

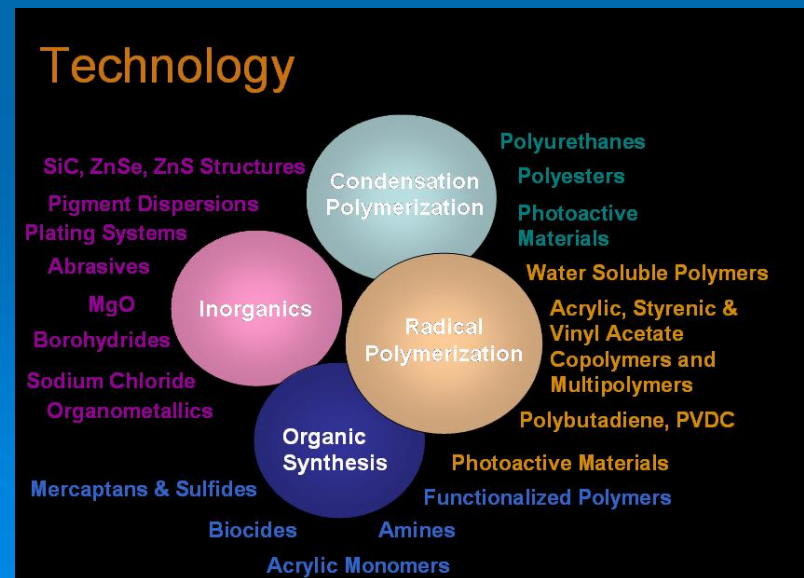
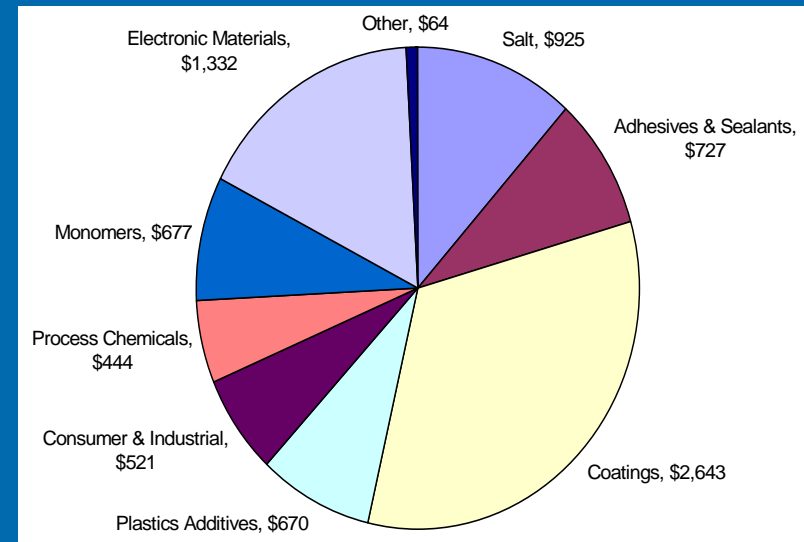
NSF-Sponsored Solid State Chem.: Industrial Relevance & Impact

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Opinions expressed are my own and not necessarily those of
the Rohm and Haas Company.

Rohm and Haas Profile

- 2005 sales: \$8Bn, ca. 50% N. America
- 16,500 employees
- 100 facilities in 27 countries
- 2005 R&D: \$273MM
- Imagine the possibilities TM



Industrial Team

- Bob Bedard (**UOP**), zeolites, perovskites, dielectrics, sulfides, zirconium silicates
- Nate Brese (**Rohm and Haas**), electronics, SiC, batteries, nitrides
- Guang Cao (**ExxonMobil**), zeolites, layered phosphonates
- Sandeep Dhingra (**Dow**), zeolites, chalcogenides
- Cherie Kagan (**IBM**), organic electronics, nano CdSe
- Dave Mitzi (**IBM**), chalcogenide films, superconductors

Anatomy of a Roadmap

- Key attributes
- Situation
- Critical issues
- Needs
- Gaps
- Recommendations

Look at the past. Extrapolate to the future.
Roadmaps are self-fulfilling prophecies.

NSF Mission

- To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes.
- Three strategic goals:
 - **PEOPLE** – Developing "a diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens";
 - **IDEAS** – Enabling "discovery across the frontier of science and engineering, connected to learning, innovation and service to society"; and
 - **TOOLS** – Providing "broadly accessible, state-of-the-art and shared research and education tools."

Industrial Impact and Relevance of NSF-sponsored Solid State Research

- People
 - I. Trained scientists and engineers
 - a. Technical skills
 - b. Other training
 - II. Fundamental material studies
 - III. New functional materials
 - a. Magnetic
 - b. Electronic
 - c. Luminescent
 - d. Energy
 - e. Catalysts
 - f. Porous solids
 - IV. Collaborators and consultants
 - V. Future prospects
- Ideas
- Tools

Typical Technical Skills of a Solid-State Chemist

- Synthesis
 - Solid-solid, flux, exchange reactions
 - Hydro- and solvento- thermal techniques
 - Sol-gel chemistry
 - Crystal growth
 - Safe handling of sensitive materials handling (drybox, Schlenk)
- Characterization
 - Crystallography (X-ray, neutron, powder)
 - Microscopy (Optical, electron, scanning probe)
 - Electrical and magnetic
 - Thermal (TGA, DSC)
 - Optical, IR, UV
- Simulation
 - Empirical
 - Semi-empirical
 - First principles

