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From materials science to nano-ceramics: Citation analysis identifies the key journals and players

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The *Science Citation Index* was designed primarily to help the scientist or engineer retrieve relevant literature on specific topics. This database is now on-line as part of *ISIs Web of Science* and covers over thirty million papers containing nearly a half-billion cited references. For each source paper included, backward and foreward links are provided to the cited and citing papers. ISI also publishes additional databases such as the *Journal Citation Reports* and *Journal Performance Indicators* which can provide qualitative and quantitative information on thousands of journals, including impact factors. Using these files and a variety of bibliometric techniques we demonstrate how to identify the core journals of materials science, ceramics, and nano-ceramics. Other ISI resources such as *ISI Essential Science Indicators* identify the leading countries, institutions, and authors of materials science. The output of a *WoS* search is used to analyze over 10,000 papers on nano-crystals and nano-ceramics. We have identified dozens of highly-cited papers, which are visualized as a series of historiographs and topological maps These *HistCite* maps and tables demonstrate the chronological development of the field [1].

Key words: nano-ceramics, Science citation index, Ctation analysis, Web of science, ISI.

Introduction

Rustum Roy has often spoken about the ethical responsibilities of research scientists, including the proper use of the archive of published knowledge. Publishing scientists and engineers should not only keep up with the literature, but also, when publishing, they should accurately cite relevant prior sources.

Since I became an information scientist 50 years ago, I have promoted the radical notion that editors should hold authors to the same "due diligence" standards required by patent examiners for inventors. Authors, like inventors, should formally assert to their best knowledge that their ideas are original. This implies they do not unwittingly duplicate discoveries already reported in the literature. Authors should be required to acknowledge the "prior art" that influenced their research directly or indirectly and spell out the exact parameters of their literature searches. These historical antecedents are critical for newcomers and students.

To accomplish this task has never been easy. In the past, diligent scientists and engineers spent days in the library searching printed indexes and abstracting services, library catalogs, as well as textbooks and journals. Today, we have electronic tools for searching. Nevertheless authors complain about information overload. They often use that excuse to ignore the literature. I remember hearing that same complaint decades ago. Not long ago in *The Scientist* we published a series of letters from senior scientists who complained about the "disregard" syndrome. Younger scientists often say that if it isn't electronic it doesn't exist!! [1].

It has never been entirely clear to me why so many researchers are unwilling to attend to these tasks. Sometimes I think it is due to overly exaggerated statements about the size of the literature. But maybe it is due to human vanity-scientists often fear to learn that their work is not entirely novel. And the history of science is full of examples which justify those fears.

The Size of the Literature

The *Science Citation Index*® consistently demonstrates that about 90 percent of the millions of references cited each year were published sometime in the past three decades. And 50 percent involve papers published in the last ten years. As in earlier decades, the vast majority of citations are to relatively recent papers. Nevertheless, authors continue to cite relatively older works. If indeed 90% of what is cited is less than 30 years old, then 10% are over that age. ISI processes about 20 million cited references per year. That means two million are over 30 years old! This percentage might even increase in the future as more electronic legacy files are created. What people read is not necessarily what they cite when publishing. Nevertheless, electronic access to the full texts of the older journals significantly increases its use [2].

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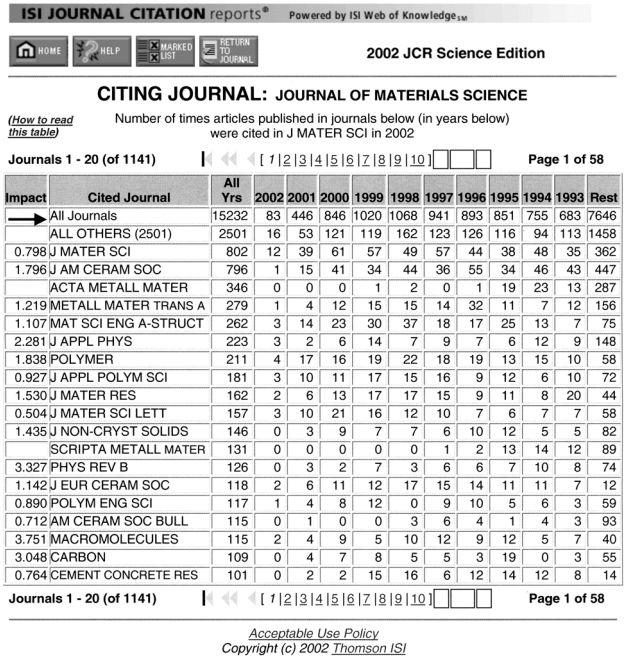

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CITING JOURNAL: JOURNAL OF MATERIALS SCIENCE

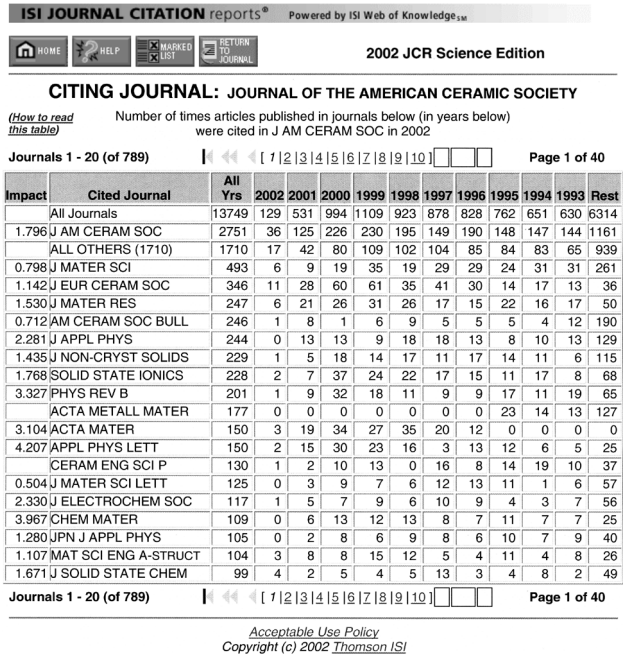
(How to read this table) Number of times articles published in journals below (in years below) were cited in J MATER SCI in 2002

Journals 1 - 20 (of 1141) [1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10] Page 1 of 58

Impact	Cited Journal	All Yrs	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	Rest
→	All Journals	15232	83	446	846	1020	1068	941	893	851	755	683	7646
	ALL OTHERS (2501)	2501	16	53	121	119	162	123	126	116	94	113	1458
0.798	J MATER SCI	802	12	39	61	57	49	57	44	38	48	35	362
1.796	J AM CERAM SOC	796	1	15	41	34	44	36	55	34	46	43	447
	ACTA METALL MATER	346	0	0	0	1	2	0	1	19	23	13	287
1.219	METALL MATER TRANS A	279	1	4	12	15	15	14	32	11	7	12	156
1.107	MAT SCI ENG A-STRUCT	262	3	14	23	30	37	18	17	25	13	7	75
2.281	J APPL PHYS	223	3	2	6	14	7	9	7	6	12	9	148
1.838	POLYMER	211	4	17	16	19	22	18	19	13	15	10	58
0.927	J APPL POLYM SCI	181	3	10	11	17	15	16	9	12	6	10	72
1.530	J MATER RES	162	2	6	13	17	17	15	9	11	8	20	44
0.504	J MATER SCI LETT	157	3	10	21	16	12	10	7	6	7	7	58
1.435	J NON-CRYST SOLIDS	146	0	3	9	7	7	6	10	12	5	5	82
	SCRIPTA METALL MATER	131	0	0	0	0	0	1	2	13	14	12	89
3.327	PHYS REV B	126	0	3	2	7	3	6	6	7	10	8	74
1.142	J EUR CERAM SOC	118	2	6	11	12	17	15	14	11	11	7	12
0.890	POLYM ENG SCI	117	1	4	8	12	0	9	10	5	6	3	59
0.712	AM CERAM SOC BULL	115	0	1	0	0	3	6	4	1	4	3	93
3.751	MACROMOLECULES	115	2	4	9	5	10	12	9	12	5	7	40
3.048	CARBON	109	0	4	7	8	5	5	3	19	0	3	55
0.764	CEMENT CONCRETE RES	101	0	2	2	15	16	6	12	14	12	8	14

Journals 1 - 20 (of 1141) [1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10] Page 1 of 58

Fig. 1. 2002 *JCR* Citing Journal Listing for *Journal of Materials* Science.



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CITING JOURNAL: JOURNAL OF THE AMERICAN CERAMIC SOCIETY

(How to read this table) Number of times articles published in journals below (in years below) were cited in J AM CERAM SOC in 2002

Journals 1 - 20 (of 789) [1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10] Page 1 of 40

Impact	Cited Journal	All Yrs	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	Rest
	All Journals	13749	129	531	994	1109	923	878	828	762	651	630	6314
1.796	J AM CERAM SOC	2751	36	125	226	230	195	149	190	148	147	144	1161
	ALL OTHERS (1710)	1710	17	42	80	109	102	104	85	84	83	65	939
0.798	J MATER SCI	493	6	9	19	35	19	29	29	24	31	31	261
1.142	J EUR CERAM SOC	346	11	28	60	61	35	41	30	14	17	13	36
1.530	J MATER RES	247	6	21	26	31	26	17	15	22	16	17	50
0.712	AM CERAM SOC BULL	246	1	8	1	6	9	5	5	5	4	12	190
2.281	J APPL PHYS	244	0	13	13	9	18	18	13	8	10	13	129
1.435	J NON-CRYST SOLIDS	229	1	5	18	14	17	11	17	14	11	6	115
1.768	SOLID STATE IONICS	228	2	7	37	24	22	17	15	11	17	8	68
3.327	PHYS REV B	201	1	9	32	18	11	9	9	17	11	19	65
	ACTA METALL MATER	177	0	0	0	0	0	0	0	23	14	13	127
3.104	ACTA MATER	150	3	19	34	27	35	20	12	0	0	0	0
4.207	APPL PHYS LETT	150	2	15	30	23	16	3	13	12	6	5	25
	CERAM ENG SCI P	130	1	2	10	13	0	16	8	14	19	10	37
0.504	J MATER SCI LETT	125	0	3	9	7	6	12	13	11	1	6	57
2.330	J ELECTROCHEM SOC	117	1	5	7	9	6	10	9	4	3	7	56
3.967	CHEM MATER	109	0	6	13	12	13	8	7	11	7	7	25
1.280	JPN J APPL PHYS	105	0	2	8	6	9	8	6	10	7	9	40
1.107	MAT SCI ENG A-STRUCT	104	3	8	8	15	12	5	4	11	4	8	26
1.671	J SOLID STATE CHEM	99	4	2	5	4	5	13	3	4	8	2	49

Journals 1 - 20 (of 789) [1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10] Page 1 of 40

Fig. 2. 2002 *JCR* Citing Journal Listing for Journal of the American Ceramic Society.

