, DDL-OMNI Engineering, LLC, or the Institute for Defense Analyses).

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Introduction

Nanotechnology is a growth industry. Production of nanotechnology journal papers has increased exponentially for a decade and a half [KOSTOFF & AL., 2007]. In periods of rapid growth, there is always the danger that increase in quantity will outpace increase in quality.

The purpose of the present paper is to examine the quantity-quality relationship for one of the rapid growth countries, South Korea. From 1991 to 2005, South Korea increased its production of nanotechnology papers forty-fold [KOSTOFF & AL., 2007A, 2007B]. How did its quality change, and in particular, what were the quantity-quality relationships at the institutional level?

We will address the problem by examining quantity-quality relationships at different levels of aggregation. To place the South Korea results in their larger context, we will first start by examining how the major nanotechnology producing countries have fared with respect to quality over the past decade. Then we will examine how the major nanotechnology producing institutions globally have fared with respect to quality over the same time frame, and where the major South Korean institutions are positioned with respect to the global leaders. Finally, we will examine how the major nanotechnology paper producing institutions in South Korea have fared with respect to quality.

Background

As the production of nanotechnology papers has expanded, a number of studies have been generated that track the patterns of publication. BRAUN & AL. [1997] examined literature growth phenomena and nanotechnology sub-field research activity. MEYER & PERSSON [1998] used bibliometric (e.g., country, institutional, and co-authorship bibliometrics) as well as patent data to examine patterns of country collaboration and degree of boundary-spanning publications. HULLMANN & MEYER [2003] examined nanotechnology/nanoscience bibliometrics (including country publications and growth rates). They also looked at citations, from the perspective of connecting nanoscience to nanotechnology (patents to publications).

Two European studies in mapping excellence in nanotechnology [MEYER & AL., 2001; NOYONS & AL., 2003] present details of highly cited papers, and relate these highly cited papers to total papers in countries/departments. MEYER & AL. [2001] present graphs of numbers of citations for a paper vs. sum of papers cited by a Department, which provide some indication of numbers of highly cited papers related to total output. No temporal trend data is provided. NOYONS & AL. [2003] present total number of citations received, number of citations per publication, average number of citations per publication normalized by traditional science areas, and number of publications contributed to the top-10% of most highly cited publications. Publications

are listed for a five year block of time; no temporal trends are presented. Organizations with highest citation impact are shown, using different citation metrics rankings.

KOSTOFF & AL. [2006, 2007A, 2007B] examined both the publication bibliometrics of global nanoscience/nanotechnology (prolific authors/journals/institutions/countries) and the citation bibliometrics (most cited authors/papers/journals). Citations were also used for the purpose of bibliographic coupling for nanosciences mapping by BASSECOULARD & AL. [2007]. HULLMANN [2007] provided limited citation data for countries.

Thus, nanotechnology citations have been used to show infrastructure bibliometrics, science to technology linkages, mapping relationships, and point examples of highly cited papers to overall production. There appear to be no examples of temporal trends of ratios of highly cited nanotechnology/nanoscience papers to total nanotechnology/nanoscience papers, where the ratios are computed over small periods of time. We believe this type of analysis is important for organizations/countries that are experiencing rapid growth. In this case, aggregate ratios of highly cited papers to total papers may be misleading due to the large number of recent papers that contribute to the total publication statistics but have not yet had time to generate citations.

Approach

The quality metric employed for this analysis is the efficiency of highly cited nanotechnology document production; i.e., the ratio of highly cited nanotechnology documents produced to overall nanotechnology documents produced. The present section addresses some methods for arriving at this ratio.

While quality has many dimensions, the specific proxy metric we will use for quality is document citations. We will define a citation threshold (based on a percentage of total nanotechnology publications) for highly cited nanotechnology documents, or at least high quality nanotechnology documents. For each country, or institution, we calculate the number of highly cited papers that it has produced in selected time frames of interest, then take the ratio of this number to total number of publications the entity has produced over the selected time frame, and use this as our Figure of Merit.

In the first part of this paper, citations (and publications) for nanotechnology documents published by major producing nations and major producing global institutions in four uneven time frames are examined. The purpose is to obtain some time trend data to ascertain the evolution of quality. All nanotechnology documents in the Science Citation Index for 1998, 1999–2000, 2001–2002, 2003 were retrieved and analyzed in March 2007. These years were selected to be as close to the present as possible, in order to insure currency of findings, yet sufficiently vintaged to insure accumulation of adequate citations.

In the second part of this paper, all the nanotechnology documents produced by South Korean institutions were retrieved and examined. All nanotechnology documents produced in South Korea (each document had at least one author with a South Korea address) in each of the above time frames were retrieved and analyzed. The South Korean institutions were extracted, and their fraction of total highly cited documents was compared to their fraction of total published documents. Non-Korean institutions that co-authored papers were included as well, to offer some perspective on the value of collaboration.

A nanotechnology query with 300+ terms [KOSTOFF & AL., 2007B] was used to retrieve documents from the SCI/SSCI for 1998–2003. This query is shown in Appendix 1. The distribution of numbers of publications among institutions and countries was generated by the TechOasis software. Then, the publications for each year were ordered according to Times Cited. The most highly cited publications were extracted, and the country and institution distributions for those documents were generated. The country and institution publication distributions were then compared to the citation distributions. This allowed a comparison of countries and institutions with high number of citations relative to the number of their publications (and thus were producing highly cited papers more efficiently than their publication statistics would predict), as well as institutions whose citation fractions were less than their publication fractions.

A central issue is how one defines most highly cited. Are these highly cited papers the top 10, top 100, top 1% of the total papers? After parametric analyses, it was decided to use the top 1% of all publications as threshold for ‘most cited’.

Results

Normalized country production of seminal nanotechnology papers

Table 1 (see Appendix 2) contains the country distributions for 1998. The left side is the total publications by country, and the right side is the number of highly cited publications (top 1%) by country. On either side, the first column is the country, the second column (Rec Count) is number of SCI/SSCI records, the third column (CIT%) is the country’s highly cited papers as a percentage of the total highly cited papers, the fourth column (PUB%) is the country’s published papers as a percentage of total published papers in that year, and the last column (CIT/PUB) is the ratio of highly cited papers fraction to total papers fraction.

As an example, in 1998 there were 285 most cited papers. The USA at 170 record count produced 59.65% (170/285) of the most cited nanotechnology papers, and the USA produced 7302 papers out of the total 28463 papers, or 25.65% (7302/28463) of total nanotechnology papers. Thus, the USA is both the most prolific nanotechnology

publishing country and most represented country on highly cited nanotechnology papers for 1998. Its ratio of percent representation on most highly cited nanotechnology papers to percent of total nanotechnology publications (ratio = $59.65/25.65$) is 2.33. A ratio greater than one means that a country has higher representation on most cited papers than would be expected from its publications alone, and a ratio less than one means that a country has lower representation. In other words, a higher than one ratio means that a country's papers are cited more often relative to the number of papers it publishes. A ratio of 2.33 for the USA means that the USA representation on most highly cited records is 2.33 times what would be expected based on the number of nanotechnology publications alone.

None of the other large producers has ratios approaching that of the USA (for 1998 publications), and only some of the smaller hi-tech countries have comparable ratios. In fact, Israel at 2.81 and the Netherlands at 2.58 have higher ratios than the US, and Switzerland at 1.67 is closely behind. The cases of Austria at 2.16 and Ireland at 2.53 are exceptions due to the small number of citations. Countries that have exhibited rapid growth in SCI/SSCI nanotechnology paper production in recent years (e.g., China, South Korea) have ratios an order of magnitude less than that of the USA (for 1998). The remainder of the lowest tier for 1998 includes Belgium, Poland, Taiwan, and India.

