# Mining Patents + Research Publications to Improve Technology Management: Nano Illustrations

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Search Technology, Inc.
and
Technology Policy and Assessment Center
Georgia Tech

## Outline

- The Technology Management Challenge
- Tech Mining
- Nano Science & Technology Illustrations

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## How well do we manage technology?

- Cultural differences: Should we bother to plan? To systematically look ahead?
- R&D Peer Review: Faith-based prioritizing
- Strategic Management:
  - Managers overvalue their tacit judgment
  - Reinforce with casual, agreeable expertise
- In sum – Amateurish – tremendous opportunity to improve

Managers are turning to data mining:
• Sports Mgt

Empirical Knowledge is highly valued in:
• Production Mgt
• Financial Mgt
• Marketing
• Sales

How about:
•Technology Mgt?

1234567890THESTATSTHATMATTER1234567890

# Playing the numbers game

Now more than ever, the sports world is looking to statistics for performance-enhancing insight, fueling the quest to devise perfect predictors of success *By Steve Gietschier*

## A New Dawn in Managing Technology

A. Management of Technology (MOT) has been largely *intuitive*

B. Patent, R&D publication, and business information resources are rich sources of *empirical* intelligence

C. Need to add "B" to "A" to gain competitive advantage

D. Goal = Transform MOT (Management of Technology)

## Text Mining – The new Perspective

When we talk about a new perspective, we are talking about treating text as data.

*Text* = data

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## Tech Mining

Bad:

Only read Science, Technology & Innovation (ST&I) information

Better:

Too much to read! – apply text data mining techniques

Best:

"Tech Mining" redirection -- purposive, targeted decision support for technology management

## Answer: Who, What, When, Where?

- Profile R&D Domain(s) of concern:
  - Who is doing what?
  - What topics are heating up (when)?
  - etc.
- Where? Map Relationships: Teams & topical emphases
- When? Derive forecasts
- What? Develop Innovation Indicators
- So what? Draw MOT implications

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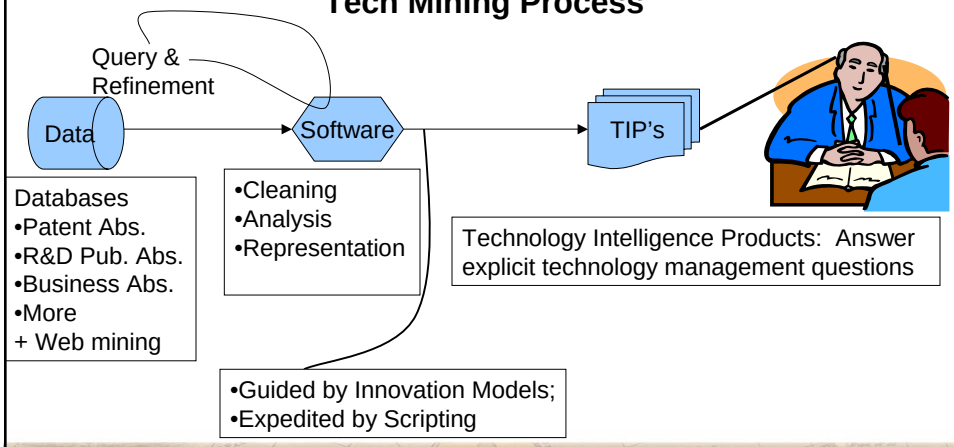
## Tech Mining Players

1) Information Professionals
2) Technology Analysts
3) Researchers
4) Senior Manager User Community

## Tech Mining Process




## MOT Issues, Questions & *Innovation Indicators*

**13 MOT Issues**

- R&D Portfolio Mgt
- R&D Project Initiation
- **Engr Project Initiation**
- New Product Development
- Strategic Planning,
- etc.

**39 MOT Questions**

1. **What's hot?**
2. Fit into tech landscape?
3. Drivers?
4. Competing technologies?
5. Likely development paths?
6. etc.

**~200 Innovation Indicators**

**WHAT?**

- Mapping of topic clusters within the technology
- 3-D trend charts for topic clusters
- Ratio of conference to journal papers (benchmarked)
- Scorecard rate-of-change metrics for topic clusters
- Time slices to show evolution of topical emphases
- Topic growth modeling (S-curve) fit & extrapolation

**WHO?**

- Pie chart: Company vs. Academic vs. Government publishing
- Topical main players' profiles
- Spreading (or constricting) # of players by topic