What I have said so far is a general observation on the whole of science and technology literature. The age distribution of the cited literature varies from field to field. What about materials science?

Figure 1 is taken from the 2002 Journal *Citation Reports (JCR)* published by ISI. The first line shows the total number of references cited by the *Journal of Materials* Science in 2002, followed by the number cited for each previous year in reverse chronological order until 1993 followed by the "rest." As you can see, there were 15,232 references cited in the 2002 issues of this journal. Of these, 49.8% were to papers published from 1993-2002. The remaining 50.2% were papers or books older than 10 years. This tells us that materials science is significantly different than other fields in the age distribution of its cited references. Only 21% of references cited in the *Journal of Biological* Chemistry are over ten years old and even less for journals in molecular biology!

What about the field of ceramics? A comparable analysis for the *Journal of the American Ceramic* Society shows that 47% are to the last decade, thus confirming the pattern for the material sciences. Another way to express these ideas is to say that materials science and ceramics have low "immediacy" or relatively high half-life. It will be interesting to see how and if the numbers change as more electronic legacy files are created in the future. In the past, the time and effort involved in using the then available printed indexes to *Chemical Abstracts, Physics Abstracts, Engineering Abstracts,* etc. discouraged authors from searching the literature. While electronic on-line access to Dialog and other vendors in the 1970s made it easier to search the literature, researchers continued to rely on library specialists to deal with the techno-Babel of search languages "spoken" by each database. However, the revolution in personal computer and compact disk technologies initially enabled researchers to personally access -- directly, conveniently, and rapidly -- vast bibliographic databases. These technologies also offered many more search options than were available with printed indexes. ISI has published CD-ROM products since 1980 and still publishes a

CD-ROM Citation Index product covering materials science. However, for this paper, it is simpler for me to demonstrate searches of the *Science Citation Index* by using the *Web of Science* online edition to perform a topical search on nano-ceramics.

The *Materials Science Citation Index (MSCI)* on CD-ROM [3] was launched a little over ten years ago to meet the specific information needs of materials science researchers. It fully covers more than 500 of the leading journals in this specialty, including many publications and conference material not covered as sources in the *Science Citation Index.* Additionally, the *MSCI* includes selective coverage of the thousands of other source journals in the *Web of Science*. On an annual basis, the MSCI indexes about 150,000 individual materials articles selected from over 1,700 journals.

There are some popular myths about the scientific literature, which would have you believe there are over 120,000 Sci-Tech journals published. In reality there are only about 15,000 substantive [4, 5] scientific journals published today. The mythical estimate includes not just primary research journals but also thousands of trade and popular magazines, newsletters, annual reports,

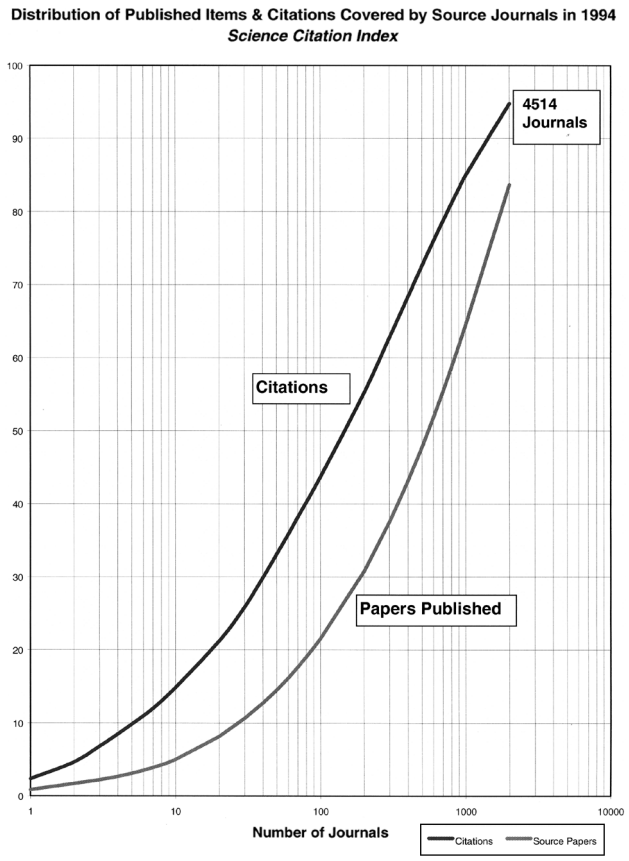

Fig. 3. Distribution of Published Papers and Citations Covered by Source Journals in 1994 *SCI.*

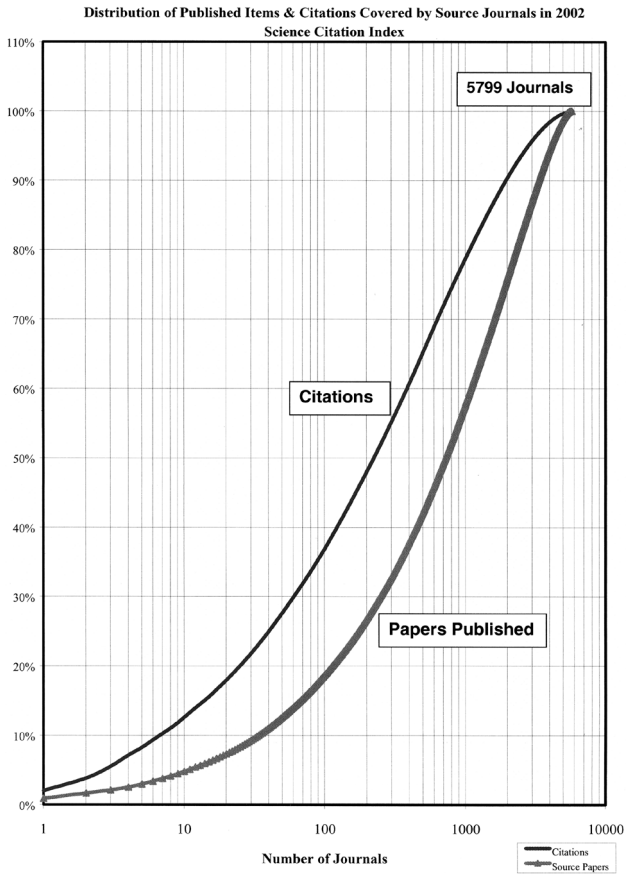

Fig. 4. Distribution of Published Papers and Citations Covered by Source Journals in 2002 *SCI.*

and so on. Without proper quantitative and qualitative definitions, estimates of primary research journals are meaningless. ISIs data consistently show that a comparatively small number of journals accounts for the vast majority of what is published and what is cited. This is demonstrated in the following graph.

Figure 3 shows the percentage of papers and citations covered by ISIs source journals in 1994.

The data shown here are based on about 4,500 journals that were covered in the 1994 *SCI Journal Citation Reports.* The blue line shows that just 100 journals accounted for more than 20 percent of the articles covered in *SCI*. Even more interesting, the pink line shows that 100 journals accounted for more than 40 percent of the papers cited. 600 journals accounted for more than half of what is indexed -- and over 75 percent of the citations.

The comparable data for 2002 is reported in Fig. 4. By indexing 6,000 journals, ISI is confident that it is capturing not only the most significant journals of international research but also a large component of the low-impact literature as well. In 2002, however, 100 journals account for 18% of the papers published and 37% of the citations.

Another rough way to estimate the journal population is to assume that the average journal publishes100 articles per year. Taking the previous estimate of

2002 *JCR* SCIENCE EDITION JOURNAL SUMMARY LIST

Selection: MATERIALS SCIENCE, CERAMICS
Sorted by: Impact Factor SORT AGAIN JOURNAL TITLE CHANGES

Journals 1 - 20 (of 24) [1 | 2] **Page 1 of 2**

MARK ALL UPDATE MARKED LIST *Ranking is based on your journal and sort selections.*

Mark	Rank	Abbreviated Journal Title *(linked to full journal information)*	2002 Total Cites	Impact Factor	Immediacy Index	2002 Articles	Cited Half-life
☐	1	J AM CERAM SOC	21957	1.796	0.210	562	10.0
☐	2	J NON-CRYST SOLIDS	13204	1.435	0.149	792	8.4
☐	3	J EUR CERAM SOC	3482	1.142	0.264	348	4.2
☐	4	J ELECTROCERAM	255	1.033	0.097	31	3.5
☐	5	J SOL-GEL SCI TECHN	1295	0.897	0.209	86	4.9
☐	6	CERAM INT	847	0.731	0.081	136	5.5
☐	7	AM CERAM SOC BULL	2322	0.712	0.115	78	>10.0
☐	8	PHYS CHEM GLASSES	1308	0.691	0.222	36	>10.0
☐	9	J CERAM SOC JPN	1340	0.688	0.083	218	5.7
☐	10	KEY ENG MATER	1187	0.497	0.059	1267	4.9
☐	11	BRIT CERAM T	719	0.362	0.041	49	>10.0
☐	12	CERAM-SILIKATY	77	0.354	0.115	26	
☐	13	GLASS TECHNOL	281	0.345	0.125	24	>10.0
☐	14	CFI-CERAM FORUM INT	134	0.273	0.018	56	5.8
☐	15	BOL SOC ESP CERAM V	152	0.250	0.068	73	3.6
☐	16	GLASS PHYS CHEM+	151	0.232	0.136	66	4.5
☐	17	J INORG MATER	260	0.222	0.057	227	3.7
☐	18	IND CERAM	86	0.186	0.059	17	
☐	19	GLASS SCI TECHNOL	117	0.170	0.108	37	3.6
☐	20	GLASS CERAM+	272	0.154	0.049	82	>10.0

Fig. 5. Materials Science, Ceramics Journals (from 2002 JCR).