Table 2 (see Appendix 2) contains the same type and structure of data as Table 1, but for 1999–2000. The USA remains dominant in nanotechnology publications and representation on most highly cited nanotechnology papers in ratio as well. Switzerland and the Netherlands remain on par with the U.S., but Israel dropped in ratio while Canada moved up. Table 3 (see Appendix 2) contains the data for 2001–2002. Again the US at 2.50 remains dominant in the ratio of CIT/PUB, without any other country coming even close. Table 4 (see Appendix 2) contains data for 2003. Similarly, the US at 2.63 is ahead of Denmark, the Netherlands and Switzerland.

Over the total time frame from 1998–2003, the USA's performance is remarkably consistent, with about 25% of total nanotechnology publications and about 60% of total highly cited papers. Its ratio hovers around 2.5. Switzerland and Netherlands maintain reasonably high ratios, and except for one time period, so do Israel and Denmark.

Of the other large producers of publications, Japan hovers around a ratio of about 0.5, indicating that its papers are less cited than one would expect from the large number of papers. Germany climbed slightly to a ratio near unity, the UK hovers around a ratio of unity, and thus the citations are as one would expect to be proportional to the number of papers published. France oscillates around a ratio of about 0.65. Russia had a remarkably consistent ratio of about 0.37, then dropped recently to 0.10. Poland and Taiwan have remained consistently very low.

China and South Korea have climbed in the publications rankings from 6th and 9th in 1998, respectively, to 3rd and 7th in 2003, respectively (and to 2nd and 6th in 2005, respectively [KOSTOFF & AL., 2007A, 2007B]). China's ratio has monotonically

increased from .16 to .45 over the 1998–2003 period, and South Korea's ratio has increased from .11 to about .6 over that same period, indicating their papers are getting more and more citations proportionately. Thus, under rapid growth conditions, China and South Korea have been able to increase their share of participation in highly cited papers. As of 2003, China and South Korea have ratios comparable to nations like Japan, France, Italy, and Australia but not yet approaching those of the highly cited countries. This can be seen more graphically in Figure 1, where ratio is plotted vs time for selected countries.

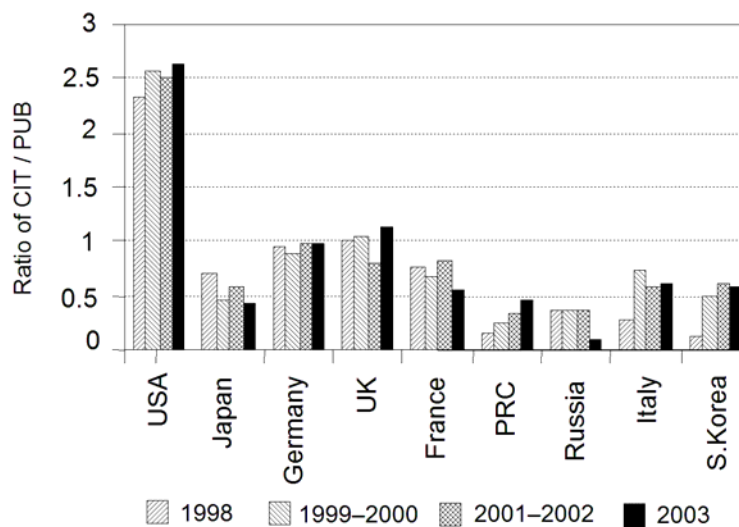


Figure 1. Ratio of citation percentage over publication percentage from 1998 to 2003

The numbers for China and South Korea have to be viewed in a larger context. For technology and engineering development, it is very important to have a trained cadre of researchers available to address the research issues that inevitably arise in the course of development. It is not necessary for these researchers to all be highly cited authors in order for them to have substantial value for supporting and accelerating technology and engineering development. If researchers are of the caliber to publish in the high quality journals typically accessed by the SCI/SSCI, they can offer expert assessment of what is being produced globally, and can exploit this cutting edge research in the development process.

Thus, if China and South Korea are increasing the numbers of nanotechnology researchers rapidly, and if their participation in highly cited papers is increasing at the same time, this rapid and increasing quality growth translates into a powerful foundation for accelerated growth in the industrial capability of their national development in the future. They are building a strong foundation not only for enhanced research quantity and quality capability, but for the more commercially and militarily important industrial capability as well.

Normalized institution production of seminal nanotechnology papers

Table 5 (see Appendix 2) lists the global institutions that produced the most nanotechnology publications and institutions that produced the most highly cited (top 1%) publications. It has the same structure as Tables 1–4, and reflects data for 1998.

Of the top ten publications producers, only two are from the USA (University of Illinois, University of California at Berkeley), and they are ninth and tenth in ranking, respectively. The top six producers all have ratios below unity. The thirteenth ranked University of California at Santa Barbara has a high 4.90 ratio and nineteenth ranked MIT at 4.14 is also high. For the top ten highly cited publications producers, a different picture from that of the top ten publications producers emerges. Nine of the top ten highly cited institutions are from the USA. All of the USA institutions in the highly cited side have ratios above 2. Harvard, Rice, and Max Planck have exceptionally high ratios at 12.25, 14.74, and 15.77, respectively. These institutions have highly cited papers relative to the total number of citations. University of North Carolina at 10.63 is also quite high, although the number of citation count at 5 is relatively small.

A word about institution aggregation. The SCI Analyze function, which we used for validation purposes only, aggregates all the USA state academic institution campuses into one unit for each state, except for California. Thus, the University of Illinois at Champaign-Urbana, University of Illinois at Chicago, etc., are aggregated into University of Illinois. However, University of California at Berkeley et al are treated as separate institutions. The SCI Analyze function also aggregates other large institutions as well, with the exception of the Max Planck institutes. We chose to follow this aggregating convention. If the University of California campuses were combined into one state unit, they would dominate the other institutions in both number of total papers and number of highly cited papers. If the Max Planck institutes were combined into one unit, they would appear on this table, although not as dominant as the University of California.

Tables 6, 7, and 8 (see Appendix 2) contain data for 1999–2000, 2001–2002, 2003, respectively. Over the 1998–2003 time period, the top six total publications producers remain the same, with Chinese Academy of Science (which consists of many research institutes) wresting the lead from Russian Academy of Science in 1999, and thereafter

increasing the gap. Over this same time period, the USA institutions constitute about 90% of the top ten most cited papers list. Harvard and UCB vie for the lead over this period. Harvard and Rice maintain ratios typically above 10 in this period. In 1998, there were eight USA institutions on the list of most publications producers, and by 2003 only two were left. This is a consequence of the rapid production growth rate of the Asian institutions.

Two institutions that seem to have plummeted in ratio are the Russian Academy of Science (0.55 in 1998 monotonically to 0.09 in 2003) and Tokyo Institute of Technology (1.94 in 1998 almost monotonically to 0 in 2003). Kyoto University, on the other hand, increased its ratio almost monotonically from 0 in 1998 to 1.38 in 2003. The major Chinese producing institution, Chinese Academy of Science, grew from a ratio of 0 in 1998 to ~0.5 in 2003, and China's second major producer, Tsing Hua University, grew from 0.28 in 1999–2000 to 1.18 in 2003. Korea's major producer, Seoul National University, grew from a negligible ratio in 1998 (not shown) to a ratio of 1.28 in 2003. This was accompanied by a growth in total publications over that period from negligible in 1998 (not shown) to 391 in 2003. Thus, the leading Chinese and South Korean institutions not only increased their total publications production rapidly, but increased quality as well. While they are not in the quality league of the leading USA institutions, they are making steady progress.

Production efficiency of highly cited nanotechnology papers by South Korean institutions

The first section of this paper was a global comparison of nanotechnology paper production at the national level, and the second section was a global comparison at the major institutional level. The present section addresses the next level of detail, a national comparison at the institutional level.