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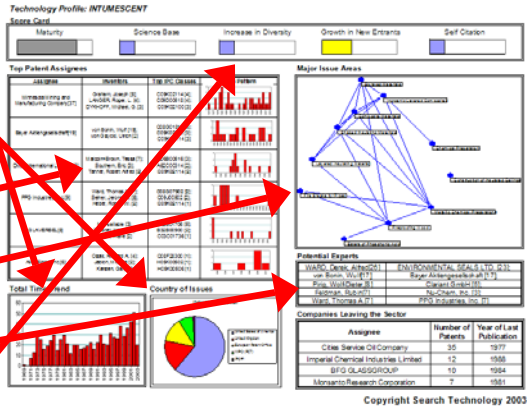
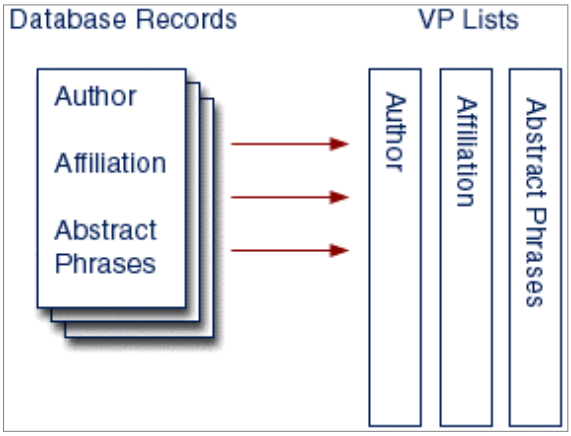
# Start with questions; Work to empirical answers

- When was research done?
- Where was it patented?
- Who are the major organizations?
  - What do they do?
- What are the technology areas?
- Are companies led by a single inventor?
- What is the state of the industry?




# Search information on topic importing multiple data sources

- Search
  - Patents
  - Literatures
- Import into VantagePoint [**Thomson Data Analyzer**]



# Clean data

- Thesaurus
- List Cleanup

| | # Records | # Instances | Priority Countries |
|---|---|---|---|
| 1 | 594 | 677 | Japan |
| 2 | 433 | 887 | United States Of America |
| 3 | 89 | 105 | Great Britain |
| 4 | 51 | 55 | European |
| 5 | 51 | 64 | France |
| 6 | 51 | 55 | Germany |
| 7 | 32 | 33 | Korea, Republic of |
| 8 | 10 | 19 | Denmark |
| 9 | 8 | 8 | Australia |
| 10 | 7 | 7 | Patent Co-operation Treaty |
| 11 | 4 | 4 | Brazil |

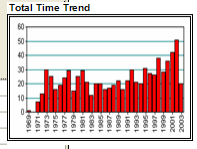
| | # Records | # Instances | Patent Assignees |
|---|---|---|---|
| 1 | 311 | 311 | LION CORP |
| 2 | 130 | 130 | PROCTER & GAMBLE CO |
| 3 | 125 | 126 | COLGATE PALMOLIVE CO |
| 4 | 103 | 115 | SUNSTAR CHEM IND CO LTD |
| 5 | 99 | 231 | UNILEVER NV |
| 6 | 82 | 82 | KAO CORP |
| 7 | 52 | 52 | CHESEBROUGH PONDS USA CO |
| 8 | 34 | 38 | HENKEL KGAA |
| 9 | 34 | 34 | L OREAL SA |
| 10 | 33 | 38 | WARNER LAMBERT CO |
| 11 | 32 | 35 | SMITHKLINE BEECHAM PLC |
| 12 | 30 | 33 | LG CHEM LTD |
| 13 | 24 | 34 | GILLETTE CANADA INC |
| 14 | 23 | 30 | BLOCK DRUG CO |
| 15 | 20 | 33 | RHONE-POULENC CHIM |

# Lists [Find, Group,…]

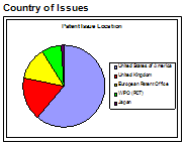
- When was research done?
- Where was it patented?

| | # Records | # Instances | Priority Years |
|---|---|---|---|
| 1 | 25 | 39 | 2003 |
| 2 | 130 | 329 | 2002 |
| 3 | 267 | 1131 | 2001 |
| 4 | 257 | 1574 | 2000 |
| 5 | 235 | 1515 | 1999 |
| 6 | 223 | 1628 | 1998 |
| 7 | 246 | 1707 | 1997 |
| 8 | 239 | 2044 | 1996 |
| 9 | 204 | 1758 | 1995 |

Total Time Trend



Country of Issues



| | # Records | # Instances | Priority Countries |
|---|---|---|---|
| 1 | 594 | 677 | Japan |
| 2 | 433 | 887 | United States Of America |
| 3 | 89 | 105 | Great Britain |
| 4 | 51 | 55 | European |
| 5 | 51 | 64 | France |
| 6 | 51 | 55 | Germany |
| 7 | 32 | 33 | Korea, Republic of |
| 8 | 10 | 19 | Denmark |
| 9 | 8 | 8 | Australia |
| 10 | 7 | 7 | Patent Co-operation Treaty |
| 11 | 4 | 4 | Brazil |