Additional Skills of Solid State Chemists Needed in Industry

- Multidisciplinary approaches
 - Chemistry
 - Physics
 - Materials Science
 - Mathematics
- Broad experience base
 - Multiple focus areas in research groups
 - Variety of projects and project shifts
- Team skills
 - Collaboration with other disciplines
 - Co-authorship
 - Leading and participating
- External networks
 - National labs
 - Other universities
 - Industrial collaborators
- Broad experience base
 - Projects shift quickly
 - Must become local expert in minimal time
- Teams
 - Scientists
 - Engineers
 - Marketing, Sales
 - Legal
 - Finance, purchasing, accounting
- Networks
 - Critical to finding information and solving problems
- Management skills
 - Project
 - People

Industrial Relevance of SSC

- Luminescent materials
 - Phosphors, HBLEDs, lasers
- Giant Magneto Resistant (GMR) materials
 - Magnetic storage
- Support and separation materials
 - Gas/liquid purification, household detergents
- Heterogeneous catalysts
 - Energy/petroleum, environmental, conversions
- Energy conversion materials
 - Batteries, fuel cells, photovoltaics
- Superconductors
 - Medical imaging, analytical
- Piezoelectrics
 - Scanners, telecommunications, memory, sensors
- Thermoelectrics
 - Coolers for communications and consumers
- Nanotechnology
 - You name it