We used the same approach as in the first two sections, with the same metrics. The one difference is that we lowered the threshold for highly cited papers (from top 1% to top 5%) in order to get adequate statistics.

Tables 9–12 (see Appendix 2) present the South Korean institutional results for the same four time periods: 1998, 1999–2000; 2002–2002; 2003. Additionally, institutions from other countries are in these tables because there is collaboration and co-authorship with researchers in South Korea. The consistent leaders in terms of numbers of publications have been Seoul National University and Korea Advanced Institute of Science and Technology. The second tier (in terms of quantity) for the last few years has consisted of Hanyang University, Sungkyunkwan University, Korea Institute of Science and Technology, and Yonsei University. In terms of numbers of highly cited papers, the first publication tier is also the first citation tier.

In terms of the ratio of highly cited nanotechnology papers to all nanotechnology publications, the picture is murkier because of the wide swings. The two publications

leaders are consistently above unity in this ratio, meaning they have continued to display quality even under conditions of very rapid growth. Another institution that has had a ratio above unity for most of the time frame of interest is Pohang University of Science and Technology.

Some moderate publications producers that started with very low ratios and have consistently climbed above unity include Kwangju Institute of Science and Technology, Samsung Advanced Institute of Technology, and Chonbuk National University (monotonic climb above unity only recently).

Smaller South Korean nanotechnology publications producers that appear sporadically on the tables with high ratios include Hannam University (1998, 2001–2002), Chosun University (1998), Kunsan University (1999–2000), and Jeonbuk University (1999–2002). Foreign institutions that appear in the tables typically have high ratios. Examples with more than one highly cited paper include Tokyo Institute of Technology (1998), University of Utah (1999–2000), University Gesamthoch Paderborn (1999–2000), University of Illinois (1999–2000), UCB (1999–2000), Tohoku University (1999–2002), Kent State University (1999–2003), Carnegie-Mellon University (2001–2002), Kyoto University (2003), Oak Ridge National Lab (2003), and MIT (2003). Clearly, collaboration with foreign institutions, on average, is the path to highly cited papers.

Institutions with moderate publication rates and consistently low ratios include Electric and Telecommunications Research Institute (except for 2001–2002). Institutions that have exhibited a monotonic ratio decline include Korea Institute of Science and Technology. Chungnam National University started with a high ratio in 1998, but has had a very low ratio since that time.

In summary, the two major publications producers (Seoul National University and Korea Advanced Institute of Science and Technology) have maintained good ratios of highly cited documents to total nanotechnology publications under high growth conditions. Most other institutions, with exceptions noted above, have exhibited ratio swings over time, some quite large. Papers with foreign institution participation tend to have high citation performance.

Summary and conclusions

We have examined temporal trends in the ratio of highly cited nanotechnology/nanoscience papers to total nanotechnology/nanoscience papers for countries, global institutions, and South Korean institutions. For countries, the USA remains a dominant and consistent leader, with a ratio hovering around 2.5 for the total period examined. Other countries with high ratios tend to be much smaller (e.g., Israel, Netherlands, Switzerland, Denmark), and their ratios are less consistent.

China and South Korea have climbed in the publications rankings from 6th and 9th in 1998, respectively, to 3rd and 7th in 2003, respectively (and to 2nd and 6th in 2005, respectively). China's ratio has monotonically increased from 0.16 to 0.45 over the 1998–2003 period, and South Korea's ratio has increased from 0.11 to about 0.6 over that same period, indicating their papers are getting more and more citations proportionately. Thus, under rapid growth conditions, China and South Korea have been able to increase their share of participation in highly cited papers. As of 2003, China and South Korea have ratios comparable to nations like Japan, France, Italy, and Australia but not yet approaching those of the highly cited countries.

For global institutions, of the top ten publications producers, only two are from the USA (University of Illinois, University of California at Berkeley), and they are ninth and tenth in ranking, respectively. For the top ten highly cited publications producers, a different picture from that of the top ten publications producers emerges. Nine of the top ten highly cited institutions are from the USA. All of the USA institutions in the highly cited side have ratios above 2. Harvard, Rice, and Max Planck have exceptionally high ratios at 12.25, 14.74, and 15.77 respectively. These institutions have highly cited papers relative to the total number of citations. University of California at Berkeley et al are treated as separate institutions. If the University of California campuses were combined into one state unit, they would dominate the other institutions in both number of total papers and number of highly cited papers.

Over the 1998–2003 time period, the top six total publications producers remain the same, with Chinese Academy of Science (which consists of many research institutes) wresting the lead from Russian Academy of Science in 1999, and thereafter increasing the gap. Over this same time period, the USA institutions constitute about 90% of the top ten most cited papers list. Harvard and UCB vie for the lead over this period. Harvard and Rice maintain ratios typically above 10 in this period. In 1998, there were eight USA institutions on the list of most publications producers, and by 2003 only two were left. This is a consequence of the rapid production growth rate of the Asian institutions.

The major Chinese producing institution, Chinese Academy of Science, grew from a ratio of 0 in 1998 to ~0.5 in 2003, and China's second major producer, Tsing Hua University, grew from 0.28 in 1999–2000 to 1.18 in 2003. Korea's major producer, Seoul National University, grew from a negligible ratio in 1998 (not shown) to a ratio of 1.28 in 2003. This was accompanied by a growth in total publications over that period from negligible in 1998 (not shown) to 391 in 2003. Thus, the leading Chinese and South Korean institutions not only increased their total publications production rapidly, but increased quality as well. While they are not in the quality league of the leading USA institutions, they are making steady progress.

For South Korean institutions specifically, the two major publications producers (Seoul National University and Korea Advanced Institute of Science and Technology)

have maintained good ratios of highly cited documents to total nanotechnology publications under high growth conditions. Most other South Korean institutions, with exceptions noted above, have exhibited ratio swings over time, some quite large. Papers with foreign institution participation tend to have high citation performance.

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Appendix 1

Nanotechnology/nanoscience literature retrieval query

The following sets of keywords are used in queries to retrieve the data in the literature (* denotes the wild-card character used in most search engines), and the union of these sets constitutes the operational definition of nanotechnology/ nanoscience used by the authors.

SET 1 – TOPIC

NANOPARTICLE* OR NANOTUB* OR NANOSTRUCTURE* OR NANOCOMPOSITE* OR NANO-COMPOSITE* OR NANOWIRE* OR NANOCRYSTAL* OR NANOFIBER* OR NANOFIBRE* OR NANOSPHERE* OR NANOROD* OR NANOTECHNOLOG* OR NANOCLUSTER* OR NANOCAPSULE* OR NANOMATERIAL* OR NANOFABRICAT* OR NANOPOR* OR NANOPARTICULATE* OR NANOPHASE OR NANOPOWDER* OR NANOLITHOGRAPHY OR NANO-PARTICLE* OR NANODEVICE* OR NANODOT* OR NANOINDENT* OR NANO-INDENT* OR NANOLAYER* OR NANOSCIENCE OR NANOSIZE* OR NANO-SIZE* OR NANOSCALE* OR NANO-SCALE* OR NANOROBOT*

SET 2 – TOPIC

((NM OR NANOMETER* OR NANOMETRE*) SAME (SURFACE* OR FILM* OR GRAIN* OR POWDER* OR SILICON OR DEPOSITION OR LAYER* OR DEVICE* OR CLUSTER* OR CRYSTAL* OR MATERIAL* OR SUBSTRATE* OR STRUCTURE* OR ROUGHNESS OR MONOLAYER* OR RESOLUTION OR PARTICLE* OR ATOMIC FORCE MICROSCOP* OR TRANSMISSION ELECTRON MICROSCOP* OR SCANNING TUNNELING MICROSCOP*))