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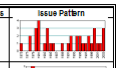
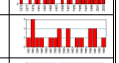
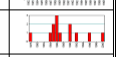
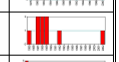
# Matrices [Co-occurrence – for Trends, Relationships, …]

| Reset | | Patent Assignees (Cleaned) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | # Records | 1176 | 5 | 24 | 17 | 8 | 15 | 28 | 10 | 5 | 20 |
| assifications | # Records | Show Values >= 1<br>Cooccurrence<br># of Records | A61K | B01F | C11D | C07H | C09K | C12P | C07C | C07K | C08B | C01B |
| 1 | 311 | LION CORP | 285 | 4 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| 2 | 130 | PROCTER & GAMBLE CO | 126 | | 3 | | 1 | | | 3 | | |
| 3 | 125 | COLGATE PALMOLIVE CO | 117 | | 1 | | | | 2 | | | |
| 4 | 103 | SUNSTAR CHEM IND CO LTD | 98 | | | | | | | | | |
| 5 | 99 | UNILEVER NV | 89 | | 8 | 1 | 1 | | 1 | 1 | | |
| 6 | 82 | KAO CORP | 81 | | 1 | | | | 1 | | | |
| 7 | 52 | CHESEBROUGH PONDS USA CO | 51 | | 1 | | | | | | | |
| 8 | 34 | L OREAL SA | 30 | | | 2 | 2 | | 8 | 1 | | |
| 9 | 34 | HENKEL KGAA | 27 | | 4 | 1 | | | 2 | | | |

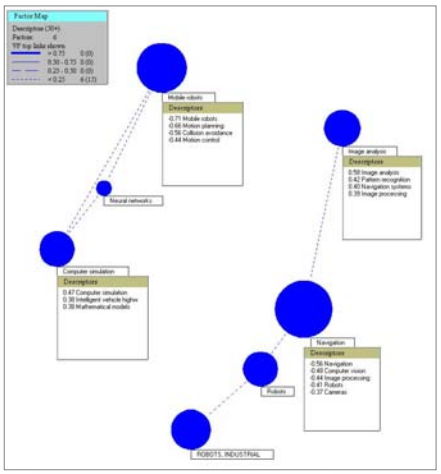
Top Patent Assignees

| Assignee | Inventors | Top IPC Classes | Issue Pattern |
|---|---|---|---|
| Minnesota Mining and Manufacturing Company[37] | Graham, Joseph [5]; LANGER, Roger, L. [5]; DYKHOFF, Michael, G. [3] | C09K02114 [4]; C09D00518 [4]; C09K02100 [3] |  |
| Bayer Aktiengesellschaft[19] | von Bonin, Wulf [19]; von Glaycki, Ulrich [2] | C08G01814 [4]; C09K02100 [3]; C09K02114 [3] |  |
| Dixon International Limited[13] | Malcolm-Brown, Tessa [7]; Southern, Eric [3]; Tanner, Robert Alfred [2] | B06B00516 [3]; A62C00314 [2]; C09K02114 [2] |  |
| PPG Industries, Inc.[9] | Ward, Thomas A. [7]; Seiner, Jerome A. [5]; Heber, Robert W. [2] | C08G07902 [2]; C09J00502 [2]; C09K02114 [1] |  |
| GLAVERBEL[8] | NotAvailable [3]; De Boel, Marcel [2]; Goeff, Pierre [2] | B32B01706 [5]; B32B00900 [2]; C03C01736 [1] | |
| AlliedSignal Inc.[6] | Ozak, Richard A. [4]; Jabion, Michael [2]; Kiesten, Gary [2] | C08F28300 [1]; H09K00502 [1]; H09K00506 [1] | |

- Who are the major organizations?
- What are they pursuing?

# Maps and clustering [to recognize relationships]

- What are the technology areas?
- Who are the leaders?



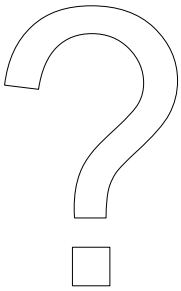
# Innovation Indicators

- Actionable Technical Intelligence!

– Patent/literature ratio

– Number of organizations

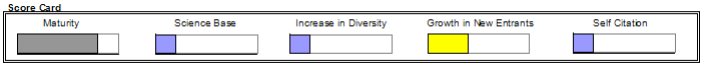
– Use of new vocabulary



– Size of inventor teams

– Citation of other fields

– Number of new entrants




# Illustrative Tech Mining Cases

1. Assessing Tech Opportunities – ceramics for automotive engines (US Army)
2. Plastic molding technologies to assess relative R&D priorities (Combining empirical & expert data -- UFSC)
3. Geo-mapping based on text and data mining (M. Persegona)
4. Hazardous Substances Data Bank (cross-chemical analyses, National Library of Medicine)
5. Fuel Cell exploring (*Tech Mining*)
6. Nano Science & Technology Profiling