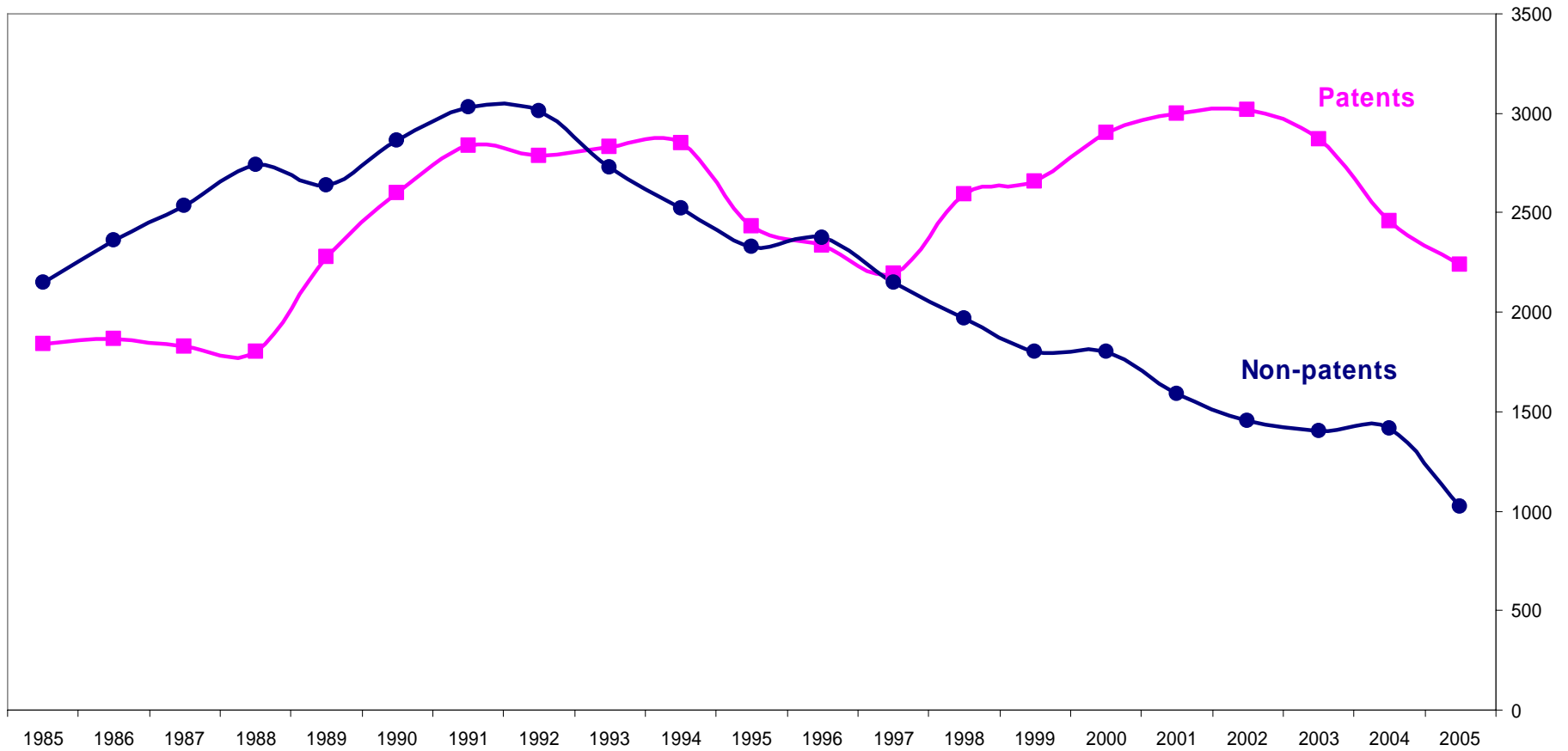
ExxonMobil Award Winners

Year	Recipient		University
1979	Horia	Metiu	UCSB
1980	Arthur	Ellis	U. Wisconsin, Madison
1981	Steven	Bernasek	Princeton
1982	Richard	Masel	U. Illinois
1983	Steven	Suib	U. Conn.
1984	Andrew	Bocarsly	Princeton
1985	Jay	Benzinger	Princeton
1986	Thomas.	Mallouk	U. Texas, Austin
1987	Angelica	Stacy	UC, Berkeley
1988	Douglas	Keszler	Oregon State
1989	Richard	Kaner	UCLA
1990	Mercouri	Kanatzidis	Michigan State
1991	A. Paul	Alivisatos	UC, Berkeley
1992	William	Hammack	Carnegie Mellon
1993	Emily	Carter	UCLA
1994	Hanno	Loye	MIT
1995	Gordon	Miller	Iowa State