2002 JCR SCIENCE EDITION JOURNAL SUMMARY LIST

Selection: MATERIALS SCIENCE, CERAMICS
Sorted by: Total Cites SORT AGAIN JOURNAL TITLE CHANGES

Journals 1 - 20 (of 24) [1 | 2] Page 1 of 2
MARK ALL UPDATE MARKED LIST *Ranking is based on your journal and sort selections.*

Mark	Rank	Abbreviated Journal Title *(linked to full journal information)*	2002 Total Cites	Impact Factor	Immediacy Index	2002 Articles	Cited Half-life
☐	1	J AM CERAM SOC	21957	1.796	0.210	562	10.0
☐	2	J NON-CRYST SOLIDS	13204	1.435	0.149	792	8.4
☐	3	J EUR CERAM SOC	3482	1.142	0.264	348	4.2
☐	4	AM CERAM SOC BULL	2322	0.712	0.115	78	>10.0
☐	5	J CERAM SOC JPN	1340	0.688	0.083	218	5.7
☐	6	PHYS CHEM GLASSES	1308	0.691	0.222	36	>10.0
☐	7	J SOL-GEL SCI TECHN	1295	0.897	0.209	86	4.9
☐	8	KEY ENG MATER	1187	0.497	0.059	1267	4.9
☐	9	CERAM INT	847	0.731	0.081	136	5.5
☐	10	BRIT CERAM T	719	0.362	0.041	49	>10.0
☐	11	POWDER METALL MET C+	317	0.138	0.028	72	>10.0
☐	12	GLASS TECHNOL	281	0.345	0.125	24	>10.0
☐	13	GLASS CERAM+	272	0.154	0.049	82	>10.0
☐	14	J INORG MATER	260	0.222	0.057	227	3.7
☐	15	J ELECTROCERAM	255	1.033	0.097	31	3.5
☐	16	BOL SOC ESP CERAM V	152	0.250	0.068	73	3.6
☐	17	GLASS PHYS CHEM+	151	0.232	0.136	66	4.5
☐	18	CFI-CERAM FORUM INT	134	0.273	0.018	56	5.8
☐	19	GLASS SCI TECHNOL	117	0.170	0.108	37	3.6
☐	20	SILIC IND	115	0.128	0.000	13	>10.0

Fig. 6. Materials Science, Ceramics Journals Sorted by Times Cited.

2002 JCR SCIENCE EDITION JOURNAL SUMMARY LIST

Selection: MATERIALS SCIENCE, CERAMICS
Sorted by: Current Articles SORT AGAIN JOURNAL TITLE CHANGES

Journals 1 - 20 (of 24) [1 | 2] Page 1 of 2
MARK ALL UPDATE MARKED LIST *Ranking is based on your journal and sort selections.*

Mark	Rank	Abbreviated Journal Title *(linked to full journal information)*	2002 Total Cites	Impact Factor	Immediacy Index	2002 Articles	Cited Half-life
☐	1	KEY ENG MATER	1187	0.497	0.059	1267	4.9
☐	2	J NON-CRYST SOLIDS	13204	1.435	0.149	792	8.4
☐	3	J AM CERAM SOC	21957	1.796	0.210	562	10.0
☐	4	J EUR CERAM SOC	3482	1.142	0.264	348	4.2
☐	5	J INORG MATER	260	0.222	0.057	227	3.7
☐	6	J CERAM SOC JPN	1340	0.688	0.083	218	5.7
☐	7	CERAM INT	847	0.731	0.081	136	5.5
☐	8	MATER WORLD	103	0.145	0.024	124	4.5
☐	9	J SOL-GEL SCI TECHN	1295	0.897	0.209	86	4.9
☐	10	GLASS CERAM+	272	0.154	0.049	82	>10.0
☐	11	AM CERAM SOC BULL	2322	0.712	0.115	78	>10.0
☐	12	BOL SOC ESP CERAM V	152	0.250	0.068	73	3.6
☐	13	POWDER METALL MET C+	317	0.138	0.028	72	>10.0
☐	14	GLASS PHYS CHEM+	151	0.232	0.136	66	4.5
☐	15	REFRACT IND CERAM+	6	0.016	0.000	59	
☐	16	CFI-CERAM FORUM INT	134	0.273	0.018	56	5.8
☐	17	BRIT CERAM T	719	0.362	0.041	49	>10.0
☐	18	GLASS SCI TECHNOL	117	0.170	0.108	37	3.6
☐	19	PHYS CHEM GLASSES	1308	0.691	0.222	36	>10.0
☐	20	J ELECTROCERAM	255	1.033	0.097	31	3.5

Fig. 7. Materials Science, Ceramics Journals Sorted by Number of Articles.

15,000 journals, then the size of the annual literature should be about 1.5 million published articles.

Let's take a look at the journals in the field of ceramics. The *ISI Journal Citation Reports*® (*JCR*®) includes several categories under "materials science." One of them is devoted to ceramics. In Fig. 5, ceramics journals are ranked by Impact Factor: The 2002 journal impact factor is a measure of how often articles published in 2000-2001 have been cited in 2002. Not surprisingly, the *Journal of the American Ceramics Society* is at the top but note that two much smaller journals rank quite high.

The *JCR* uses several criteria to rank journals. In Fig. 6, we see the ranking by frequency of citation, that is, total cites for 2002.

Another perspective can be found by looking at the absolute number of 2002 articles published. The journal *Key Engineering Materials* published 1287 articles in 2002, followed by the *Journal of Non-Crystalline Solids* with 792.

Another ISI product called *Journal Performance Indicators* provides a cumulative historical analysis of citation and publication performance. *JPI* covers 22 years of the literature. Fig. 8 shows the ranking by papers published, citations, and impact for all items followed by impact for cited items only. For the *Journal of the American Ceramic Society*, the impact of the average article over the 22-year period is 15.15. But this does not tell you the extremes. Some articles are cited hundreds of times while others are never cited.

The literature of ceramics is quite large. In a conference on nano-ceramics, what can we say about the literature of this field? How can we identify the journals in which such articles are published?

As the first step in answering this question, let me show you how to use the *Web of Science* to search on the general topic of nano-ceramics.

In Fig. 9, I have shown the search window of the *Web of Science* for the title search for **Nanoceram* or (Nano* and Ceram*)** at the top and first page of results at the bottom.

In Fig. 10, I have plotted the results of that simple search year by year in *WoS* using the keywords *Nanoceram* or (Nano* and Ceram*)*. Just doing a title search produced a total of 571 papers. If we limit each search by year, we obtain the picture of the growth of this field. Starting with 1993, the literature has grown enormously, but especially since 2000 the growth has been spectacular.

Using a program which I will explain later, we obtained the following ranked list of journals for this topic. It is apparent that the literature of nano-ceramics involves many different journals including those in ceramics per se, materials science, as well as physics, chemistry, etc.. This list is quite different from what we found for the JCR listings for ceramics. In fact, over 200 different journals are represented in this search.

Journal Performance Indicators, 1986-2002
Materials Science, Ceramics

Ranked by Papers Published

Rank	Journal	Papers	Citations
1	J NON-CRYST	13,257	122,020
2	J AM CERAM	9,865	149,435
3	KEY ENG MAT	3,497	2,311
4	J EUR CERAM	2,851	10,647
5	AM CERAM S	2,447	18,164
6	J CERAM S J	1,844	3,305
7	J SOL-GEL S	1,265	4,048
8	CERAM INT	1,254	4,050
9	PHYS C GLAS	1,049	8,980
10	GLASTEC BER	777	3,312
11	GLASS TECH	761	1,749
12	BRIT CERAM	458	1,063
13	SILIKATY	323	431
14	BRIT CER T	319	1,670
15	GL SCI T-GL	264	143
16	T J BR CER	237	1,050
17	J ELECTROCE	219	569

Ranked by Total Citations

Rank	Journal	Citations	Papers
1	J AM CERAM	149,435	9,865
2	J NON-CRYST	122,020	13,257
3	AM CERAM S	18,164	2,447
4	J EUR CERAM	10,647	2,851
5	PHYS C GLAS	8,980	1,049
6	CERAM INT	4,050	1,254
7	J SOL-GEL S	4,048	1,265
8	GLASTEC BER	3,312	777
9	J CERAM S J	3,305	1,844
10	KEY ENG MAT	2,311	3,497
11	GLASS TECH	1,749	761
12	BRIT CER T	1,670	319
13	BRIT CERAM	1,063	458
14	T J BR CER	1,050	237
15	J ELECTROCE	569	219
16	SILIKATY	431	323
17	GL SCI T-GL	143	264