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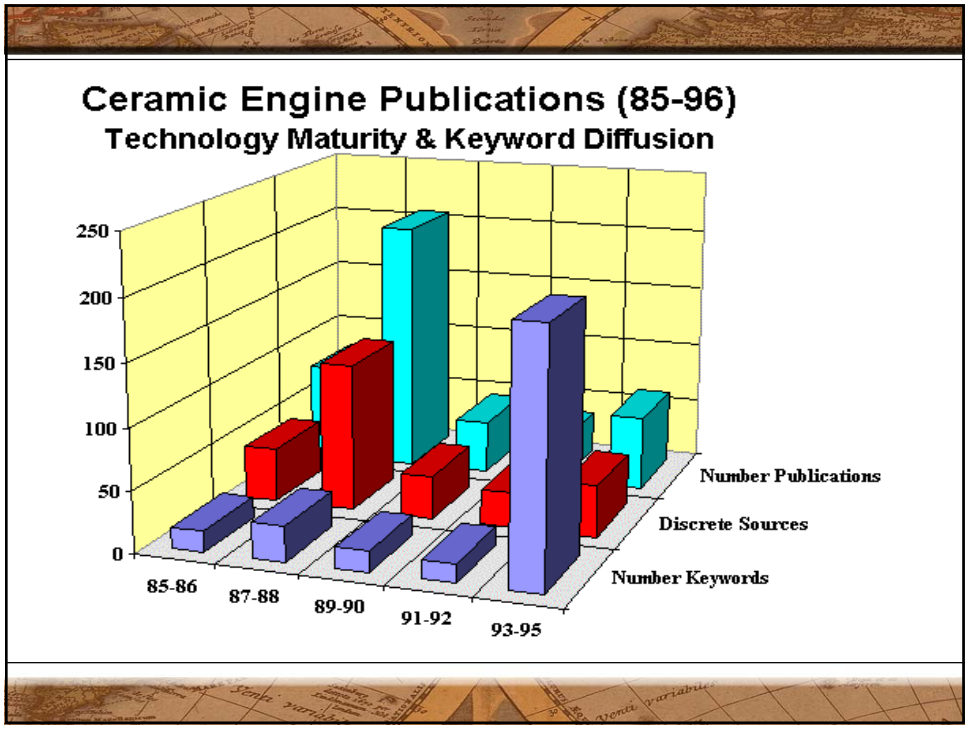
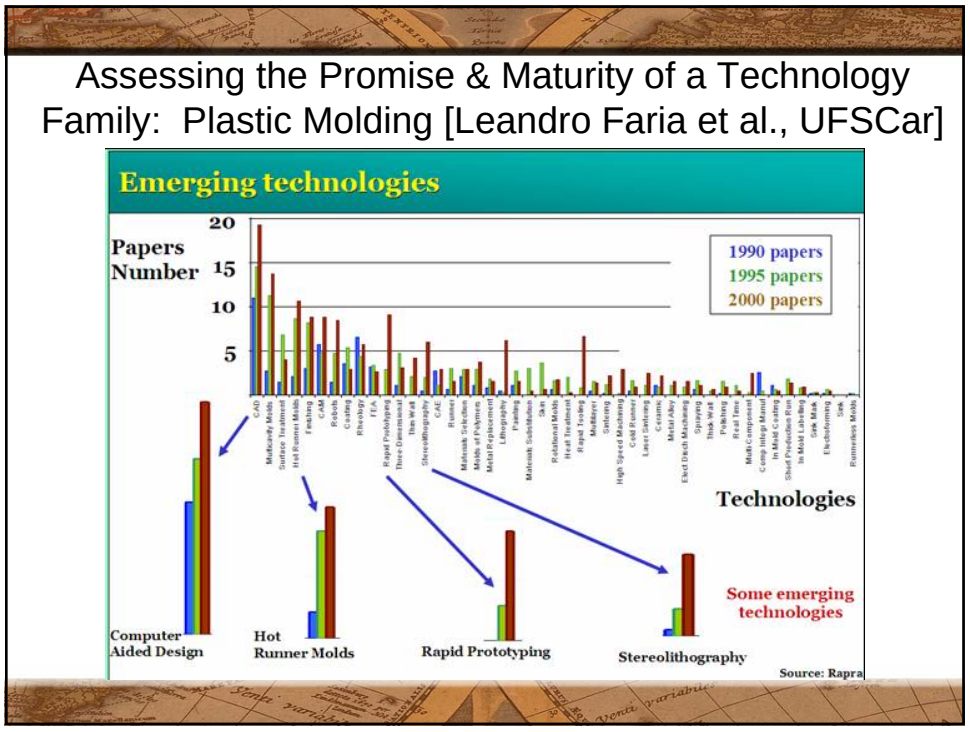

Ceramic Engine Publications (85-96)
Technology Maturity & Keyword Diffusion
250
200
150
100
50
0
85-86
87-88
89-90
91-92
93-95
Number Publications
Discrete Sources
Number Keywords


Assessing the Promise & Maturity of a Technology Family: Plastic Molding [Leandro Faria et al., UFSCar]
Emerging technologies
Papers Number
20
15
10
5
1990 papers
1995 papers
2000 papers
Technologies
Some emerging technologies
Computer Aided Design
Hot Runner Molds
Rapid Prototyping
Stereolithography
Source: Rapra

# Technology Information Products: "One-Pagers"

- Design with the Users
- Compile indicators to resolve one technology management issue
- Specialize the answers to fit the pertinent questions
  - Profile a technology
  - Profile an organization
  - Accomplish a particular task (illustration)