1996	Peter	Dorhout	Colorado State
1997	Jackie	Ying	MIT
1998	Omar	Yaghi	Arizona State
1999	Slavi	Sevov	Notre Dame
2000	Z. John	Zhang	Georgia Tech.
2001	Peidong	Yang	UC, Berkeley
2003	Shiv	Halasyamani	U. Houston
2004	Julia	Chan	LSU
2005	Ram	Seshadri	UC, Santa Barbara
2006	Teri	Odom	Northwestern

Topics include luminescence, magnetic materials, piezoelectrics, thermoelectrics, porous frameworks, Zintl compounds, theory, structural chemistry and nano.

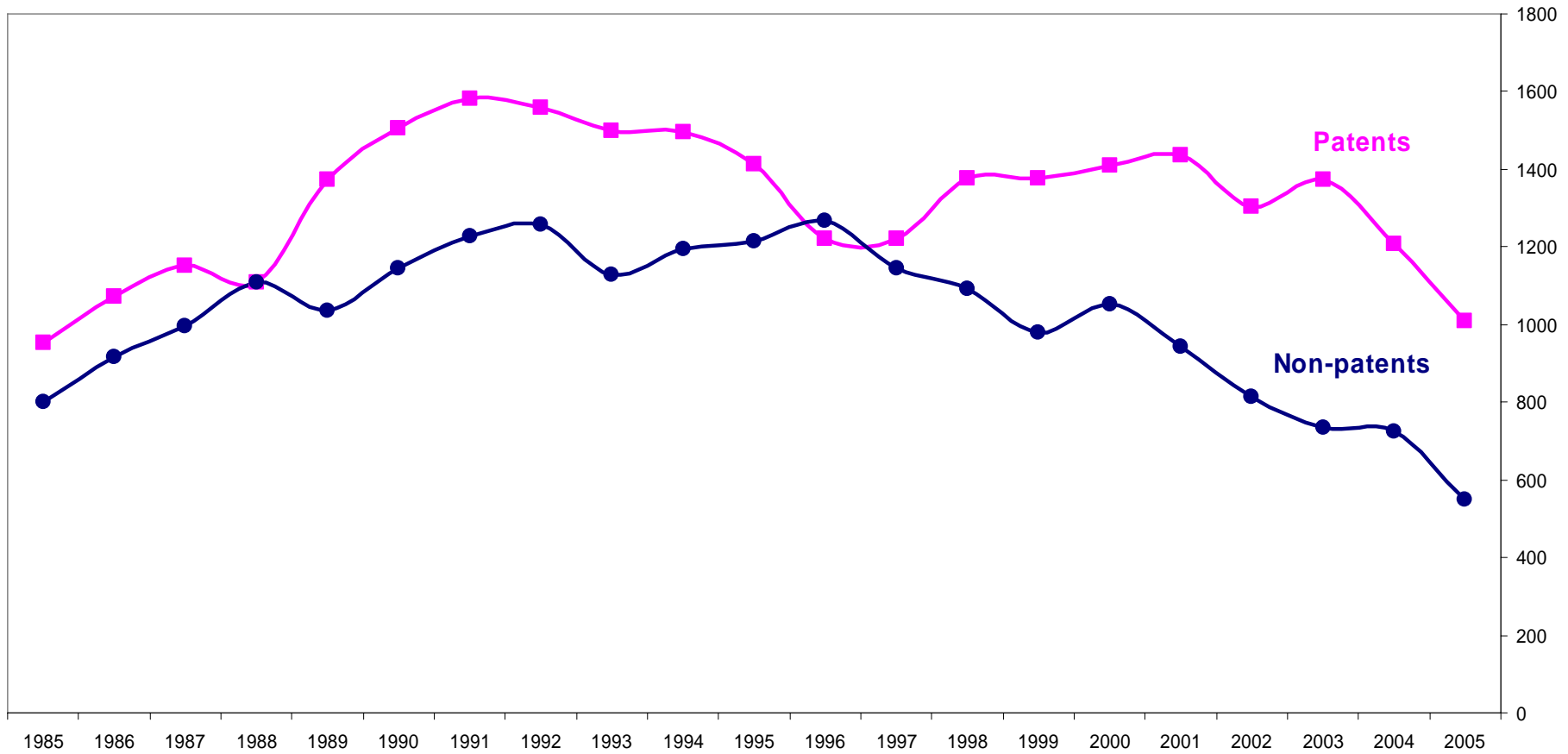
Industry Reliance on NSF-SSC Increases

Total Industrial Publications from
Air Products, Celanese, Dow, DuPont, Exxon, IBM, Kodak, Rohm and Haas, UOP