SET 3 – TOPIC

(AFM OR ATOMIC FORCE MICROSCOP* OR SCANNING ELECTRON MICROSCOP* OR SEM OR SCANNING TUNNELING MICROSCOP* OR STM OR SELF-ASSEMBL* OR SELF-ORGANIZ* OR TRANSMISSION ELECTRON MICROSCOP* OR TEM) SAME (SURFACE* OR FILM* OR LAYER* OR SUBSTRATE* OR ROUGHNESS OR MONOLAYER* OR MOLECU* OR STRUCTURE* OR RESOLUTION OR ETCH* OR GROW* OR SILICON OR SI OR DEPOSIT* OR PARTICLE* OR FORMATION OR TIP OR ATOM* OR GOLD OR AU OR POLYMER* OR COPOLYMER* OR GAAS OR INAS OR SUPERLATTICE* OR ADSORPTION OR ADSORB* OR ISLAND* OR SIZE OR POWDER* OR RESOLUTION OR QUANTUM OR MULTILAYER* OR ARRAY* OR NANO*)

SET 4 – TOPIC

(NSOM OR CHEMICAL VAPOR DEPOSITION OR CVD OR CHEMICAL VAPOUR DEPOSITION OR X-RAY PHOTOELECTRON SPECTROSCOPY OR DIFFERENTIAL SCANNING CALORIMETRY OR X-RAY DIFFRACTION OR XRD OR SURFACE PLASMON RESONANCE OR "NEAR" FIELD SCANNING OPTICAL MICROSCOP*) SAME (SURFACE* OR FILM* OR LAYER* OR SUBSTRATE* OR ROUGHNESS OR MONOLAYER* OR MOLECU* OR STRUCTURE* OR RESOLUTION OR ETCH* OR GROW* OR SILICON OR SI OR DEPOSIT* OR PARTICLE* OR FORMATION OR TIP OR ATOM* OR GOLD OR AU OR POLYMER* OR COPOLYMER* OR GAAS OR INAS OR SUPERLATTICE* OR ADSORPTION OR ADSORB* OR ISLAND* OR SIZE OR POWDER OR RESOLUTION OR QUANTUM OR MULTILAYER* OR ARRAY* OR NANO*)

SET 5 – TOPIC

NANOMECHANICAL OR NANO ELECTRONIC* OR NANO HARDNESS OR NANORIBBON* OR NANOBELT* OR NANO GRAIN* OR NANOCABLE* OR NANOCHANNEL* OR NANOSHEET* OR NANODIAMOND* OR NANOMAGNET* OR NANODISK* OR NANOSHELL* OR NANOCONTACT* OR NANOREACTOR* OR NANOIMPRINT* OR NANO HOLE* OR NANOWHISKER* OR NANO CHEMISTRY OR NANOGRAPHITE OR NANO ELECTRODE* OR NANO GRANULAR OR NANOFOAM* OR NANOMETER-SIZE* OR NANO COLLOID* OR NANORING* OR NANOPHOTONIC* OR NANOSENSOR* OR NANO ELECTROSPRAY* OR NANO BRIDGE* OR NANOMETER-SCALE* OR NANO BIO* OR BIONANO* OR HIPCO

SET 6 – TOPIC

MOLECUL* MOTOR* OR MOLECUL* RULER* OR MOLECUL* DEVICE* OR MOLECULAR ENGINEERING OR MOLECULAR ELECTRONIC* OR COULOMB STAIRCASE* OR QUANTUM DOT* OR QUANTUM WELL* OR QUANTUM WIRE* OR COULOMB BLOCKADE* OR MOLECULAR WIRE*

SET 7 – JOURNALS

(BULK "AND" GRADED NANOMETALS OR CURRENT NANOSCIENCE OR FROM NANOPOWDERS TO FUNCTIONAL MATERIALS OR FULLERENES NANOTUBES "AND" CARBON NANOSTRUCTURES OR FULLERENES NANOTUBES "AND" CARBON NANOSTRUCTURES OR FUNCTIONAL MOLECULAR NANOSTRUCTURES OR IEEE TRANSACTIONS ON NANOBIO SCIENCE OR IEEE TRANSACTIONS ON NANOTECHNOLOGY OR INORGANIC POLYMERIC NANOCOMPOSITES "AND" MEMBRANES OR JOURNAL OF COMPUTATIONAL "AND" THEORETICAL NANOSCIENCE OR JOURNAL OF NANOPARTICLE RESEARCH OR JOURNAL OF NANOSCIENCE "AND" NANOTECHNOLOGY OR MICROSYSTEM TECHNOLOGIES MICRO "AND" NANOSYSTEMS INFORMATION STORAGE "AND" PROCESSING SYSTEMS OR NANO LETTERS OR NANOPOROUS MATERIALS IV OR NANOTECHNOLOGY OR ON THE CONVERGENCE OF BIO INFORMATION ENVIRONMENTAL ENERGY SPACE "AND" NANO TECHNOLOGIES PTS 1 "AND" 2 OR PHYSICA E LOW DIMENSIONAL SYSTEMS NANOSTRUCTURES OR PRECISION ENGINEERING JOURNAL OF THE INTERNATIONAL SOCIETIES FOR PRECISION ENGINEERING "AND" NANOTECHNOLOGY OR SYNTHESIS "AND" REACTIVITY IN INORGANIC METAL ORGANIC "AND" NANO METAL CHEMISTRY)

SET 8 – ADDRESS

NANO* NOT NANOPHOTON*

The first six sets of the query are generated using an iterative relevance feedback technique [Kostoff et al, 1997] applied to the phrases in the Abstract fields of the SCI/ SSCI records. The seventh set is applied to the journal Titles field, and represents journals that contain 'nano*' in the title. The eighth set is applied to the author address field, and represents organizations that contain nano* in their address but not nanophoton*. The retrievals from each query set have been validated for relevance and precision. The full query (the union of all eight sets) is used to retrieve relevant documents from selected source databases.

Appendix 2
Tables

Table 1. Country distributions – overall records/top 1% cited records – 1998

Country/Territory	Total Records 28463				Most Cited: 1% = 285 Records (159 CITES MIN)				
	Rec Count	CIT%	PUB%	CIT/PUB	Country/Territory	Rec Count	CIT%	PUB%	CIT/PUB
USA	7302	59.65%	25.65%	2.33	USA	170	59.65%	25.65%	2.33
Japan	4742	11.58%	16.66%	0.70	Germany	36	12.63%	13.37%	0.94
Germany	3806	12.63%	13.37%	0.94	Japan	33	11.58%	16.66%	0.70
UK	2293	8.07%	8.06%	1.00	UK	23	8.07%	8.06%	1.00
France	2085	5.61%	7.33%	0.77	France	16	5.61%	7.33%	0.77
Peoples R China	1875	1.05%	6.59%	0.16	Netherlands	14	4.91%	1.90%	2.58
Russia	1365	1.75%	4.80%	0.37	Switzerland	11	3.86%	2.31%	1.67
Italy	1018	1.05%	3.58%	0.29	Israel	10	3.51%	1.25%	2.81
South Korea	936	0.35%	3.29%	0.11	Spain	6	2.11%	2.80%	0.75
Spain	797	2.11%	2.80%	0.75	Austria	5	1.75%	0.81%	2.16
Canada	749	1.40%	2.63%	0.53	Russia	5	1.75%	4.80%	0.37
Switzerland	658	3.86%	2.31%	1.67	Sweden	5	1.75%	2.10%	0.84
India	647	0.35%	2.27%	0.15	Canada	4	1.40%	2.63%	0.53
Sweden	597	1.75%	2.10%	0.84	Australia	3	1.05%	1.44%	0.73
Netherlands	541	4.91%	1.90%	2.58	China	3	1.05%	6.59%	0.16
Taiwan	504	0.00%	1.77%	0.00	Italy	3	1.05%	3.58%	0.29
Poland	412	0.00%	1.45%	0.00	Denmark	2	0.70%	0.87%	0.81
Australia	409	1.05%	1.44%	0.73	Hong Kong	2	0.70%	0.71%	0.99
Belgium	359	0.00%	1.26%	0.00	Ireland	2	0.70%	0.28%	2.53
Israel	355	3.51%	1.25%	2.81	Czech Republic	1	0.35%	0.63%	0.56

Table 2.