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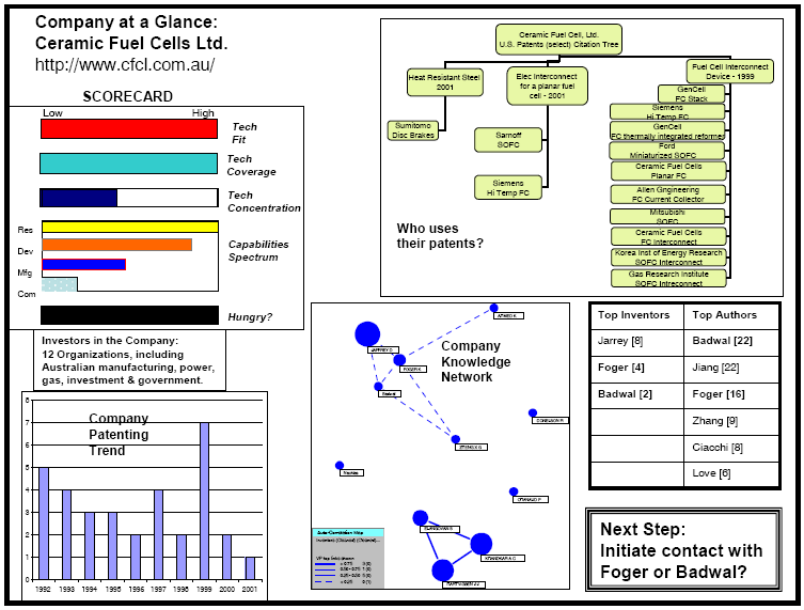

## Nano R&D: Global to Local

- Selected illustrations
- Brazilian study using Derwent data
- Ongoing Georgia Tech project using publications + patents

## Classifying Uses along the Nano Value Chain [by Simone Alencar and Adelaide Antunes, UFRJ

| Main IPC [# patents] | Main uses description in the nanopatents | Position along the Nano Value Chain |
|---|---|---|
| H01L-Semiconductor Devices; Electric Solid State Devices Not Otherwise Provided [2870] | • Electron device<br>• Semiconductor device<br>• Solar cell | • Nanointermediate<br>• Nanointermediate<br>• Nano-products |
| C01B-Non-Metallic Elements; Compounds Thereof [2716] | • carbon nanotube<br>• fuel cell<br>• catalyst | • Nano-raw material<br>• Nano-products<br>• Nanointermediate |
| A61K-Preparations For Medical, Dental, Or Toilet Purposes [1863] | • Cancer (treatment, medication)<br>• Cosmetics<br>• drugs | • Nano-products<br>• Nano-products<br>• Nano-products |
| B82B-Nano-Structures; Manufacture Or Treatment Thereof Chemistry [1615] | • Carbon nanotube<br>• Electron device<br>• catalyst | • Nano-raw material<br>• Nanointermediate<br>• Nanointermediate |

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## Georgia Tech Project
## Nano Science & Engineering Profiling

- Searches: 1990-2006 (Summer)
  - Encompassing, modular search strategy
- R&D Publication Abstracts
  - Web of Science ~420,000
  - INSPEC ~300,000+
  - EI Compendex ~ 300,000+
- Patent Abstracts ~61,000 patent families
  - MicroPatent
  - INPADOC
  - EKMS Patent Citation Database

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## Ongoing Process

- Search Iteration; Expert Review; Refinement
- Data Operations: Desktop computer challenges
- VantagePoint [**Thomson Data Analyzer**] Functions
  - Duplicate removal & information consolidation [cross-databases; geographic location data]
  - Exclusions
  - Author/inventor cleaning
  - Author organization/Patent assignee cleaning
- Nano Profiles: Publications + Patents