Citation Impact (All items)

Rank	Journal	Impact	Citations	Papers
1	J AM CERAM	15.15	149,435	9,865
2	J NON-CRYST	9.20	122,020	13257
3	PHYS C GLAS	8.56	8,980	1,049
4	AM CERAM S	7.42	18,164	2,447
5	BRIT CER T	5.24	1,670	319
6	T J BR CER	4.43	1,050	237
7	GLASTEC BER	4.26	3,312	777
8	J EUR CERAM	3.73	10,647	2,851
9	CERAM INT	3.23	4,050	1,254
10	J SOL-GEL S	3.20	4,048	1,265
11	J ELECTROCE	2.60	569	219
12	BRIT CERAM	2.32	1,063	458
13	GLASS TECH	2.30	1,749	761
14	J CERAM S J	1.79	3,305	1,844
15	SILIKATY	1.33	431	323
16	KEY ENG MT	0.66	2,311	3,497
17	GL SCI T-GL	0.54	143	264

Citation Impact (Cited Items Only)

Rank	Journal	Cited Impact	Cited Citations	Cited Papers
1	J AM CERAM	17.17	149,435	8,701
2	AM CERAM S	13.77	18,164	1,319
3	J NON-CRYST	12.12	122,020	10,070
4	PHYS C GLAS	10.54	8,980	852
5	BRIT CER T	7.32	1,670	228
6	T J BR CER	6.95	1,050	151
7	GLASTEC BER	5.75	3,312	576
8	J EUR CERAM	5.43	10,647	1,960
9	J SOL-GEL S	5.31	4,048	763
10	CERAM INT	4.80	4,050	844
11	J ELECTROCE	4.59	569	124
12	GLASS TECH	4.55	1,749	384
13	BRIT CERAM	3.94	1,063	270
14	J CERAM S J	3.14	3,305	1,052
15	KEY ENG AT	2.67	2,311	865
16	SILIKATY	2.49	431	173
17	GL SCI T-GL	1.79	143	80

Fig. 8. *Journal Performance Indicators, 1986-2002* for Materials Science, Ceramics, Including Papers, Citations, Citation Impact.

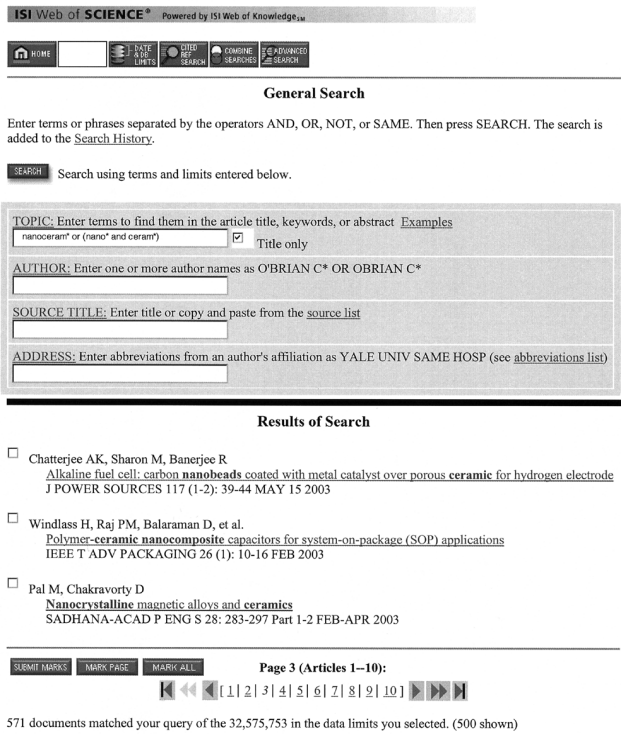

Fig. 9. Typical General Search on *Web of Science* Nanoceram* or (Nano* and Ceram*).

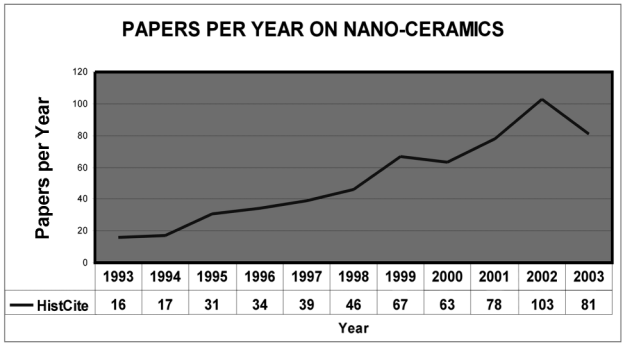

Fig. 10. Papers Per Year on Nano-Ceramics.

This is what information scientists would call a typical example of Bradford's Law [6].

Once we completed the *WoS* search on nano-ceramics, we took the output of the search and fed it into a program we call *HistCite.*™ *HistCite* analyzes the file and tells us which authors publish most and ranks the papers in the collection by citation frequency.

In Fig. 12, we see the first output of *HistCite* arranged by date. Note the two earliest papers were published in 1978 by Mock and Holt.

In Fig. 13, we have sorted the file by Local Citation Score, that is, by frequency in the collection of nano-ceramics papers. The paper by Roy and Chakravorty is at the top. This paper has been cited globally in the *SCI*

RANKED JOURNAL LIST
1978-2003 Papers with "nanoceram* or (nano* and ceram*)" in the title

Total: 212
Sorted by **pubs**

#	Title	Pubs
1	NANOSTRUCTURED MATERIALS	30
2	JOURNAL OF MATERIALS RESEARCH	24
3	ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY	22
4	JOURNAL OF THE AMERICAN CERAMIC SOCIETY	20
5	JOURNAL OF THE EUROPEAN CERAMIC SOCIETY	17
6	JOURNAL OF MATERIALS SCIENCE	15
7	JOURNAL OF MATERIALS SCIENCE LETTERS	15
8	MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING	14
9	JOURNAL OF APPLIED PHYSICS	12
10	SCRIPTA MATERIALIA	11
11	APPLIED PHYSICS LETTERS	10
12	EURO CERAMICS VII, PT 1-3	10
13	JOURNAL OF INORGANIC MATERIALS	8
14	JOURNAL OF THE CERAMIC SOCIETY OF JAPAN	8
15	CERAMICS INTERNATIONAL	8
16	SCIENCE OF ENGINEERING CERAMICS II	7
17	MATERIALS LETTERS	7
18	THIN SOLID FILMS	7
19	JOURNAL OF MATERIALS CHEMISTRY	6
20	JOURNAL OF ALLOYS AND COMPOUNDS	6
21	ADVANCED MATERIALS	6
22	JOURNAL OF MEMBRANE SCIENCE	6
23	BRITISH CERAMIC TRANSACTIONS	6
24	METASTABLE, MECHANICALLY ALLOYED AND NANOCRYSTALLINE MATERIALS, PTS 1 AND 2	5
25	FERROELECTRICS	5
26	CFI-CERAMIC FORUM INTERNATIONAL	5
27	CHEMISTRY OF MATERIALS	5
28	MATERIALS RESEARCH BULLETIN	4
29	BIOMATERIALS	4
30	JOURNAL OF NON-CRYSTALLINE SOLIDS	4

Fig. 11. Ranked Journal List Showing Papers Published on Nano-Ceramics.

59 times. Note that the second paper is a 1996 paper cited 75 times. This is also seen in the next Fig..

In Fig. 14, we see the sort by global score which brings new papers to the top of the rankings. The global score is the citation count for the entire scientific literature, the frequency you would observe in the *WoS* search. The paper by Page et al in the 1992 *Journal of Materials Research* was cited 168 times.

In Fig. 15, we see the list of so-called Outer References. This is a list of papers that were frequently cited in our collection of nano-ceramics papers but did not contain the keywords in the title. Note that many of these papers by definition were published before the earliest paper in the collection. Since *HistCite* is designed to be an interactive process we can easily add these earlier papers to our collection. To do this, we use the autolink to *Wos* which retrieves the bibliographic data. We then add that information to the *HistCite* file as can be seen in Fig. 16.

In Fig. 16, we have the new *HistCite* file.

All users of bibliographic databases are aware of the problems involved in using terminology to conduct literature searches. To bypass these problems we take advantage of *SCI*s unique cited reference search

Outer References Missing Links? Journal list All-Author list Citation Matrix Graphs HistCite Guide

1978-2003 Papers with "nanoceram* or (nano* and ceram*)" in the title

Nodes: 571
Sorted by **year, journal, volume, page**.
Page **1**: 1 2 **Chronological**

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	1 1978 BULLETIN OF THE AMERICAN PHYSICAL SOCIETY 23(1):35-35 **MOCK W; HOLT WH** *Electrical Response of Shock-Depoled PZT 56-44 snd PZT 95-5 Ferroelectric Ceramics into Nanofarad Capacitor Loads*	1	0
2	0	2 1978 JOURNAL OF APPLIED PHYSICS 49(12):5846-5854 **MOCK W; HOLT WH** *Pulse Charging of Nanofarad Capacitors grom yhe Shock Depoling of PZT 56-44 and PZT 95-5 Ferroelectric Ceramics*	6	0
3	0	3 1980 AMERICAN CERAMIC SOCIETY BULLETIN 59(8):838-838 **CROSS LE** *Effects of Some Macrostructural, Microstructural and Nanostructural Features on the Properties of Electronic Ceramics*	0	0
4	0	4 1987 JOURNAL OF ELECTRON MICROSCOPY TECHNIQUE 7(4):301-312 **WEN SL** *Some Nanostructural Features in Ceramics*	1	0
5	0	5 1988 ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY 196():41-IEC **AKINC M** *Nanosize Ceramic Powders by Homogeneous Precipitation*	0	0
6	0	6 1988 SOLID STATE IONICS 26(2):149-149 **BURGGRAAF AJ; KEIZER K; VANHASSEL B** *Ceramic Membranes and Nanoscale Composite Layers*	0	0
7	0	7 1989 SOLID STATE IONICS 32-3():771-782 **BURGGRAAF AJ; KEIZER K; VANHASSEL BA** *Ceramic Nanostructure Materials, Membranes and Composite Layers*	29	0
8	0	8 1990 CERAMICS INTERNATIONAL 16(5):291-294 **KARCH J; BIRRINGER R** *Nanocrystalline Ceramics - Possible Candidates for Net-Shape Forming*	39	2
9	0	9 1990 CHEMISTRY OF MATERIALS 2(6):772-776 **NANDI M; CONKLIN JA; SALVATI L; SEN A** *Molecular-Level Ceramic Polymer Composites .1. Synthesis of Polymer-Trapped Oxide Nanoclusters of Chromium and Iron*	32	1
10	0	10 1990 JOURNAL OF MATERIALS SCIENCE 25(4):2118-2124 **LIPOWITZ J; RABE JA; FREVEL LK; MILLER RL** *Characterization of Nanoporosity in Polymer-Derived Ceramic Fibers by X-Ray-Scattering Techniques*	21	

Fig. 12. Chronological *Histcite* File of Nano-Ceramics Papers 1978-2003.