Country/Territory	1999-2000				Most Cited: 1% = 632 Records (141 CITES MIN)				
	Rec Count	CIT%	PUB%	CIT/PUB	Country/Territory	Rec Count	CIT%	PUB%	CIT/PUB
USA	15566	63.13%	24.66%	2.56	USA	399	63.13%	24.66%	2.56
Japan	10394	7.75%	16.47%	0.47	Germany	69	10.92%	12.28%	0.89
Germany	7752	10.92%	12.28%	0.89	Japan	49	7.75%	16.47%	0.47
Peoples R China	5667	2.37%	8.98%	0.26	UK	48	7.59%	7.20%	1.05
France	4838	5.06%	7.66%	0.66	Switzerland	34	5.38%	2.10%	2.56
UK	4547	7.59%	7.20%	1.05	France	32	5.06%	7.66%	0.66
Russia	2956	1.74%	4.68%	0.37	Netherlands	26	4.11%	1.94%	2.12
South Korea	2423	1.90%	3.84%	0.49	Canada	21	3.32%	2.41%	1.38
Italy	2213	2.53%	3.51%	0.72	Italy	16	2.53%	3.51%	0.72
Spain	1812	1.27%	2.87%	0.44	Peoples R China	15	2.37%	8.98%	0.26
Canada	1519	3.32%	2.41%	1.38	Sweden	13	2.06%	2.08%	0.99
India	1422	0.95%	2.25%	0.42	South Korea	12	1.90%	3.84%	0.49
Switzerland	1325	5.38%	2.10%	2.56	Russia	11	1.74%	4.68%	0.37
Sweden	1311	2.06%	2.08%	0.99	Belgium	8	1.27%	1.26%	1.01
Taiwan	1240	0.47%	1.96%	0.24	Spain	8	1.27%	2.87%	0.44
Netherlands	1226	4.11%	1.94%	2.12	Denmark	7	1.11%	0.69%	1.61
Poland	1037	0.16%	1.64%	0.10	India	6	0.95%	2.25%	0.42
Brazil	951	0.63%	1.51%	0.42	Austria	5	0.79%	0.93%	0.85
Australia	939	0.63%	1.49%	0.43	Australia	4	0.63%	1.49%	0.43
Belgium	795	1.27%	1.26%	1.01	Brazil	4	0.63%	1.51%	0.42
Israel	782	0.63%	1.24%	0.51	Israel	4	0.63%	1.24%	0.51

Table 3.
2001–2002

Country/Territory	Total Records 76956			Most Cited: 1% = 770 Records (103 CITES MIN)			
	Rec Count	CIT%	PUB%	Country/Territory	Rec Count	CIT%	PUB%
USA	18356	59.74%	23.85%	USA	460	59.74%	23.85%
Japan	12110	9.09%	15.74%	Germany	87	11.30%	11.39%
Peoples R China	9028	4.16%	11.73%	Japan	70	9.09%	15.74%
Germany	8769	11.30%	11.39%	France	46	5.97%	7.26%
France	5589	5.97%	7.26%	UK	42	5.45%	6.76%
UK	5204	5.45%	6.76%	Peoples R China	32	4.16%	11.73%
Russia	3658	1.69%	4.75%	Switzerland	23	2.99%	1.74%
South Korea	3617	2.86%	4.70%	South Korea	22	2.86%	4.70%
Italy	2808	2.08%	3.65%	Canada	21	2.73%	2.27%
Spain	2258	1.17%	2.93%	Italy	16	2.08%	3.65%
India	2062	1.30%	2.68%	Sweden	15	1.95%	2.06%
Taiwan	1765	0.39%	2.29%	Netherlands	14	1.82%	1.75%
Canada	1748	2.73%	2.27%	Israel	13	1.69%	1.21%
Sweden	1583	1.95%	2.06%	Russia	13	1.69%	4.75%
Brazil	1413	1.04%	1.84%	India	10	1.30%	2.68%
Poland	1353	0.13%	1.76%	Denmark	9	1.17%	0.62%
Netherlands	1347	1.82%	1.75%	Spain	9	1.17%	2.93%
Switzerland	1339	2.99%	1.74%	Belgium	8	1.04%	1.23%
Australia	1135	0.91%	1.47%	Brazil	8	1.04%	1.84%
Singapore	1031	0.65%	1.34%	Australia	7	0.91%	1.47%

Table 4.

Total Records 47945		2003		Most Cited: 1% = 480 Records (73 CITES MIN)					
Country/Territory	Rec Count	CIT%	PUB%	CIT/PUB	Country/Territory	Rec Count	CIT%	PUB%	CIT/PUB
USA	11408	62.50%	23.79%	2.63	USA	300	62.50%	23.79%	2.63
Japan	7196	6.67%	15.01%	0.44	Germany	48	10.00%	10.24%	0.98
Peoples R China	6717	6.25%	14.01%	0.45	Japan	32	6.67%	15.01%	0.44
Germany	4911	10.00%	10.24%	0.98	UK	32	6.67%	5.85%	1.14
France	3338	3.75%	6.96%	0.54	Peoples R China	30	6.25%	14.01%	0.45
UK	2805	6.67%	5.85%	1.14	France	18	3.75%	6.96%	0.54
South Korea	2640	3.13%	5.51%	0.57	Netherlands	17	3.54%	1.74%	2.04
Russia	2015	0.42%	4.20%	0.10	Switzerland	16	3.33%	1.68%	1.99
Italy	1803	2.29%	3.76%	0.61	South Korea	15	3.13%	5.51%	0.57
India	1498	0.63%	3.12%	0.20	Spain	14	2.92%	2.69%	1.09
Spain	1288	2.92%	2.69%	1.09	Italy	11	2.29%	3.76%	0.61
Taiwan	1234	0.42%	2.57%	0.16	Israel	9	1.88%	1.06%	1.77
Canada	1193	0.83%	2.49%	0.33	Sweden	9	1.88%	1.67%	1.12
Poland	857	0.21%	1.79%	0.12	Denmark	7	1.46%	0.62%	2.35
Netherlands	834	3.54%	1.74%	2.04	Austria	6	1.25%	0.95%	1.32
Switzerland	804	3.33%	1.68%	1.99	Australia	5	1.04%	1.60%	0.65
Sweden	803	1.88%	1.67%	1.12	Belgium	4	0.83%	1.20%	0.69
Australia	768	1.04%	1.60%	0.65	Brazil	4	0.83%	1.57%	0.53
Brazil	755	0.83%	1.57%	0.53	Canada	4	0.83%	2.49%	0.33
Singapore	662	0.83%	1.38%	0.60	Singapore	4	0.83%	1.38%	0.60

Table 5.