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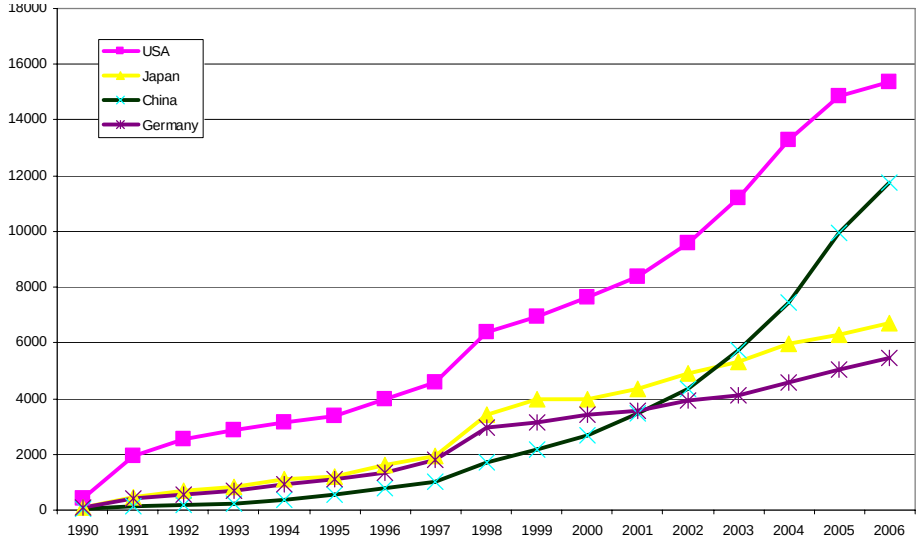
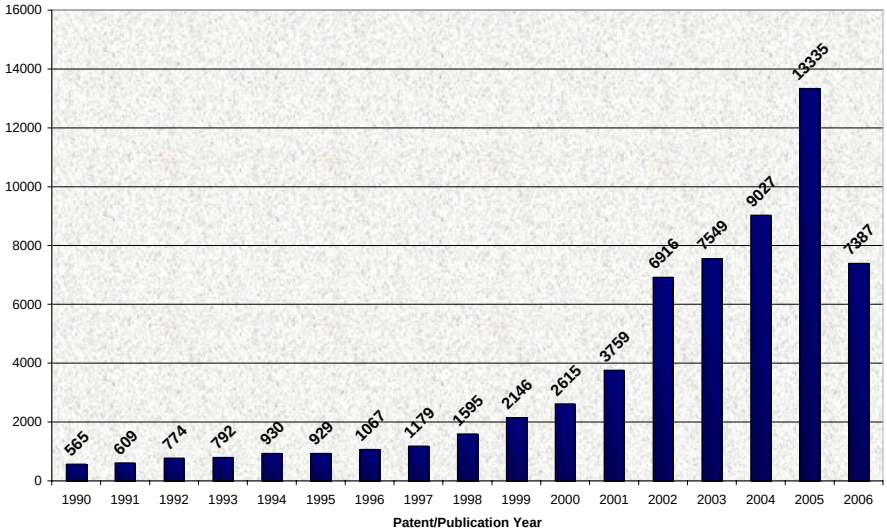
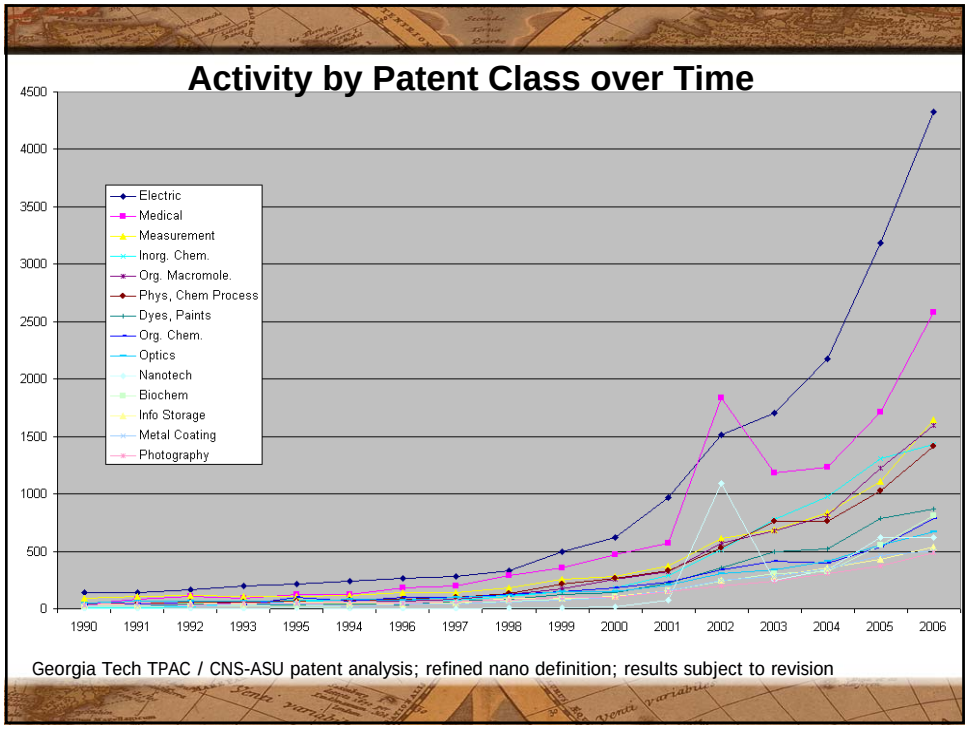
## **Nano Publications by Country** -- 1990-2006 (partial)