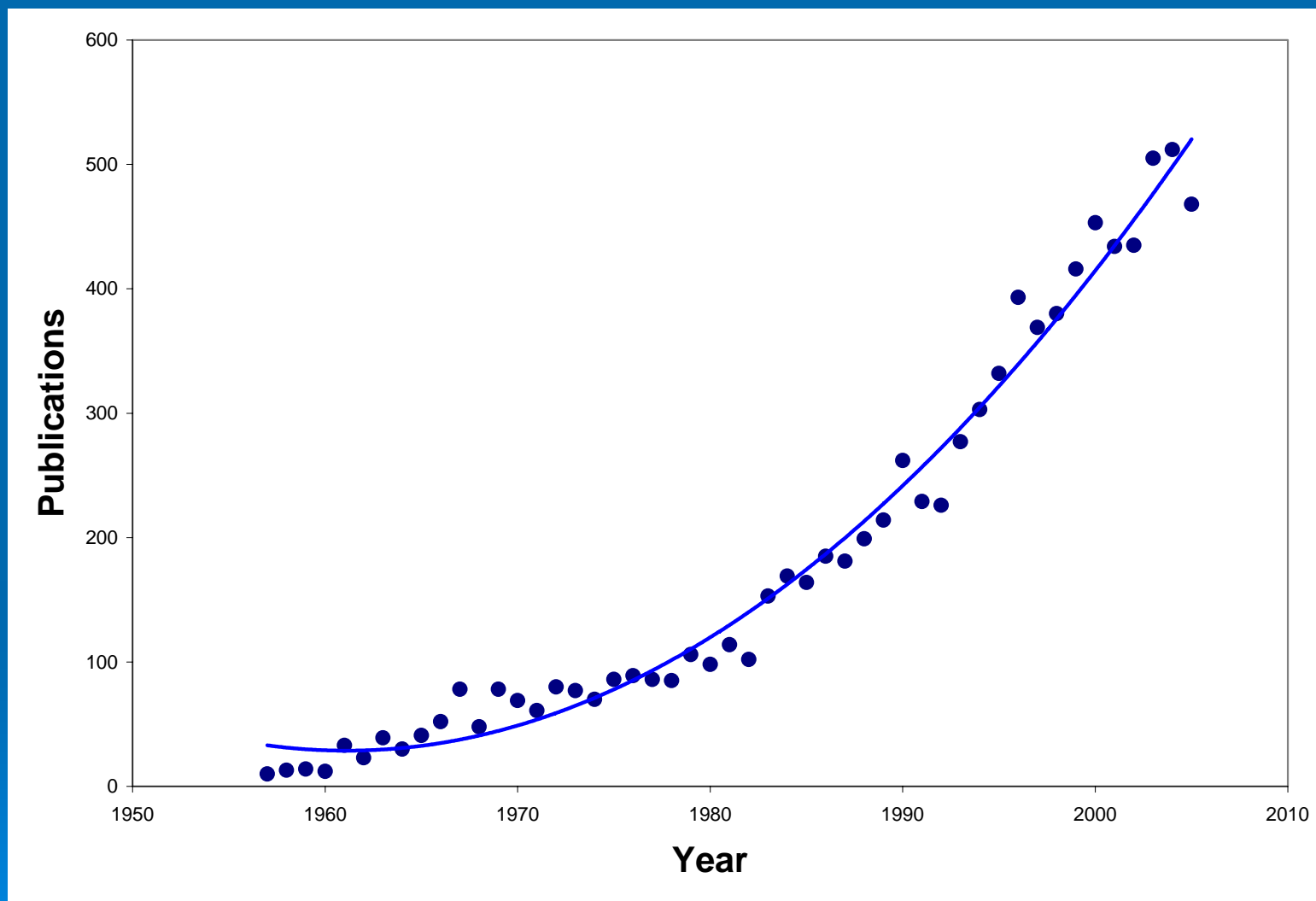


Industry Reliance on NSF-SSC Increases

Chemical Industry Publications
Air Products, Celanese, Dow, DuPont, Rohm and Haas, UOP



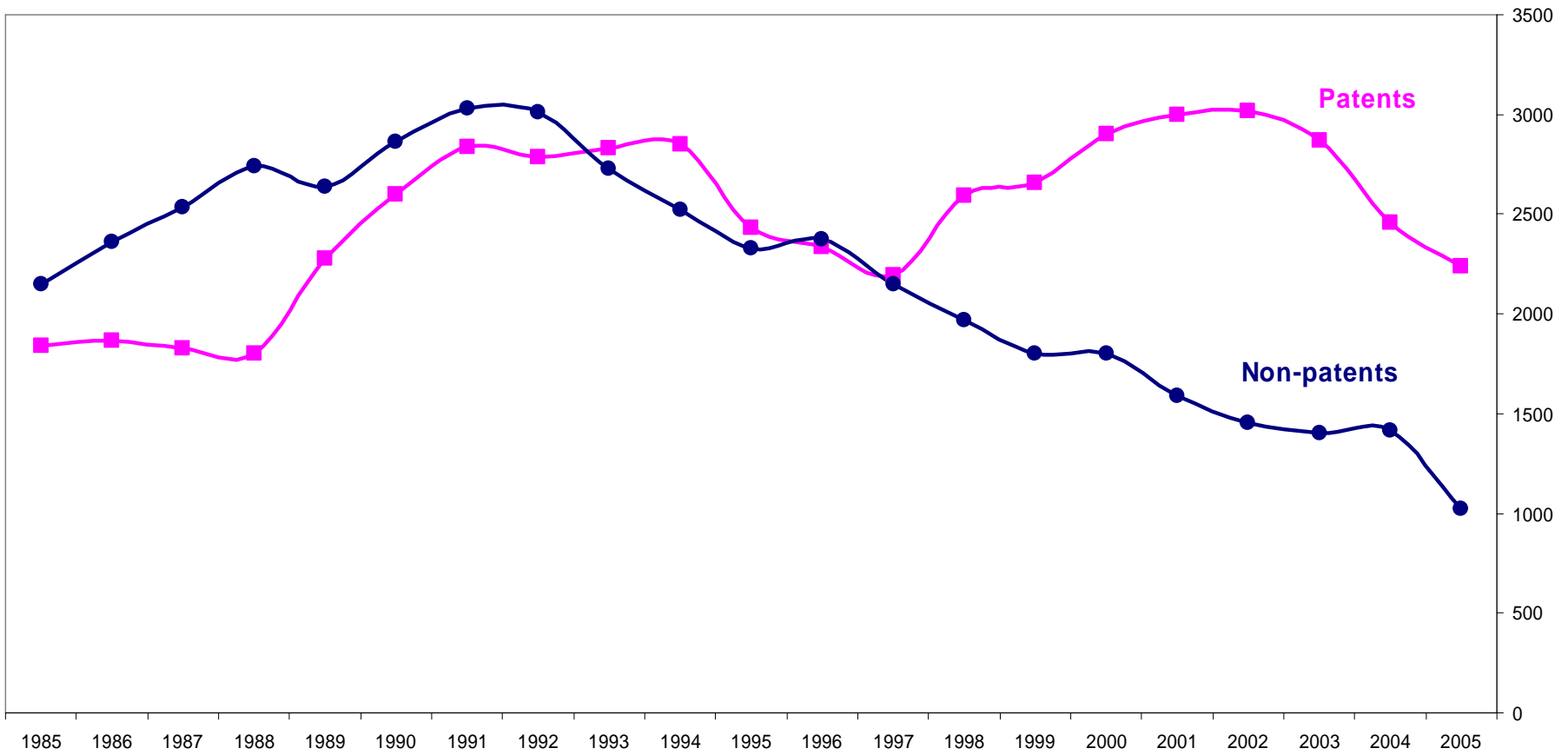
Publications with “solid state chemistry”