Total Records 28463		1998					Most Cited: 1% = 285 Records (159 CITES MIN)				
Institution Name	Rec Count	CIT%	PUB%	CIT/PUB	Institution Name	Rec Count	CIT%	PUB%	CIT/PUB		
Russian Acad Sci	725	1.40%	2.55%	0.55	Harvard Univ	13	4.56%	0.37%	12.25		
Chinese Acad Sci	546	0.00%	1.92%	0.00	Univ Calif Santa Barbara	11	3.86%	0.79%	4.90		
Univ Tokyo	419	1.40%	1.47%	0.95	Rice Univ	9	3.16%	0.21%	14.74		
Cnrs	375	0.70%	1.32%	0.53	MIT	7	2.46%	0.59%	4.14		
Osaka Univ	347	0.70%	1.22%	0.58	Cornell Univ	6	2.11%	0.42%	4.99		
Tohoku Univ	315	1.05%	1.11%	0.95	Delft Univ Technol	6	2.11%	0.32%	6.51		
Univ Cambridge	259	1.40%	0.91%	1.54	IBM Corp	6	2.11%	0.58%	3.65		
Tokyo Inst Technol	258	1.75%	0.91%	1.94	Max Planck Inst Colloids & Interfaces	6	2.11%	0.13%	15.77		
Univ Illinois	243	0.70%	0.85%	0.82	Stanford Univ	6	2.11%	0.43%	4.87		
Univ Calif Berkeley	228	1.75%	0.80%	2.19	Northwestern Univ	5	1.75%	0.39%	4.46		
Chr	226	0.00%	0.79%	0.00	Penn State Univ	5	1.75%	0.54%	3.24		
Kyoto Univ	225	0.00%	0.79%	0.00	Tokyo Inst Technol	5	1.75%	0.91%	1.94		
Univ Calif Santa Barbara	224	3.86%	0.79%	4.90	Univ Calif Berkeley	5	1.75%	0.80%	2.19		
Csic	221	0.35%	0.78%	0.45	Univ N Carolina	5	1.75%	0.17%	10.63		
Acad Sinica	210	0.35%	0.74%	0.48	Weizmann Inst Sci	5	1.75%	0.32%	5.49		
Univ Oxford	173	1.40%	0.61%	2.31	Ecole Polytech Fed	4	1.40%	0.46%	3.03		
Polish Acad Sci	172	0.00%	0.60%	0.00	Lausanne	4	1.40%	0.26%	5.33		
Hokkaido Univ	169	0.00%	0.59%	0.00	Georgia Inst Technol	4	1.40%	2.55%	0.55		
Mit	169	2.46%	0.59%	4.14	Russian Acad Sci	4	1.40%	0.91%	1.54		
Ibm Corp	164	1.75%	0.58%	3.04	Univ Cambridge	4	1.40%	0.45%	3.15		
Univ Texas	164	1.40%	0.58%	2.44	Univ Minnesota	4	1.40%	0.61%	2.31		
Unn	164	0.70%	0.58%	1.22	Univ Oxford	4	1.40%	0.58%	2.44		
Nanjing Univ	159	0.00%	0.56%	0.00	Univ Texas	4	1.40%	1.47%	0.95		
Penn State Univ	154	1.75%	0.54%	3.24	Univ Tokyo	4	1.40%	0.24%	5.96		
Chalmers Univ Technol	146	1.05%	0.51%	2.05	Univ Utah	4	1.40%	0.49%	2.87		
					Univ Wisconsin	4	1.40%	0.49%	2.87		

Table 6.

1999-2000		Total Records 63122						Most Cited: 1% = 632 Records (141 CITES MIN)					
Institution Name	Rec Count	CIT%	PUB%	CIT/PUB	Institution Name	Rec Count	CIT%	PUB%	CIT/PUB				
Chinese Acad Sci	1797	1.11%	2.85%	0.39	Univ Calif Berkeley	31	4.91%	0.72%	6.81				
Russian Acad Sci	1600	1.27%	2.53%	0.50	Harvard Univ	27	4.27%	0.40%	10.79				
Cnrs	886	1.27%	1.40%	0.90	IBM Corp	25	3.96%	0.43%	9.26				
Tohoku Univ	837	1.27%	1.33%	0.95	MIT	20	3.16%	0.58%	5.46				
Univ Tokyo	827	1.58%	1.31%	1.21	Stanford Univ	19	3.01%	0.39%	7.62				
Osaka Univ	783	0.79%	1.24%	0.64	Rice Univ	17	2.69%	0.20%	13.70				
Tokyo Inst Technol	639	0.47%	1.01%	0.47	Univ Calif Santa Barbara	17	2.69%	0.66%	4.06				
Csic	507	0.16%	0.80%	0.20	Northwestern Univ	15	2.37%	0.42%	5.68				
Kyoto Univ	504	0.79%	0.80%	0.99	Univ Basel	13	2.06%	0.23%	9.08				
Chr	471	0.79%	0.75%	1.06	Univ Cambridge	13	2.06%	0.72%	2.85				
Univ Cambridge	456	0.79%	0.72%	1.10	Cornell Univ	11	1.74%	0.41%	4.21				
Univ Calif Berkeley	455	4.91%	0.72%	6.81	Univ Wisconsin	11	1.74%	0.48%	3.59				
Univ Illinois	449	1.11%	0.71%	1.56	Univ Tokyo	10	1.58%	1.31%	1.21				
Natl Univ Singapore	426	0.32%	0.67%	0.47	AT&T Bell Labs	9	1.42%	0.30%	4.81				
Univ Calif Santa Barbara	418	2.69%	0.66%	4.06	Delft Univ Technol	9	1.42%	0.38%	3.79				
Polish Acad Sci	399	0.16%	0.63%	0.25	Ecole Polytech Fed	9	1.42%	0.37%	3.87				
Univ Sci & Technol					Lausanne								
China	396	0.32%	0.63%	0.50	Penn State Univ	9	1.42%	0.49%	2.93				
Peking Univ	385	0.16%	0.61%	0.26	Univ Calif San Diego	9	1.42%	0.31%	4.66				
Hokkaido Univ	375	0.32%	0.59%	0.53	Univ N Carolina	9	1.42%	0.23%	6.20				
Acad Sinca	368	0.00%	0.58%	0.00	CNRS	8	1.27%	1.40%	0.90				
Mit	366	3.16%	0.58%	5.46	Russian Acad Sci	8	1.27%	2.53%	0.50				
Univ Oxford	360	1.11%	0.57%	1.94	Tohoku Univ	8	1.27%	1.33%	0.95				
Univ Paris 06	359	0.32%	0.57%	0.56	Univ Texas	8	1.27%	0.54%	2.35				
Tsing Hua Univ	351	0.16%	0.56%	0.28	Univ Washington	8	1.27%	0.30%	4.21				
Univ Texas	340	1.27%	0.54%	2.35	Yale Univ	8	1.27%	0.17%	7.33				

Table 7.

2001-2002		Most Cited: 1% = 770 Records (103 CITES MIN)					
Institution Name	Total Records 76956			Rec Count			CIT/PUB
	Rec Count	CIT%	PUB%	Rec Count	CIT%	PUB%	
Chinese Acad Sci	2699	1.17%	3.51%	39	5.06%	0.39%	12.95
Russian Acad Sci	1875	1.04%	2.44%	36	4.68%	0.72%	6.46
Cnrs	1046	1.82%	1.36%	22	2.86%	0.36%	7.88
Tohoku Univ	1025	0.39%	1.33%	21	2.73%	0.44%	6.25
Univ Tokyo	1016	1.82%	1.32%	20	2.60%	0.40%	6.49
Osaka Univ	835	0.52%	1.09%	19	2.47%	0.54%	4.55
Tokyo Inst Technol	804	0.52%	1.04%	19	2.47%	0.20%	12.33
Csic	697	0.52%	0.91%	19	2.47%	0.65%	3.78
Tsing Hua Univ	665	0.65%	0.86%	14	1.82%	1.36%	1.34
Cnr	594	0.39%	0.77%	14	1.82%	1.32%	1.38
Univ Illinois	589	0.52%	0.77%	13	1.69%	0.35%	4.83
Natl Univ Singapore	571	0.65%	0.74%	11	1.43%	0.31%	4.62
Natl Inst Adv Ind Sci & Technol	560	0.26%	0.73%	10	1.30%	0.26%	4.97
Univ Calif Berkeley	557	4.68%	0.72%	10	1.30%	0.72%	1.79
Univ Cambridge	557	1.30%	0.72%	10	1.30%	0.24%	5.43
Kyoto Univ	541	0.65%	0.70%	9	1.17%	0.29%	4.03
Polish Acad Sci	512	0.00%	0.67%	9	1.17%	3.51%	0.33
Univ Texas	502	2.47%	0.65%	9	1.17%	0.19%	6.29
Nanjing Univ	485	0.00%	0.63%	9	1.17%	0.35%	3.32
Seoul Natl Univ	478	0.65%	0.62%	9	1.17%	0.51%	2.30
Univ Sci & Technol China	477	0.00%	0.62%	9	1.17%	0.37%	3.18

Table 8.