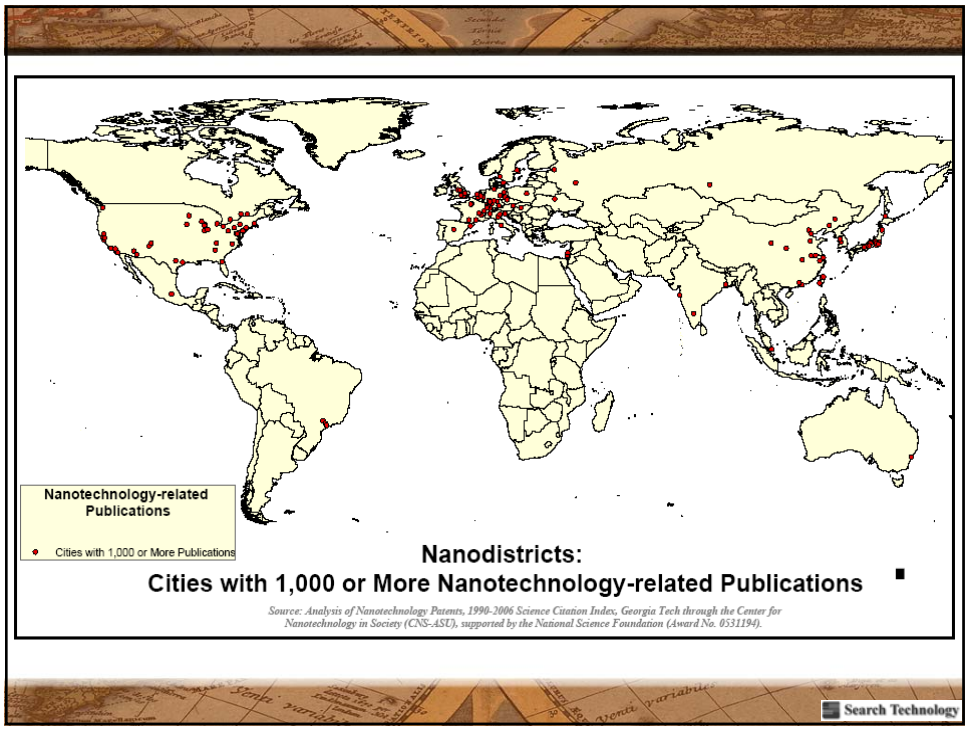


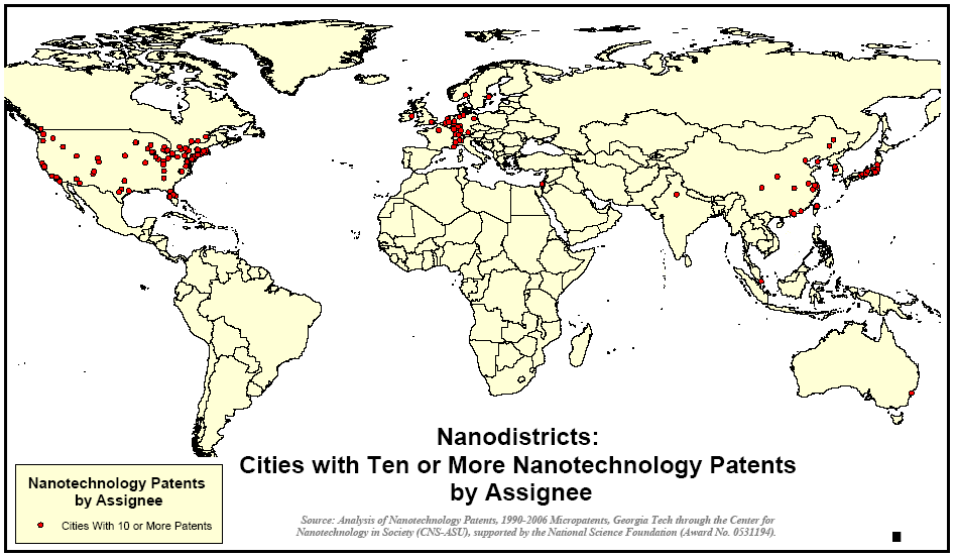

Georgia Tech TPAC / CNS-ASU Analysis of SCI Publications; refined nano definition; results subject to revision

## **Nano Patents** -- 1990-2006 (partial)




Activity by Patent Class over Time
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Electric
Medical
Measurement
Inorg. Chem.
Org. Macromole.
Phys, Chem Process
Dyes, Paints
Org. Chem.
Optics
Nanotech
Biochem
Info Storage
Metal Coating
Photography
1990 1991 1992 1993 1995 1994 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Georgia Tech TPAC / CNS-ASU patent analysis; refined nano definition; results subject to revision


Nanotechnology-related Publications
Cities with 1,000 or More Publications
Nanodistricts:
Cities with 1,000 or More Nanotechnology-related Publications
Source: Analysis of Nanotechnology Patents, 1990-2006 Science Citation Index, Georgia Tech through the Center for Nanotechnology in Society (CNS-ASU), supported by the National Science Foundation (Award No. 0531194).
Search Technology




## Zoom In: Profiling Purdue University

- 27 nano-patents
- 2042 nano-publications
- 50 Purdue researchers with 20 or more papers
- 347 with 5 or more papers
- Map showing collaboration among the leading authors (those 24 with 36 or more papers)

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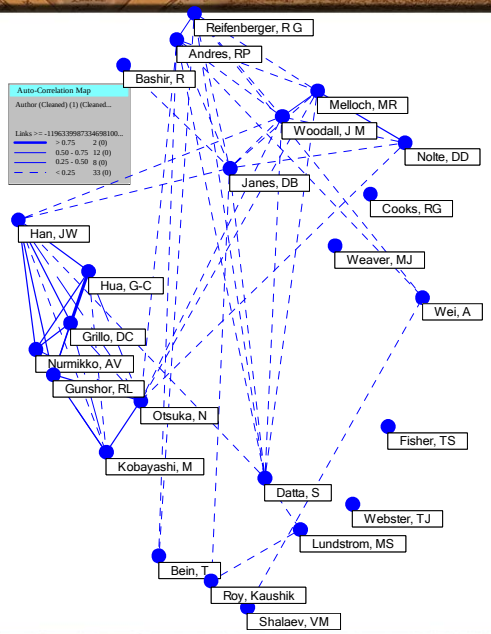
**Co-authoring Network among Purdue researchers**