Outer References Missing Links? Journal list All-Author list Citation Matrix Graphs HistCite Guide

1978-2003 Papers with "nanoceram* or (nano* and ceram*)" in the title

Nodes: 571
Sorted by **LCS**.
Page **1**: 1 2

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	11 1990 JOURNAL OF PHYSICS-CONDENSED MATTER 2(47):9323-9334 **ROY B; CHAKRAVORTY D** *Electrical Conductance of Silver Nanoparticles Grown in Glass Ceramic*	59	10
2	5	105 1996 INTERNATIONAL MATERIALS REVIEWS 41(3):85-115 **MAYO MJ** *Processing of nanocrystalline ceramics from ultrafine particles*	75	8
3	0	42 1993 MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING 166(1-2):145-159 **MAYO MJ; HAGUE DC; CHEN DJ** *Processing Nanocrystalline Ceramics for Applications in Superplasticity*	57	7
4	3	152 1997 JOURNAL OF THE EUROPEAN CERAMIC SOCIETY 17(9):1061-1082 **STERNITZKE M** *Structural ceramic nanocomposites*	76	7
5	0	41 1993 JOURNAL OF THE EUROPEAN CERAMIC SOCIETY 11(4):315-324 **THEUNISSEN GSAM; WINNUBST AJA; BURGGRAAF AJ** *Sintering Kinetics and Microstructure Development of Nanoscale Y-TZP Ceramics*	31	6
6	0	76 1995 JOURNAL OF THE CERAMIC SOCIETY OF JAPAN 103(9):901-909 **PEZZOTTI G; NISHIDA T; SAKAI M** *Physical Limitations of the Inherent Toughness and Strength in Ceramic-Ceramic and Ceramic-Metal Nanocomposites*	17	6
7	0	12 1990 JOURNAL OF THE AMERICAN CERAMIC SOCIETY 73(7):1983-1991 **KONDO K; SAWAI S** *Fabricating Nanocrystalline Diamond Ceramics by a Shock Compaction Method*	34	5
8	0	125 1996 NANOSTRUCTURED MATERIALS 7(8):835-845 **FERKEL H; RIEHEMANN W** *Bonding of alumina ceramics with nanoscaled alumina powders*	22	5
9	1	244 1999 JOURNAL OF THE AMERICAN CERAMIC SOCIETY 82(1):5-16 **BEALL GH; PINCKNEY LR** *Nanophase glass-ceramics*	24	5
10	0	306 2000 JOURNAL OF BIOMEDICAL MATERIALS RESEARCH 51(3):475-483 **WEBSTER TJ; ERGUN C; DOREMUS RH; SIEGEL RW; BIZIOS R** *Specific proteins mediate enhanced osteoblast adhesion on nanophase ceramics*	16	5

Fig. 13. Nano-Ceramics Papers Sorted by Local Citation Score.

capability. So we have not only done a search on nano-ceramics but have first added a dozen or so “outer references” to the file. These are papers that were

Outer References Missing Links? Journal list All-Author list Citation Matrix Graphs HistCite Guide

1978-2003 Papers with "nanoceram* or (nano* and ceram*)" in the title

Nodes: 571
Sorted by **GCS**.
Page **1**: 1 2

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	29 1992 JOURNAL OF MATERIALS RESEARCH 7(2):450-473 **PAGE TF; OLIVER WC; MCHARGUE CJ** *The Deformation-Behavior of Ceramic Crystals Subjected To Very Low Load (Nano)Indentations*	168	1
2	1	16 1991 CHEMISTRY OF MATERIALS 3(1):201-206 **NANDI M; CONKLIN JA; SALVATI L; SEN A** *Molecular-Level Ceramic Polymer Composites .2.1 Synthesis of Polymer-Trapped Silica and Titania Nanoclusters*	91	1
3	3	152 1997 JOURNAL OF THE EUROPEAN CERAMIC SOCIETY 17(9):1061-1082 **STERNITZKE M** *Structural ceramic nanocomposites*	76	7
4	5	105 1996 INTERNATIONAL MATERIALS REVIEWS 41(3):85-115 **MAYO MJ** *Processing of nanocrystalline ceramics from ultrafine particles*	75	8
5	1	286 2000 ANGEWANDTE CHEMIE-INTERNATIONAL EDITION 39(8):1376-1398 **CORRIU RJP** *Ceramics and nanostructures from molecular precursors*	65	3
6	0	11 1990 JOURNAL OF PHYSICS-CONDENSED MATTER 2(47):9323-9334 **ROY B; CHAKRAVORTY D** *Electrical Conductance of Silver Nanoparticles Grown in Glass Ceramic*	59	10
7	0	42 1993 MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING 166(1-2):145-159 **MAYO MJ; HAGUE DC; CHEN DJ** *Processing Nanocrystalline Ceramics for Applications in Superplasticity*	57	7
8	0	27 1992 JOM-JOURNAL OF THE MINERALS METALS & MATERIALS SOCIETY 44(3):28-30 **GIANNELIS EP** *A New Strategy for Synthesizing Polymer-Ceramic Nanocomposites*	46	0
9	0	74 1995 JOURNAL OF MATERIALS SCIENCE LETTERS 14(15):1046-1047 **NISHIMURA T; MITOMO M; HIROTSURU H; KAWAHARA M** *Fabrication of Silicon-Nitride Nano-Ceramics by Spark Plasma Sintering*	44	0
10	0	267 1999 SCIENCE 286(5445):1716-1719 Chan VZH; Hoffman J; Lee VY; Iatrou H; Avgeropoulos A; Hadjichristidis N; **MILLER RD; THOMAS EL** *Ordered bicontinuous nanoporous and nanorelief ceramic films from self assembling polymer precursors*	42	3

Fig. 14. Nano-Ceramics Sorted by Global Citation Score

heavily cited in the collection but did not themselves contain the title keywords used in the search profile. They are shown at the top of the Fig..

We also take advantage of the *SCI*'s unique capability to find papers that have cited any of the 571 papers in this file. Thus, in the next Fig. 17 the new augmented file contains a total of 2889, of which 571 are the starting group and the rest are papers that cite them.

From here we can proceed to the creation of the historiograph of most-cited papers in the collection.

The *HistCite* software aids the researcher and librarian by providing visual aids in the forms of historiographs that show the links between the most-cited papers.

In Fig. 17 we show the historiograph resulting from the integrated file. This demonstrates the board scope of the nano-ceramics literature. To the left there is one area of four key papers involving instrumentation and measurement. On its right is the main topic of nano crystalline studies. Paper 17 is the highly-cited 1989 review by Gleiter on nanocrystalline materials.

Further to the right is the area of sol-gel science. This is highlighted by the Brinker-Scherer review in the first issue of *Sol-Gel*, Volume 1, Number 1.

On the far right, the area of nano-composite literature is illustrated by the 1991 paper on covalent crystal composite published in *Nature* by Wakai et al of Nagoya.

I have given you several perspectives on the literature of ceramics. As we know, the *JCR* has been published for over 25 years. It is useful as far as it goes. It has

Cited references outside of this network
Total: 8831 (top 30 shown).
Sorted by **LCS**.