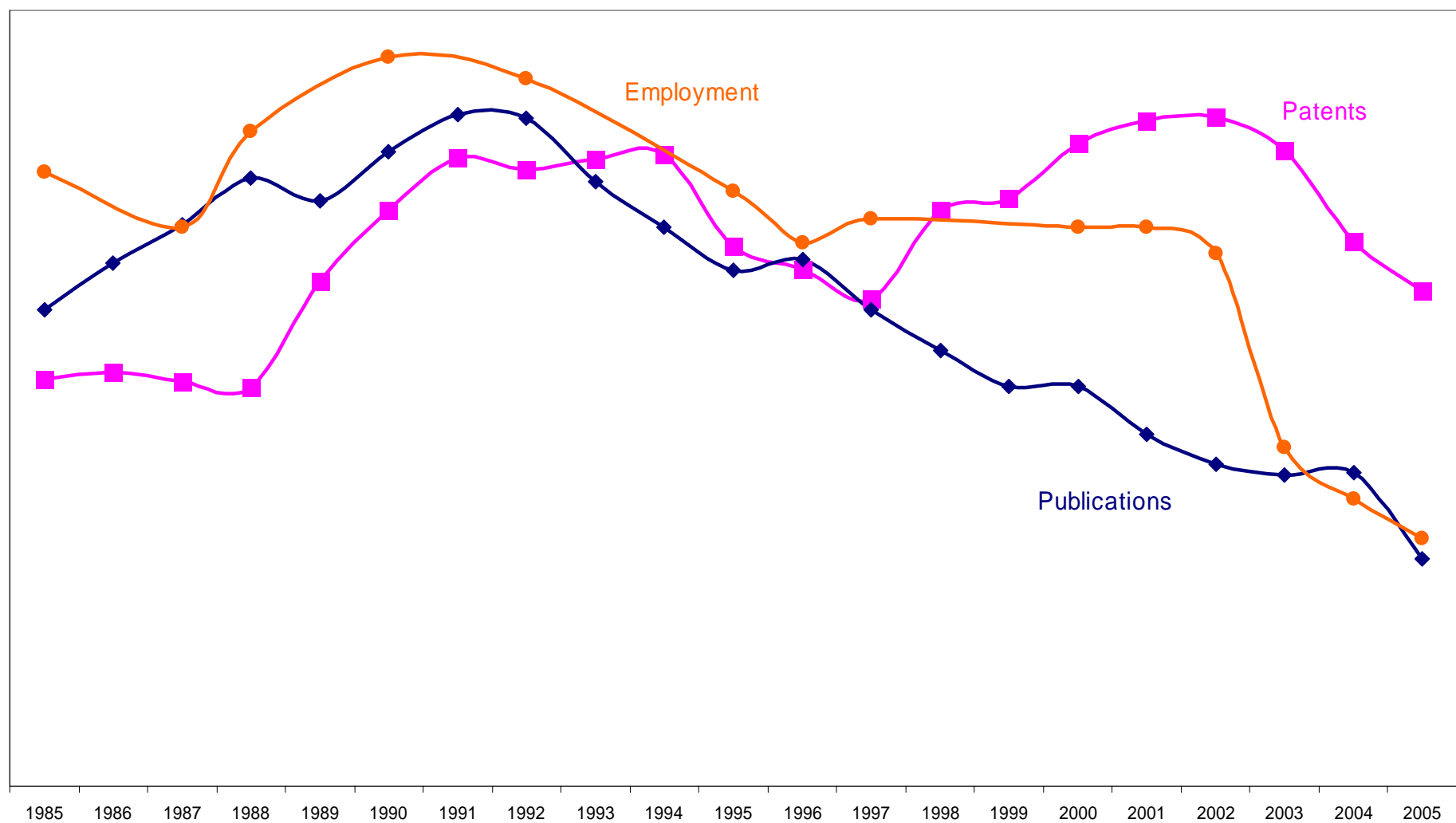
Doubles every 10 years

Industry Reliance on NSF-SSC Increases

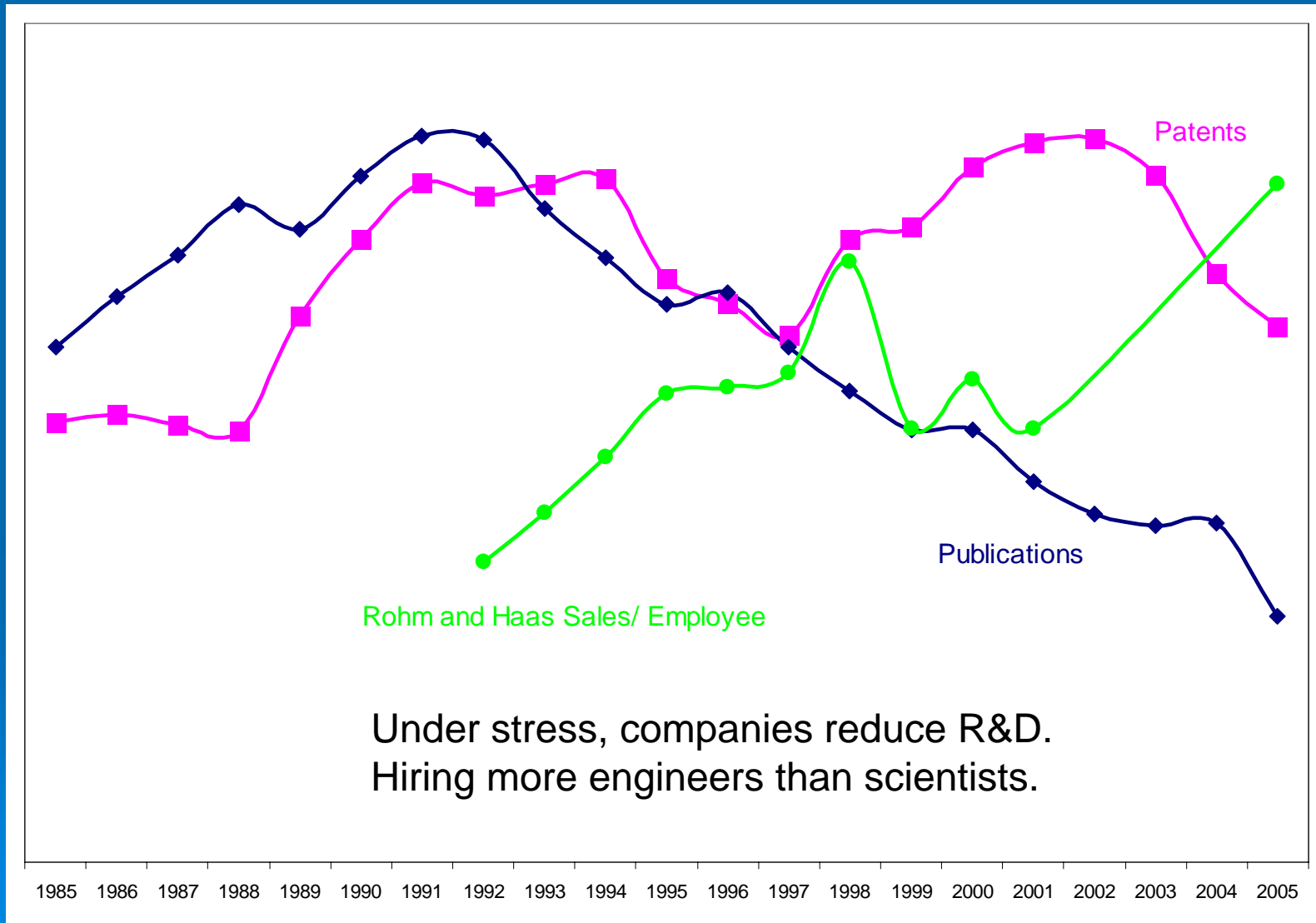