Institution Name	Total Records 47945				Most Cited: 1% = 480 Records (73 CITIES MIN)			
	Rec Count	CIT%	PUB%	CIT/PUB	Rec Count	CIT%	PUB%	CIT/PUB
Chinese Acad Sci	1894	1.88%	3.95%	0.47	22	4.58%	0.69%	6.66
Russian Acad Sci	1110	0.21%	2.32%	0.09	19	3.96%	0.40%	9.78
Cnrs	627	1.04%	1.31%	0.80	17	3.54%	0.48%	7.45
Univ Tokyo	588	1.04%	1.23%	0.85	16	3.33%	0.42%	7.91
Tohoku Univ	564	0.63%	1.18%	0.53	16	3.33%	0.67%	4.98
Osaka Univ	555	0.63%	1.16%	0.54	15	3.13%	0.29%	10.70
Natl Inst Adv Ind Sci & Technol	527	0.21%	1.10%	0.19	12	2.50%	0.33%	7.49
Tsing Hua Univ	509	1.25%	1.06%	1.18	11	2.29%	0.37%	6.14
Tokyo Inst Technol	462	0.00%	0.96%	0.00	10	2.08%	0.32%	6.52
Natl Inst Mat Sci	429	0.21%	0.89%	0.23	9	1.88%	0.26%	7.08
Seoul Natl Univ	391	1.04%	0.82%	1.28	9	1.88%	3.95%	0.47
Univ Illinois	388	1.88%	0.81%	2.32	9	1.88%	0.27%	6.86
Cnr	384	0.83%	0.80%	1.04	9	1.88%	0.81%	2.32
Nanjing Univ	377	0.21%	0.79%	0.26	9	1.88%	0.43%	4.36
Univ Cambridge	373	1.46%	0.78%	1.87	7	1.46%	0.34%	4.29
Univ Sci & Technol China	367	0.42%	0.77%	0.54	7	1.46%	0.47%	3.11
Kyoto Univ	362	1.04%	0.76%	1.38	7	1.46%	0.46%	3.19
Natl Univ Singapore	360	0.83%	0.75%	1.11	7	1.46%	0.78%	1.87
Csic	347	1.46%	0.72%	2.02	7	1.46%	0.72%	2.02
Univ Texas	346	1.46%	0.72%	2.02	7	1.46%	0.43%	3.38
Univ Calif/Berkeley	330	4.58%	0.69%	6.66	7	1.46%	0.72%	2.02

Table 9.
1998

Institution Name	Total Records 936				Most Cited: 5% (39 CITES MIN)			
	# Rec	CIT/%	PUB%	CIT/PUB	# Rec	CIT/%	PUB%	CIT/PUB
Korea Adv Inst Sci & Technol	135	17.02%	14.42%	1.18	10	21.28%	13.89%	1.53
Seoul Natl Univ	130	21.28%	13.89%	1.53	8	17.02%	14.42%	1.18
Korea Inst Sci & Technol	88	10.64%	9.40%	1.13	5	10.64%	9.40%	1.13
Yonsei Univ	69	2.13%	7.37%	0.29	5	10.64%	6.20%	1.72
Elect & Telecommun Res Inst	63	2.13%	6.73%	0.32	4	8.51%	1.71%	4.98
Pohang Univ Sci & Technol	58	10.64%	6.20%	1.72	4	8.51%	5.98%	1.42
Hanyang Univ	56	8.51%	5.98%	1.42	3	6.38%	3.10%	2.06
Korea Univ	45	4.26%	4.81%	0.89	3	6.38%	3.31%	1.93
Korea Res Inst Stand & Sci	36	6.38%	3.85%	1.66	3	6.38%	2.14%	2.99
Chungnam Natl Univ	31	6.38%	3.31%	1.93	3	6.38%	3.85%	1.66
Chonnam Natl Univ	29	6.38%	3.10%	2.06	3	6.38%	1.39%	4.60
Pusan Natl Univ	26	2.13%	2.78%	0.77	2	4.26%	0.75%	5.69
Sungkyunkwan Univ	26	0.00%	2.78%	0.00	2	4.26%	0.85%	4.98
Samsung Adv Inst Technol	25	0.00%	2.67%	0.00	2	4.26%	4.81%	0.89
Chonbuk Natl Univ	21	0.00%	2.24%	0.00	2	4.26%	0.75%	5.69
Kwangju Univ	21	0.00%	2.24%	0.00	1	2.13%	0.11%	19.92
Inha Univ	20	2.13%	2.14%	1.00	1	2.13%	0.11%	19.92
Korea Res Inst Chem Technol	20	6.38%	2.14%	2.99	1	2.13%	6.73%	0.32
Kwangju Inst Sci & Technol	20	0.00%	2.14%	0.00	1	2.13%	0.11%	19.92
Kyung Hee Univ	20	0.00%	2.14%	0.00	1	2.13%	0.96%	2.21

Table 10.

Institution Name	1999-2000				Most Cited: 5% (41 CITES MIN)					
	Total Records 2423	# Rec	CIT%	PUB%	CIT/PUB	Institution Name	# Rec	CIT%	PUB%	CIT/PUB
Seoul Natl Univ	337	25.41%	13.91%	1.83	1.83	Seoul Natl Univ	31	25.41%	13.91%	1.83
Korea Adv Inst Sci & Technol	287	22.13%	11.84%	1.87	1.87	Korea Adv Inst Sci & Technol	27	22.13%	11.84%	1.87
Korea Inst Sci & Technol	201	5.74%	8.30%	0.69	0.69	Jeonbuk Natl Univ	9	7.38%	0.66%	11.17
Yonsei Univ	156	2.46%	6.44%	0.38	0.38	Kent State Univ	7	5.74%	0.41%	13.90
Hanyang Univ	147	2.46%	6.07%	0.41	0.41	Korea Inst Sci & Technol	7	5.74%	8.30%	0.69
Pohang Univ Sci & Technol	138	4.10%	5.70%	0.72	0.72	Samsung Adv Inst Technol	7	5.74%	3.10%	1.85
Korea Univ	130	4.10%	5.37%	0.76	0.76	Korea Res Inst Stand & Sci	6	4.92%	4.09%	1.20
Korea Res Inst Stand & Sci	99	4.92%	4.09%	1.20	1.20	Inha Univ	5	4.10%	2.85%	1.44
Sungkyunkwan Univ	85	2.46%	3.51%	0.70	0.70	Korea Univ	5	4.10%	5.37%	0.76
Chungnam Natl Univ	82	0.82%	3.38%	0.24	0.24	Kunsan Natl Univ	5	4.10%	0.70%	5.84
Elect & Telecommun Res Inst	78	0.82%	3.22%	0.25	0.25	Pohang Univ Sci & Technol	5	4.10%	5.70%	0.72
Chonbuk Natl Univ	75	1.64%	3.10%	0.53	0.53	Tohoku Univ	5	4.10%	0.91%	4.51
Samsung Adv Inst Technol	75	5.74%	3.10%	1.85	1.85	Univ Calif Berkeley	4	3.28%	0.45%	7.22
Chonnam Natl Univ	73	1.64%	3.01%	0.54	0.54	Univ Illinois	4	3.28%	0.74%	4.41
Inha Univ	69	4.10%	2.85%	1.44	1.44	Hanyang Univ	3	2.46%	6.07%	0.41
Kwangju Inst Sci & Technol	65	1.64%	2.68%	0.61	0.61	Korea Res Inst Chem Technol	3	2.46%	2.27%	1.08
Kwangwoon Univ	57	1.64%	2.35%	0.70	0.70	Sogang Univ	3	2.46%	1.57%	1.57
Kyungpook Natl Univ	56	0.82%	2.31%	0.35	0.35	Sungkyunkwan Univ	3	2.46%	3.51%	0.70
Pusan Natl Univ	56	0.82%	2.31%	0.35	0.35	Univ Gesamthoch				
Korea Res Inst Chem Technol	55	2.46%	2.27%	1.08	1.08	Paderborn	3	2.46%	0.21%	11.91
Kyung Hee Univ	53	0.82%	2.19%	0.37	0.37	Univ Utah	3	2.46%	0.70%	3.50
						Yonsei Univ	3	2.46%	6.44%	0.38