#	LCS	Reference
1	32	NIIHARA K, 1991, J CERAM SOC JPN, V99, P974 WoS
2	22	GLEITER H, 1989, PROG MATER SCI, V33, P223 WoS
3	17	ZHAO JH, 1993, J AM CERAM SOC, V76, P503 WoS
4	16	KARCH J, 1987, NATURE, V330, P556 WoS
5	15	WAKAI F, 1986, ADV CERAM MATER, V1, P259 WoS
6	13	OLIVER WC, 1992, J MATER RES, V7, P1564 WoS
7	13	WAKAI F, 1990, NATURE, V344, P421 WoS
8	12	HAHN H, 1991, J AM CERAM SOC, V74, P2918 WoS
9	12	CHEN IW, 1990, J AM CERAM SOC, V73, P2585 WoS
10	11	GARVIE RC, 1975, NATURE, V258, P703 WoS
11	11	BIRRINGER R, 1986, T JAPAN I METALS S, V27, P43 WoS
12	10	SKANDAN G, 1994, J AM CERAM SOC, V77, P1706 WoS
13	10	RHODES WH, 1981, J AM CERAM SOC, V64, P19 WoS
14	10	SIEGEL RW, 1988, J MATER RES, V3, P1367 WoS
15	9	BRINKER CJ, 1990, SOL GEL SCI PHYSICS, WoS
16	9	GLEITER H, 1992, NANOSTRUCT MATER, V1, P1 WoS
17	8	LIAO SC, 1998, NANOSTRUCT MATER, V10, P1063 WoS
18	8	HAHN H, 1990, J MATER RES, V5, P609 WoS
19	8	SAWAGUCHI A, 1991, J AM CERAM SOC, V74, P1142 WoS
20	8	HAHN H, 1993, NANOSTRUCT MATER, V2, P251 WoS
21	8	LANGE FF, 1989, J AM CERAM SOC, V72, P3 WoS
22	8	LEVIN I, 1995, J AM CERAM SOC, V78, P254 WoS
23	8	NIIHARA K, 1990, ADV STRUCTURAL INORG, P637 WoS
24	7	BORSA CE, 1995, J MICROSC-OXFORD, V177, P305 WoS
25	7	BOUTZ MMR, 1995, J AM CERAM SOC, V78, P121 WoS
26	7	CHEN DJ, 1993, NANOSTRUCT MATER, V2, P469 WoS
27	7	PEZZOTTI G, 1994, J AM CERAM SOC, V77, P3039 WoS
28	7	SURYANARAYANA C, 1995, INT MATER REV, V40, P41 WoS
29	7	TAYA M, 1990, J AM CERAM SOC, V73, P1382 WoS
30	7	OHJI T, 1996, J AM CERAM SOC, V79, P33 WoS

Fig. 15. Ranked List of References Outside Nano-Ceramics *Histcite* Collection.

become an international standard for journal editors and librarians. But there are some who would prefer that *JCR* be more specific in identifying sub-categories that are not easily identified by ISI's heuristic techniques. Several years ago my colleague, Alexander Pudovkin, began a series of studies in which he mapped the relationships between journals in the field of Marine Biology [7]. More recently, he and I published a paper in the *Journal of the American Society for Information Science & Technology* which discusses an improved procedure for generating lists of related journals [8].

Without going into the details of its methodology, suffice it to say we used citation and publication data from the 1999 *SCI* on CD-ROM to find the closest "semantic" links between journals. That is done by starting with one or more known journals. We use a simple formula shown in Fig. 18 to calculate the Relatedness Factor (RF). The Relatedness Factor can be obtained manually using citation and publication statistics included in the *Journal Citation Reports* mentioned earlier. However, we use a program called

Outer References Missing Links? Journal list All-Author list Citation Matrix Graphs HistCite Guide

Title Search: Papers with "nanoceram* or (nano* and ceram*)" in the title and the citing papers, and papers pulled from Outer References

NIIHARA K, 1991, J CERAM SOC JPN, V99, P974
OLIVER WC, 1992, J MATER RES, V7, P1564
GLEITER H, 1989, PROG MATER SCI, V33, P223
ZHAO JH, 1993, J AM CERAM SOC, V76, P503
KARCH J, 1987, NATURE, V330, P556
PETHICA JB, 1983, PHILOS MAG A, V48, P593
MORIKAWA A, 1992, POLYM J, V24, P107
DOERNER MF, 1986, J MATER RES, V1, P601
KRESGE CT, 1992, NATURE, V359, P710
WAKAI F, 1990, NATURE, V344, P421
BRINKER CJ, 1990, SOL GEL SCI
BIRRINGER R, 1984, PHYS LETT A, V102, P365

Nodes: 2889
Sorted by **year, journal, volume, page**.
Page **1**: 1 2 3 4 5 6 **Chronological**

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	1 1978 BULLETIN OF THE AMERICAN PHYSICAL SOCIETY 23(1):35-35 **MOCK W; HOLT WH** *Electrical Response of Shock-Depoled PZT 56-44 and PZT 95-5 Ferroelectric Ceramics into Nanofarad Capacitor Loads*	1	1
2	0	2 1978 JOURNAL OF APPLIED PHYSICS 49(12):5846-5854 **MOCK W; HOLT WH** *Pulse Charging of Nanofarad Capacitors from the Shock Depoling of PZT 56-44 and PZT 95-5 Ferroelectric Ceramics*	6	6
3	1	3 1979 PHYSICS REPORTS-REVIEW SECTION OF PHYSICS LETTERS 55(4):255-379 **DAVISON L; GRAHAM RA** *Shock Compression of Solids*	138	0
4	0	4 1980 AMERICAN CERAMIC SOCIETY BULLETIN 59(8):838-838 **CROSS LE** *Effects of Some Macrostructural, Microstructural and Nanostructural Features on the Properties of Electronic Ceramics*	0	0
5	1	5 1980 FERROELECTRICS 23(1-2):39-45 **MOCK W; HOLT WH** *Analysis of the Ideal Response of Shock-Depoled Ferroelectric Ceramics*	0	0
6	1	6 1980 FERROELECTRICS 23(3-4):209-253 **TOYODA K** *Bibliography of Ferroelectrics*	0	0
7	1	7 1980 JOURNAL OF PHYSICS D-APPLIED PHYSICS 13(5):861-868 **BERLINSKY Y; ROSENBERG Z** *Measurement of the Hugoniot Curve Of PZT 54-46 with Commercial Manganin Stress Gauges*	0	0
8	1	8 1981 FERROELECTRICS 37(1-4):591-594 **PORAT Y; IMRY Y; AHARONY A; BRANSKY I** *Concentration-Pressure-Temperature Phase-Diagram Of PZT*	2	0
9	1	9 1983 FERROELECTRICS 49(1-4):169-176 **WANG YL; YUAN WZ; HE GR; LIN SW; LING YH; QU CF; WANG BG** *Study on Shock Wave-Explosive Energy Converter of PZT 95/5 Ferroelectric Ceramics*	12	0
10	0	10 1983 PHILOSOPHICAL MAGAZINE A-PHYSICS OF CONDENSED MATTER STRUCTURE DEFECTS AND MECHANICAL PROPERTIES 48(4):593-606 **PETHICA JB; HUTCHINGS R; OLIVER WC** *Hardness Measurement At Penetration Depths As Small As 20-NM*	355	49

Fig. 16. Chronological *Histcite* File Based on Title Search on Nanoceram* or (Nano* and Ceram*), Citing Papers, and Key Outer References.

Journal Cross Citation Analyzer (JCCA) to obtain RF values automatically.

The first step in mapping the journal literature of ceramics is to create a list of candidate journals using the RF formula. We obtained the following two lists of journals. The first is a list of the 24 journals most closely connected (by RF) to the *Journal of the American Ceramic Society.* See Fig. 19.

From this list of journals, we selected eight titles which are used to form a macrojournal of ceramics. These are shown at the top of Fig. 20.

At the bottom of Fig. 20 is the list of 24 journals most closely linked to the macrojournal of ceramics. The macrojournal is a composite of mainly the highest RF journals of the 1st list. The two lists in Figs. 19 and 20 share the 17 journals shown in bold type Thus, the combined list of 31 ceramic journals consists of 17 journals common to both lists and 14 other journals, which are not shared and are specific to each list. That list of 31 journals is shown in Fig. 21.

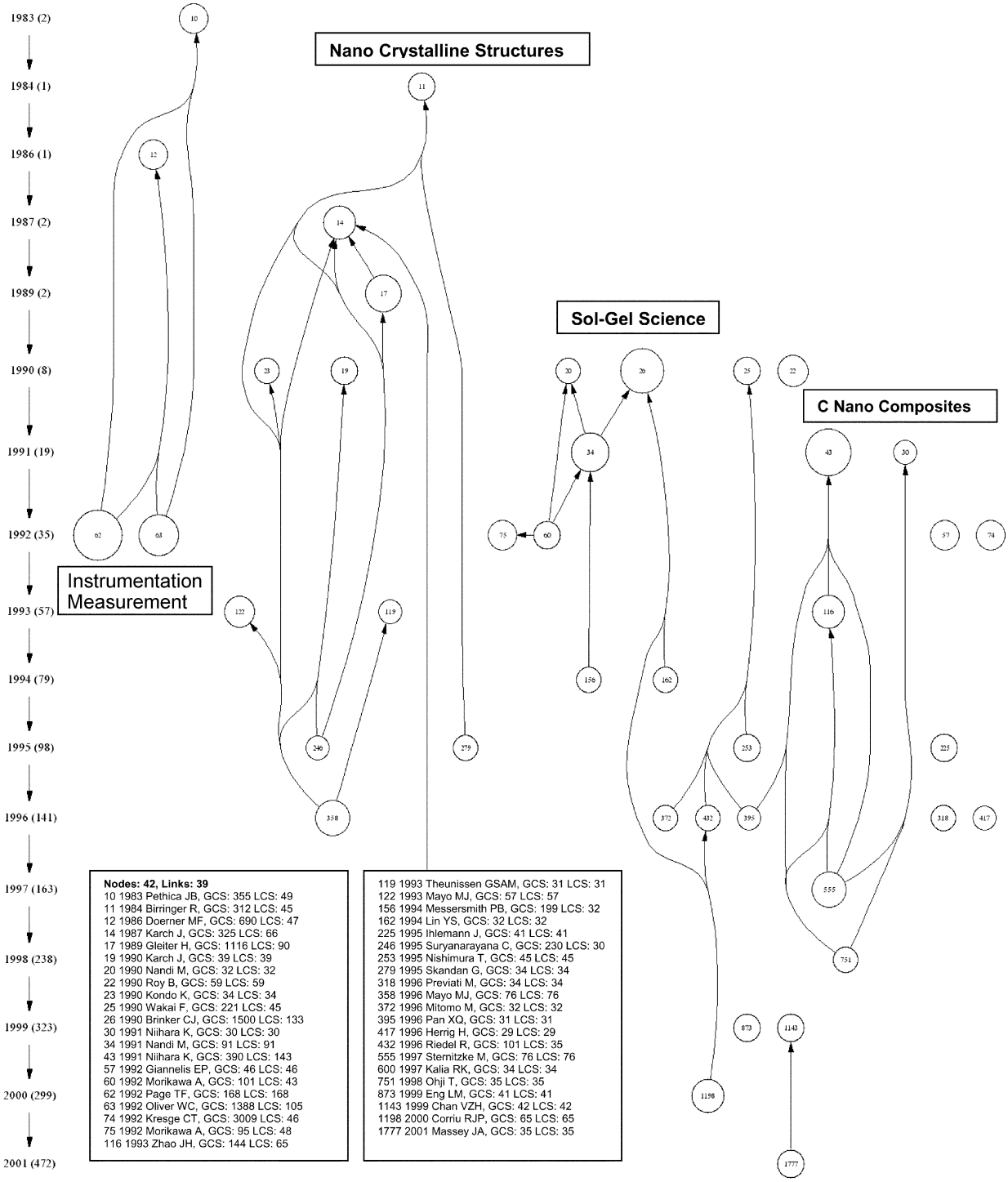

Fig. 17. Nano-Ceramics Historiograph for the Combined Title and Cited References Searches.