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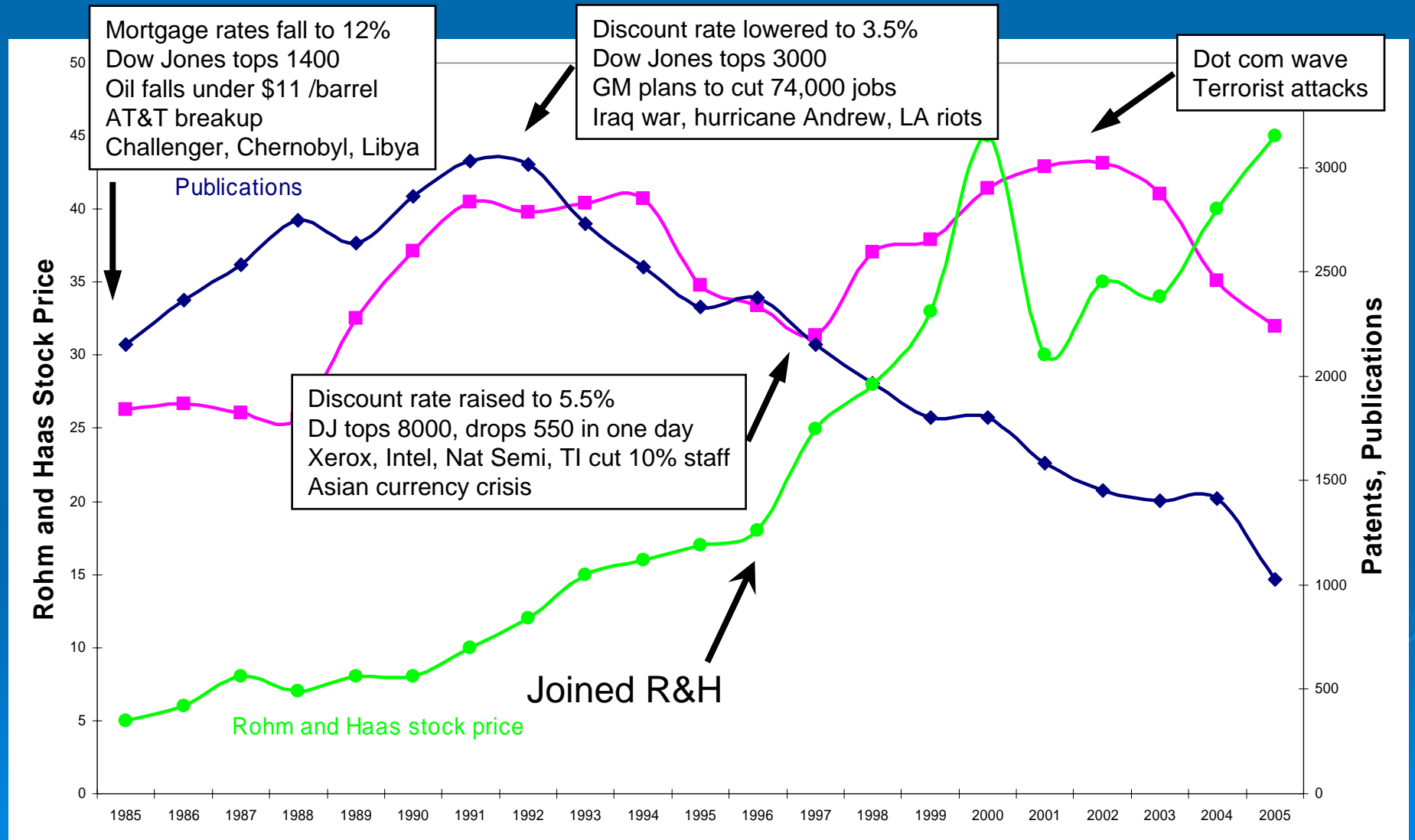
Chemical Employees Decline