Table 11.

		2001-2002				Most Cited: 5% (36 CITES MIN)				
Institution Name	Total Records 3617	# Rec	CIT%	PUB%	CIT/PUB	Institution Name	# Rec	CIT%	PUB%	CIT/PUB
Seoul Natl Univ	478	478	16.02%	13.22%	1.21	Korea Adv Inst Sci & Technol	36	19.89%	12.30%	1.62
Korea Adv Inst Sci & Technol	445	445	19.89%	12.30%	1.62	Seoul Natl Univ	29	16.02%	13.22%	1.21
Hanyang Univ	311	311	8.29%	8.60%	0.96	Pohang Univ Sci & Technol	19	10.50%	5.09%	2.06
Korea Inst Sci & Technol	292	292	4.97%	8.07%	0.62	Hanyang Univ	15	8.29%	8.60%	0.96
Yonsei Univ	274	274	5.52%	7.58%	0.73	Samsung Adv Inst	15	8.29%	3.95%	2.10
Sungkyunkwan Univ	189	189	4.97%	5.23%	0.95	Inha Univ	11	6.08%	3.12%	1.95
Pohang Univ Sci & Technol	184	184	10.50%	5.09%	2.06	Korea Univ	11	6.08%	4.73%	1.29
Korea Univ	171	171	6.08%	4.73%	1.29	Yonsei Univ	10	5.52%	7.58%	0.73
Kwangju Inst Sci & Technol	150	150	4.42%	4.15%	1.07	Korea Inst Sci & Technol	9	4.97%	8.07%	0.62
Chonbuk Natl Univ	147	147	3.87%	4.06%	0.95	Sungkyunkwan Univ	9	4.97%	5.23%	0.95
Samsung Adv Inst Technol	143	143	8.29%	3.95%	2.10	Kwangju Inst Sci & Technol	8	4.42%	4.15%	1.07
Chungnam Natl Univ	120	120	1.10%	3.32%	0.33	Chonbuk Natl Univ	7	3.87%	4.06%	0.95
Inha Univ	113	113	6.08%	3.12%	1.95	Jeonbuk Natl Univ	6	3.31%	0.50%	6.66
Kyungpook Natl Univ	104	104	0.55%	2.88%	0.19	Hannam Univ	5	2.76%	0.55%	5.00
Korea Res Inst Stand & Sci	95	95	1.66%	2.63%	0.63	Carnegie Mellon Univ	4	2.21%	0.17%	13.32
Elect & Telecommun Res Inst	87	87	2.21%	2.41%	0.92	Elect & Telecommun Res Inst	4	2.21%	2.41%	0.92
Pusan Natl Univ	85	85	2.21%	2.35%	0.94	Kent State Univ	4	2.21%	0.19%	11.42
Korea Res Inst Chem Technol	84	84	2.21%	2.32%	0.95	Korea Res Inst Chem Technol	4	2.21%	2.32%	0.95
Kwangwoon Univ	75	75	0.00%	2.07%	0.00	Pusan Natl Univ	4	2.21%	2.35%	0.94
Chonnam Natl Univ	66	66	0.55%	1.82%	0.30	Tohoku Univ	4	2.21%	0.69%	3.20

Table 12.

Total Records 2640		2003					Most Cited: 5% (27 CITES MIN)				
Institution Name	# Rec	CIT%	PUB%	CIT/PUB	Institution Name	# Rec	CIT%	PUB%	CIT/PUB		
Seoul Natl Univ	391	25.00%	14.81%	1.69	Seoul Natl Univ	33	25.00%	14.81%	1.69		
Korea Adv Inst Sci & Technol	249	14.39%	9.43%	1.53	Korea Adv Inst Sci & Technol	19	14.39%	9.43%	1.53		
Hanyang Univ	235	3.79%	8.90%	0.43	Pohang Univ Sci & Technol	19	14.39%	5.30%	2.72		
Sungkyunkwan Univ	178	3.79%	6.74%	0.56	Chonbuk Natl Univ	8	6.06%	3.86%	1.57		
Korea Inst Sci & Technol	175	3.03%	6.63%	0.46	Yonsei Univ	8	6.06%	6.25%	0.97		
Yonsei Univ	165	6.06%	6.25%	0.97	Kwangju Inst Sci & Technol	7	5.30%	2.92%	1.82		
Korea Univ	149	3.03%	5.64%	0.54	Samsung Adv Inst Technol	7	5.30%	2.95%	1.80		
Pohang Univ Sci & Technol	140	14.39%	5.30%	2.72	Korea Res Inst Stand & Sci	6	4.55%	3.22%	1.41		
Inha Univ	105	0.76%	3.98%	0.19	Hanyang Univ	5	3.79%	8.90%	0.43		
Chonbuk Natl Univ	102	6.06%	3.86%	1.57	Sungkyunkwan Univ	5	3.79%	6.74%	0.56		
Chungnam Natl Univ	95	0.76%	3.60%	0.21	Chonnam Natl Univ	4	3.03%	2.16%	1.40		
Korea Res Inst Stand & Sci	85	4.55%	3.22%	1.41	Korea Inst Sci & Technol	4	3.03%	6.63%	0.46		
Pusan Natl Univ	81	3.03%	3.07%	0.99	Korea Univ	4	3.03%	5.64%	0.54		
Kyungpook Natl Univ	80	2.27%	3.03%	0.75	MIT	4	3.03%	0.45%	6.67		
Samsung Adv Inst Technol	78	5.30%	2.95%	1.80	Oak Ridge Natl Lab	4	3.03%	0.30%	10.00		
Kwangju Inst Sci & Technol	77	5.30%	2.92%	1.82	Pusan Natl Univ	4	3.03%	3.07%	0.99		
Elect & Telecommun Res Inst	72	0.00%	2.73%	0.00	Ewha Womans Univ	3	2.27%	0.87%	2.61		
Korea Res Inst Chem Technol	63	2.27%	2.39%	0.95	Korea Inst Energy Res	3	2.27%	0.34%	6.67		
Chonnam Natl Univ	57	3.03%	2.16%	1.40	Korea Res Inst Chem Technol	3	2.27%	2.39%	0.95		
Kyung Hee Univ	43	1.52%	1.63%	0.93	Kyoto Univ	3	2.27%	0.30%	7.50		
Chung Ang Univ	38	0.00%	1.44%	0.00	Kyungpook Natl Univ	3	2.27%	3.03%	0.75		
Sejong Univ	37	1.52%	1.40%	1.08	Sogang Univ	3	2.27%	0.98%	2.31		