The ten journals in boldface are included in the *JCR* category for "Materials Science, Ceramics."

Both of the maps shown are identical except that the top shows one set of relationships and the button shows journals covered in *JCR*.

To visualize relationships among these 31 journals we used multidimensional scaling routine. MDS converts the similarity matrices consisting of RF values for all pair-wise combinations of these 31 journals into a 2-dimensional map. The journals shared by both lists are shown as open circles. Those which are specific for the 1st list are in blue, those unique to the 2nd list are in purple. The sizes of the circles are proportional to the journal sizes as measured by the pooled number of references in the year of the journal chosen.

Shared journals are positioned close to the center of

Relatedness Factor (RF) of two journals, "i" and "j" is **max($R_{i>j}$, $R_{j>i}$)**

$$R_{i>j} = \frac{H_{i>j} \times 10^6}{(Pap_j \times Ref_i)}$$

$H_{i>j}$ = the number of citations in the current year from journal "i" to journal "j" (to papers published in "j" in all years of 'j'),

Pap_j and Ref_i = the number of papers published and references cited in the j-th and i-th journals in the current year.

An arbitrary multiplier of 10^6 makes the values of the relatedness index more easily perceived and handled. **$R_{j>i}$ is reciprocal of $R_{i>j}$.**

Fig. 18. Formula for Relatedness Factor.

24 ceramics journals top ranked by Relatedness Factor to the *Journal of the American Ceramic Society*

	Journal[1]	Number in the map	RF
1	**Ceramics International**	7	560.7
2	**Journal of the American Ceramic Society**	20	526.5
3	**Journal of the European Ceramic Society**	22	430.1
4	**Journal of the Ceramic Society of Japan**	21	394.4
5	**Key Engineering Materials**	23	366.0
6	**British Ceramic Transaction**	6	316.8
7	**American Ceramic Society Bulletin**	4	240.0
8	**Physics and Chemistry of Glasses**	29	217.1
9	**Journal of Sol-Gel Science and Technology**	19	192.0
10	**Journal of Materials Science Letters**	17	173.6
11	**Materials Letters**	25	170.3
12	**Journal of Materials Research**	16	170.2
13	**Journal of Materials Science**	18	152.5
14	**Glass Technology**	14	147.8
15	**Materials Science & Engeneering R-Reports**	27	134.4
16	**Composites Part A – Applied Science and Manufacturing**	8	123.9
17	**Glass Science and Technology – Glastechnische Berichte**	13	120.2
18	Acta Materialia	2	97.2
19	Materials Chemistry and Physics	24	88.1
20	Ferroelectrics	12	82.5
21	Composites Science and Technology	10	74.4
22	Experimental Mechanics	11	70.9
23	Composites Part B – Engeneering	9	70.3
24	Solid State - Ionics	31	68.5

[1]Journals in bold are shared beween the two lists: a) journals top related to the Journal of American Ceramic Society, b) journals top related to the macrojournal of ceramics.

Fig. 19. 24 Journals Ranked by Relatedness Factor to *Journal of the American Ceramic Society.*

the diagram, while journals unique to each list are situated on the periphery. The *Journal of Materials Science* (18) occupies the central position. Very close to it are the *Journal of the American Ceramic Society* (20), the *Journal of Materials Science Letters* (17), the *Journal of the European Ceramic Society* (22). It is interesting to note that the *Journal of the Ceramic Society of Japan* (21) is somewhat isolated from the central ceramic journals (20, 22, 4, 6, 7) but closer to the "glass" journals: *Physics and Chemistry of Glasses* (29), *Glass Science and Technology* (13), and *Glass Technology* (14) on the periphery.

The 8 journals included in the ceramics macrojournal

No.	Journal	No. in map	RF to (5)
1	American Ceramic Society Bulletin	20	240.0
2	British Ceramic Transaction	6	316.8
3	Ceramics Internation	7	560.8
4	Journal of Materials Science Letters	17	173.6
5	Journal of the American Ceramic Society	20	526.5
6	Journal of the Ceramic Society of Japan	21	394.4
7	Journal of the European Ceramic Society	22	430.1
8	Key Engineering Materials	23	366.0

24 journals top ranked by Relatedness Factor to the ceramics macrojournal

	Journal[1]	Number in the map	RF
1	**Journal of the American Ceramic Society**	20	379.4
2	**Materials Science & Engeneering R-Reports**	27	189.1
3	**British Ceramic Transaction**	6	182.0
4	**Ceramics International**	7	139.7
5	**American Ceramic Society Bulletin**	4	131.7
6	**Journal of the Ceramic Society of Japan**	21	108.7
7	**Journal of the European Ceramic Society**	22	101.4
8	**Key Engineering Materials**	23	81.9
9	Progress in Materials Science	30	62.0
10	Advances in Physics	3	55.8
11	Annual Review of Materials Science	5	54.1
12	**Journal of Materials Science Letters**	17	46.4
13	**Journal of Sol-Gel Science and Technology**	19	42.6
14	**Materials Letters**	25	42.0
15	Materials Research Bulletin	26	40.8
16	**Physics and Chemistry of Glasses**	29	38.3
17	**Journal of Materials Science**	18	36.9
18	International Materials Reviews	15	36.5
19	**Journal of Materials Research**	16	36.2
20	Acta Crystallographica Section B – Structural Science	1	32.5
21	**Glass Technology**	14	30.3
22	**Composites Part A – Applied Science and Manufacturing**	8	28.5
23	**Glass Science and Technology – Glastechnische Berichte**	13	24.9
24	Modelling and Simulation in Materials Science and Engeneering	28	23.6

[1]Journals in bold are shared between the two lists: a) journals most related to the Journal of American Ceramic Society, b) journals most related to the macrojournal of ceramics.

Fig. 20. Top 8 Journals Included in Macrojournal of Ceramics Bottom -- 24 Journals Ranked by Relatedness Factor to the Macrojournal.

Combined list of 31 journals in two previous lists based on merging the RF lists for *Journal of the American Ceramic Society* and the ceramics macrojournal

Number in the map	Journals[1]
1	Acta Crystallographica Section B – Structural Science
2	Acta Materialia
3	Advances in Physics
4	**American Ceramic Society Bulletin**
5	Annual Review of Materials Science
6	**British Ceramic Transaction**
7	**Ceramics International**
8	Composites Part A – Applied Science and Manufacturing
9	Composites Part B – Engeneering
10	Composites Science and Technology
11	Experimental Mechanics
12	Ferroelectrics
13	**Glass Science and Technology – Glastechnische Berichte**
14	**Glass Technology**
15	International Materials Reviews
16	Journal of Materials Research
17	Journal of Materials Science
18	Journal of Materials Science Letters
19	**Journal of Sol-Gel Science and Technology**
20	**Journal of the American Ceramic Society**
21	**Journal of the Ceramic Society of Japan**
22	**Journal of the European Ceramic Society**
23	**Key Engineering Materials**
24	Materials Chemistry and Physics
25	Materials Letters
26	Materials Research Bulletin
27	Materials Science & Engeneering R-Reports
28	Modelling and Simulation in Materials Science and Engeneering
29	Physics and Chemistry of Glasses
30	Progress in Materials Science
31	Solid State – Ionics

[1]Journals in boldface are those included in *JCR* subject category "Materials Science, Ceramics"

Fig. 21. Combined List of Journals of 31 Journals Based on Merging the RF Lists for *Journal of the American Ceramic Society* and the Ceramics Macrojournal.