**Purdue Profile: Top Authors – % of Publications in Recent Years – Focal Areas**

| | Author (Cleaned) | Publication Year | Subject Category | Keywords (controlled) |
|---|---|---|---|---|
| | Top Authors | % from 2003 to 2006 | Top 5 Items | Top 6 Items |
| 180 | Melloch, MR | 4% of 180 | PHYSICS, APPLIED [43];<br>PHYSICS, CONDENSED MATTER [17];<br>OPTICS [16];<br>ENGINEERING, ELECTRICAL & ELECTRONIC [16];<br>MATERIALS SCIENCE, MULTIDISCIPLINARY [4] | semiconductor quantum wells [64];<br>III-V semiconductors [58];<br>gallium arsenide [57];<br>aluminum compounds [46];<br>photorefractive materials [28];<br>multiwave mixing [21] |
| 147 | Nolte, DD | 8% of 147 | PHYSICS, APPLIED [23];<br>OPTICS [18];<br>ENGINEERING, ELECTRICAL & ELECTRONIC [6];<br>PHYSICS, CONDENSED MATTER [3];<br>MATERIALS SCIENCE, MULTIDISCIPLINARY [2] | semiconductor quantum wells [71];<br>gallium arsenide [42];<br>III-V semiconductors [42];<br>aluminum compounds [38];<br>photorefractive materials [37];<br>multiwave mixing [24] |
| 111 | Gunshor, RL | 0% of 111 | PHYSICS, APPLIED [23];<br>PHYSICS, CONDENSED MATTER [17];<br>ENGINEERING, ELECTRICAL & ELECTRONIC [9];<br>CRYSTALLOGRAPHY [7];<br>MATERIALS SCIENCE, MULTIDISCIPLINARY [5] | zinc compounds [39];<br>II-VI semiconductors [39];<br>molecular beam epitaxial growth [23];<br>semiconductor growth [19];<br>transmission electron microscope examination of materials [18];<br>semiconductor epitaxial layers [17] |
| 102 | Webster, TJ | 67% of 102 | ENGINEERING, BIOMEDICAL [5];<br>MATERIALS SCIENCE, BIOMATERIALS [4];<br>CHEMISTRY, MULTIDISCIPLINARY [2] | nanostructured materials [48];<br>adhesion [35];<br>bone [32];<br>biomedical materials [28];<br>Cells [27];<br>cellular biophysics [25] |
| 96 | Otsuka, N | 0% of 96 | PHYSICS, APPLIED [26];<br>ENGINEERING, ELECTRICAL & ELECTRONIC [11];<br>CRYSTALLOGRAPHY [7];<br>MATERIALS SCIENCE, MULTIDISCIPLINARY [6];<br>PHYSICS, CONDENSED MATTER [3] | transmission electron microscope examination of materials [31];<br>zinc compounds [30];<br>II-VI semiconductors [30];<br>III-V semiconductors [28];<br>gallium arsenide [27];<br>semiconductor epitaxial layers [26] |

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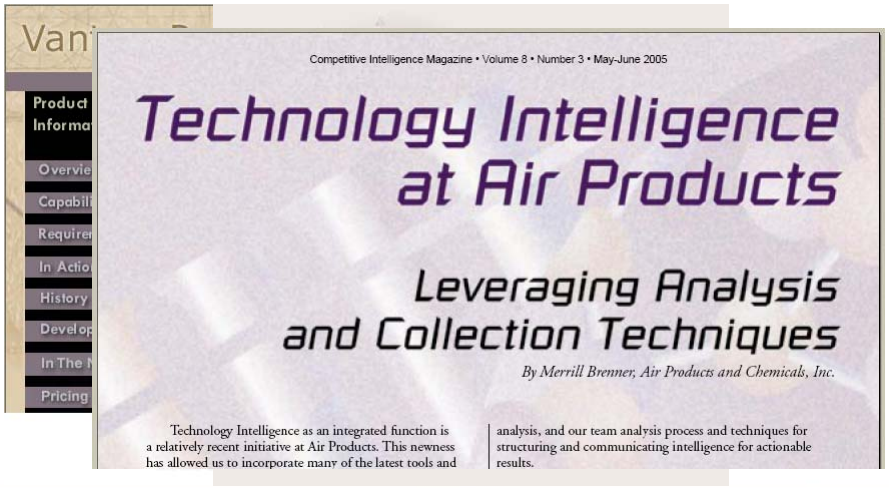
## Summary

- Too much information to read every item
- Treat text like Data – Mine it for patterns!
- Patterns speak to innovation prospects: maturation, contextual forces, market prospects
- VantagePoint [**Thomson Data Analyzer**] can tell Who, What, When and Where
- Tech Mining answers managerial questions for faster, better decisions.

## Competitive Technical Intelligence: "Recipe"



# Resources

- *Tech Mining* by Alan Porter and Scott Cunningham, Wiley, 2005
- Technology Intelligence at Air Products by Merrill Brenner, *Competitive Intelligence Magazine,* May/June, 2005
- See Thomson Scientific Exhibit re: Thomson Data Analyzer or www.theVantagePoint.com
  - the software
  - various “News” on text mining of S&T
- //tpac.gatech.edu
  - Hot Tech & TOA (Technology Opportunities Analysis)
  - papers
- aporter@searchtech.com
- 770-441-1457

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