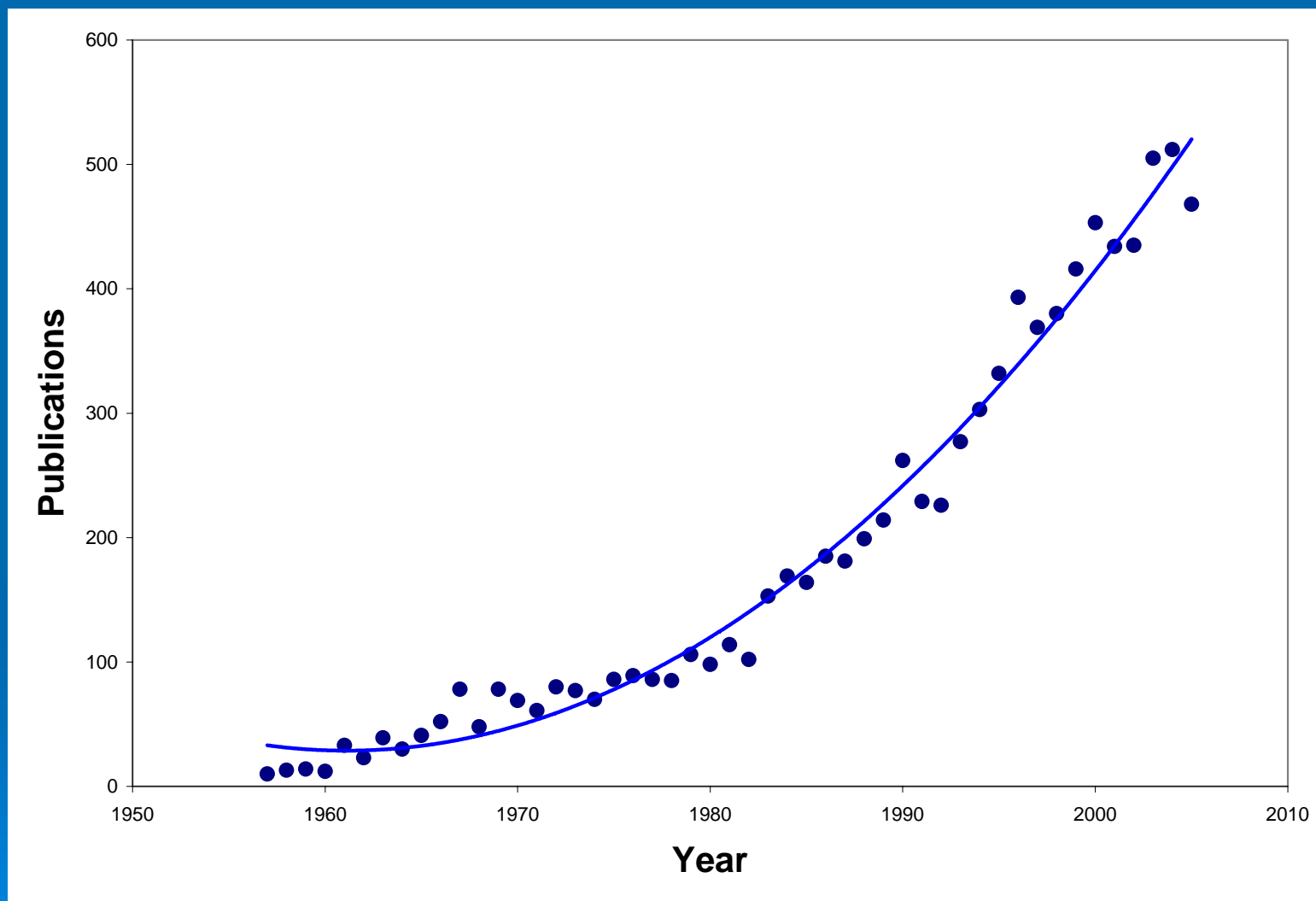
Productivity Increases



External Forces on Industry

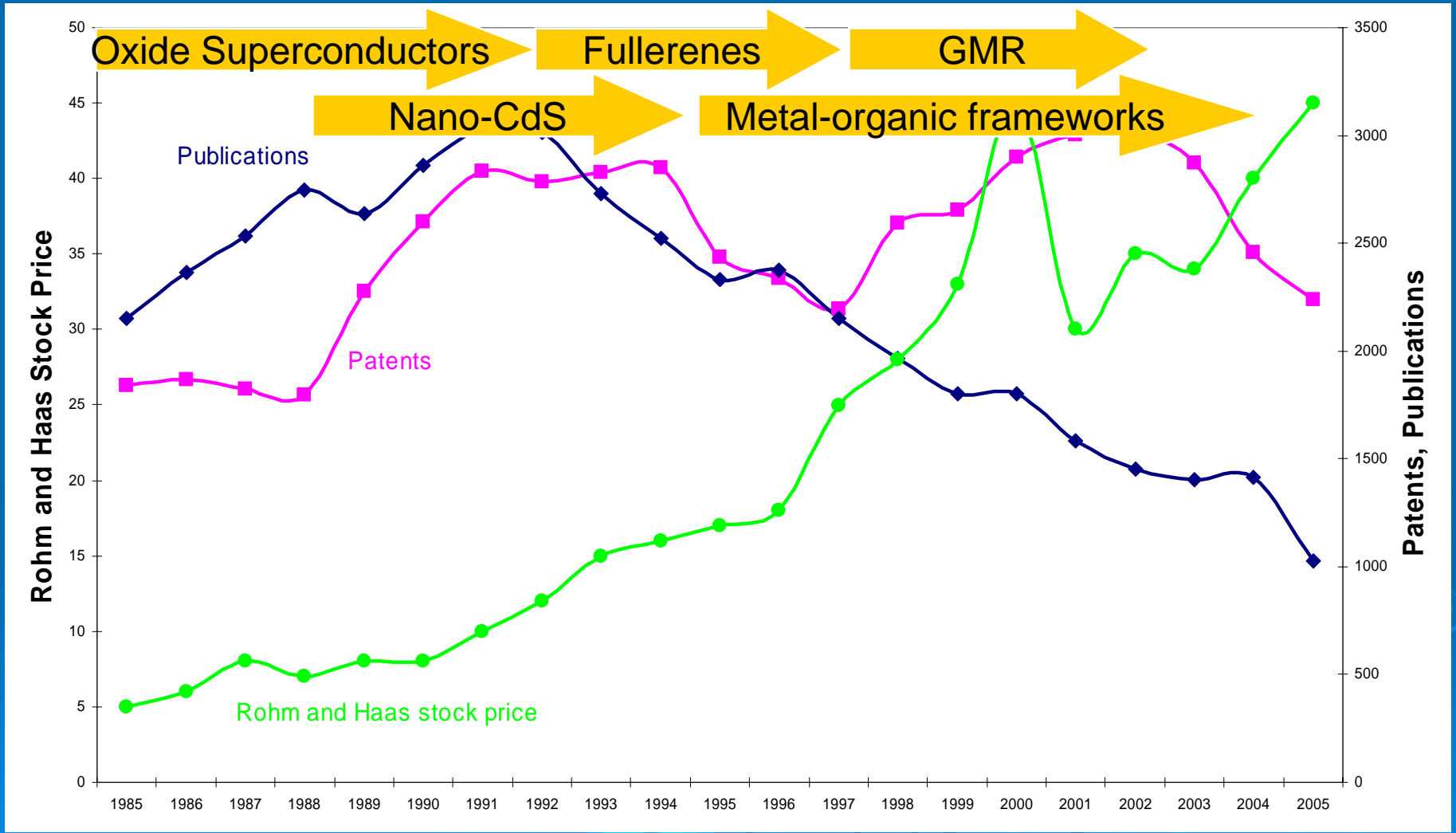


Publications with “solid state chemistry”



Doubles every 10 years

Trends in Solid State Chem



Collaborators and Consultants

- Centers of excellence
- Technology experts
- Equipment and facilities

- Contract research
- Start-ups and spin-outs
- Licensing opportunities

Industrial Trends for SSC

- Better (or equal) performance at lower cost
- Nanoscale performance
- Functional surfaces (anti-fouling, anti-microbial, stain-resistance)
- Novel feedstocks
- Environmentally-benign manufacturing
- Energy-efficiency
- Positive environmental impact (clean water, toxic mitigation, etc.)
- Want it to work the first time.

Requests

- (Continue to) support cross-disciplinary research and train students to work effectively on cross-functional teams. Training is clearly the #1 impact.
- (Continue to) support longer-term, fundamental research, with new material discovery in functional areas. This fills an increasing gap in industrial research.
- Encourage work on commercially-relevant problems, while avoiding industry conflicts. Encourage collaboration with industry.