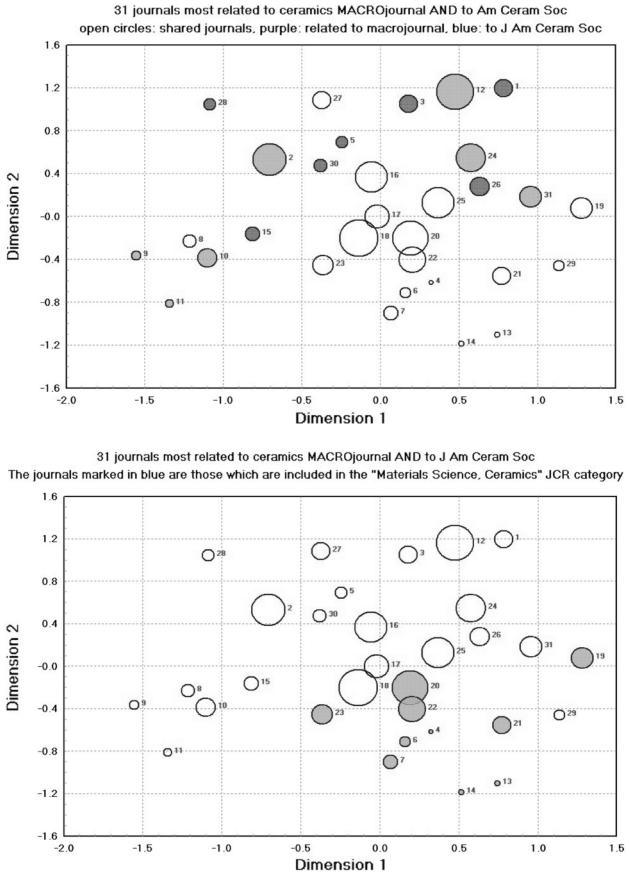

Fig. 22. Multidimensional Scaling Map of 31 Journals Showing Journals Shared by or Unique to Two Previous Groupings.

The large and centrally situated journals - *Journal of Materials Science Letters* (17), *Materials Letters* (25), *Journal of Materials Science* (18), and *Journal of Materials Research* (16) are not included in the *JCR* subject category "Materials Science--Ceramics", even though they are quite close to the other key ceramics journals: the *Journal of the American Ceramic Society* (20) and to the *Journal of the European Ceramic Society* (22). The journal *Physics and Chemistry of Glasses* (29) also is not included in the JCR ceramics category, though it does include two other "glass" journals: *Glass Science and Technology* (13), and *Glass Technology* (14).

In the bottom version of the map, only ten of the 31 journals are included in the *JCR* category of "Materials Science, Ceramics". They are shown in blue in the bottom map. Alternatively, the open circles in the map at the bottom are journals which are not included in the *JCR* category for ceramics. Of course, one might ask why *JCR* does not have a separate category for glass journals. Alternatively our data seems to indicate that the JCR category "Materials Science. Ceramics" should be enlarged to include journals presented by our maps.

The most important advice I can give to young researchers is to become "Citation Conscious". Always ask yourself when you are writing, or teaching, "Do I

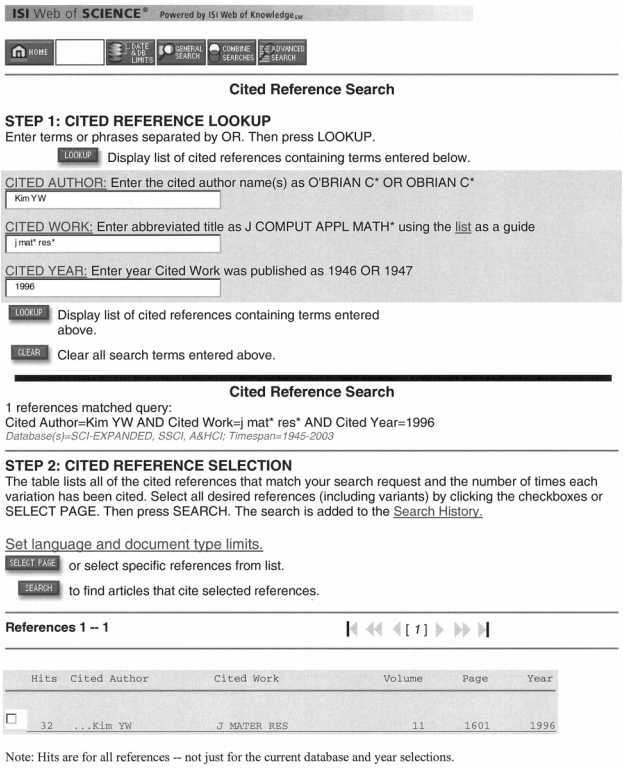

Fig. 23. Cited Reference Search on YW Kim J Mater Res 1996.

Nanotechnology Research
Institutions Ranked by Citations and Citation Impact
(Among those that published ≥ 100)
nanotechnology papers 1992-2002)

Rank	Institution	Citations 1992 - 2002
1	Univ. Calif., Berkeley	15,507
2	IBM	11,587
3	MIT	10,830
4	Chinese Academy of Sciences (PRC)	9,814
5	Ecole Polytech. Fed. Lausanne	9,758
6	Rice University	9,750
7	NEC Corporation	7,963
8	Univ. Calif., Santa Barbara	7,599
9	Harvard University	7,578
10	Northwestern University	6,821
11	Tohoku University	6,296
12	Georgia Tech	6,150
13	U.S. Navy	5,952
14	Russian Academy of Sciences	5,849
15	University of Tokyo	5,717
16	CNRS (France)	5,680
17	Pennsylvania State University	5,588
18	University of Illinois	5,579
19	Lucent Technologies	5,166
20	Cornell University	4,922
21	University of Paris 6	4,750
22	Osaka University	4,595
23	Caltech	4,527
24	Delft Univ. of Technology	4,518
25	University of Minnesota	4,249

Rank	Institution	Impact 1992 - 2002
1	Rice University	37.64
2	NEC Corporation	28.64
3	Colorado State University	25.32
4	Michigan State University	24.96
5	Lucent Technologies	24.48
6	Harvard University	23.68
7	Lawrence Berkeley Natl. Lab	23.30
8	University of Pennsylvania	23.02
9	IBM	21.34
10	Univ. Calif., Berkeley	21.24
11	Univ. Calif., Santa Barbara	20.93
12	University of Utah	20.25
13	Ecole Polytech. Fed. Lausanne	19.17
14	Delft University of Technology	18.83
15	MIT	17.73
16	Hahn-Meitner Institute, Berlin	17.30
17	Caltech	17.02
18	Natl. Renewable Energy Lab	16.69
19	Princeton University	16.42
20	University of Liverpool	16.30
21	University of North Carolina	16.27
22	Northwestern University	15.90
23	University of Toronto	15.85
24	Stanford University	15.84
25	University of Kentucky	15.69

Fig. 24. Nanotech Research Institutions Ranked by Citations and Impact.

have up-to-date information on the papers that I use?" For that purpose you simply do a basic "cited reference" search. This search will tell you whether the paper in question is still valid or has, in some way, confirmed, improved upon, or become obsolete. If you are tempted to cite old classical resources, you might be surprised to learn where and how they have been cited in the recent literature. Many of the classical dogmas we take for granted have been challenged. Very little in science is forever! To illustrate how easy this process is, I have shown in Fig. 20 how we do a search on the paper by Y. W. Kim in the *Journal of Materials Research*, 1996.

Some of you will remember a paper I presented about ten years ago in Boston in 1993 [9]. Some of you may have been present or read this paper which was published in the *Journal of Materials Education* in 1994. In closing, I simply wish to call your attention to the paper which can be found on my website. The key point one has to remember is that there is an important distinction between the literature used, that is, cited by nano-ceramists and the literature of nano-ceramics. To put it another way, you are what you cite, not what you say you are!

Appendix

Let me call to your attention a recent analysis of nanotechnology reported in ISI's *Science Watch*. "Sweating the Small Stuff," 1992-2002 [10]. The article

Most-Cited Authors in Nanotechnology, 1992 - 2002
(Ranked by total citations)

Rank	Name	Affiliation	Dept. /Field	Papers	Citations
1	Richard E. Smalley	Rice University	Chemistry/ Physics	109	7,936
2	A. Paul Alivisatos	Univ. Calif., Berkeley	Chemistry/ Materials	133	6,107
3	Hongjie Dai	Stanford University	Chemistry	72	4,937
4	Andrew G. Rinzler	University of Florida	Physics	42	4,271
5	Charles M. Lieber	Harvard University	Chemistry	106	4,253
6	Michael Gratzel	EPFL, Switzerland	Physical Chemistry	116	4,101
7	Pulickel M. Ajayan	Rensselaer Polytechnic Institute	Materials Engineering	112	4,086
8	Andreas Thess	m-phasys GmbH, Germany	Biotechnology	20	3,666
9	Thomas W. Ebbesen	Universite Louis Pasteur	Nanostructures	41	3,505
10	Daniel T. Colbert	Rice University	Chemistry	27	3,491
11	Sumio Iijima	NEC/Meijo University	Materials	143	3,458
12	Moungi G. Bawendi	MIT	Chemistry	83	3,453
13	Cees Dekker	Delft University of Technology	Molecular Biophysics	34	3,205
14	Mildred S. Dresselhaus	MIT	Physics/ Elect. Engineering	121	2,658
15	Galen D. Stucky	Univ. Calif., Santa Barbara	Chemistry	53	2,646
16	John E. Fischer	University of Pennsylvania	Materials	43	2,509
17	Pavel Nikolaev	NASA Johnson Space Center	Materials	23	2,496
18	Emmanuel P. Giannelis	Cornell University	Materials	55	2,456
19	Charles R. Martin	University of Florida	Bioanalytical Chemistry	87	2,389
20	Zhong L. Wang	Georgia Tech	Materials	121	2,348
21	Akihisa Inoue	Tohoku University	Materials	282	2,316
22	Christopher B. Murray	IBM	Materials	36	2,276
23	Horst Weller	University of Hamburg	Physical Chemistry	81	2,269
24	Steven G. Louie	Univ. Calif., Berkeley	Physics	41	2,261
25	Marie-Paule Pileni	Univ Paris 6	Materials	125	2,091

Fig. 25. Nanotech Most-Cited Authors.

includes two lists of 25 institutions each of which are ranked by citations and by impact, Fig. 25.

While the University of California at Berkeley ranked first by citations, it was fourth by impact. While NEC ranked second by impact, it ranked seventh by citations!!

The article also provides a list of 25 most-cited authors including Nobelist Richard Smalley.

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