Semiconductor Research Corporation

PIONEERS IN COLLABORATIVE RESEARCH®

global RESEARCH COLLABORATION

SRC: A Successful Collaborative Research Model

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Arlington Virginia
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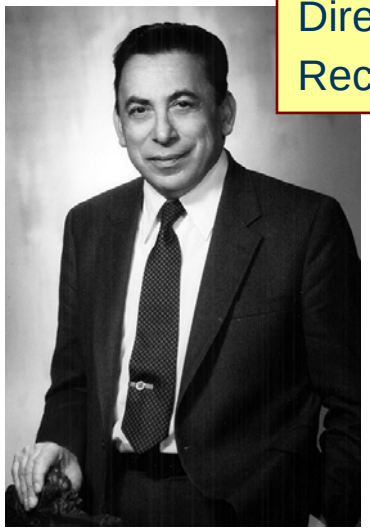
SRC's "Founding Fathers"

Erich Bloch, IBM vice president
Director of the National Science Foundation,
Recipient of the National Medal of Technology

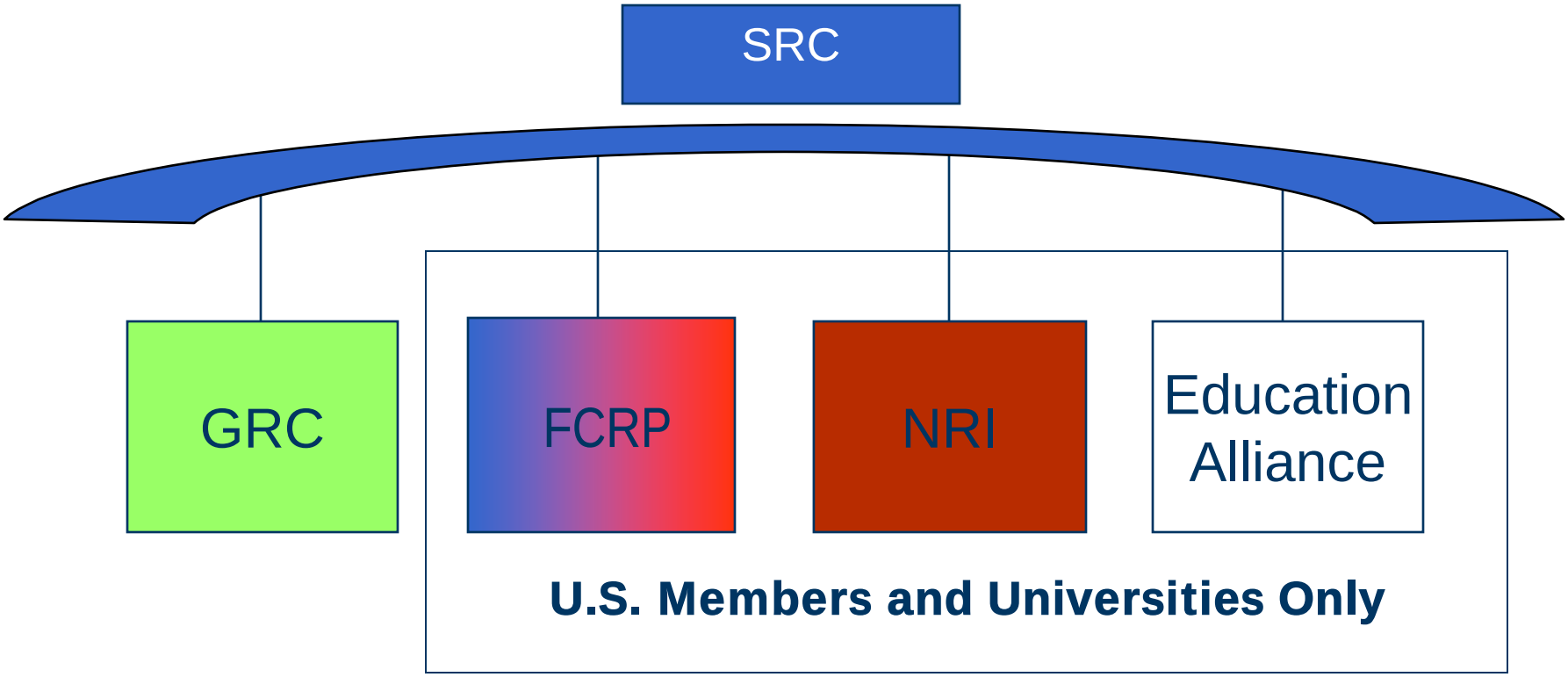


Robert Noyce, "the Mayor of Silicon Valley", co-founder of Intel and co-inventor of the integrated circuit.

Jack Kilby, Nobel Prize Laureate for the invention of the integrated circuit

SRC was formed in 1982

SRC Brands: A Family of Distinct but Related Program Entities



Current Technical Directions of SRC Program Entities

- GRC: Addressing CMOS scaling and scaling independent challenges collectively aimed toward continuing the viability of the current industry.
- FCRP: Addressing technical barriers faced by semiconductor industry to enable execution of ultimate-CMOS while developing linkages to beyond-CMOS.
- NRI: Addressing identification of the next “switch” or “information element” enabling revolutionary new approaches that significantly increase functionality and expand system application space.

SRC Numbers* ...

SRC Research Programs

- $976M invested by SRC Members
- $827M contract funding
- $243M leveraged funding
- 2,677 contracts
- 6,845 students
- 1,525 faculty members
- 227 universities

Deliverables

- 38,708 technical documents
- 295 patents in SRC portfolio
- 701 patent applications
- 596 inventor awards
- 548 software programs
- 2,022 tasks/themes in research catalog

Recipient of the National Technology Medal

** Inception Thru December 2006*

Nanoelectronics Research Initiative: A recent example of collaboration

- Compelling evidence from physics that CMOS scaling would end within 20 years
- SRC/NSF workshops in 2003, 2004 and 2005 on ‘Silicon Nanoelectronics and Beyond’
  - Collaborative Board for Advancing Nanoelectronics formed in 2003
  - Five technical working groups activated in 2003
- Parallel industry workshops

NRI- Continued

- Five major technical thrusts defined
  - Computational state vectors other than electronic charge
  - Non-equilibrium systems
  - Novel, non-charge data transfer mechanisms
  - Nanoscale phonon engineering for thermal management
  - Directed self-assembly of such structures
- NRI launched in 2005
  - Collaborative funding by industry, NSF, NIST, and the states of New York, Texas, California and Georgia

NRI Sponsored Nanoelectronics Research Institutes

- NRI Mission: Demonstrate novel computing devices to enable the semiconductor industry to extend Moore's Law beyond the limits of CMOS
- Leverage industry, university, and both state & fed government funds, and use to drive university fabrication infrastructure
  - Initial program 2006-2009, with future expansion planned

WIN Western Institute of Nanoelectronics	**INDEX** Institute for Nanoelectronics Discovery & Exploration	**SWAN** SouthWest Academy for Nanoelectronics	**NSF NSEC & MRSEC** Supplemental Funding
UCLA, UCSB, Berkeley, Stanford	**SUNY-Albany**, GIT, Harvard, MIT, Purdue, RPI, Yale	**UT-Austin**, UT-Dallas, TX A&M, Rice, ASU, Notre Dame, U of MD	Funding 12 projects at 10 NSF centers
Theme 1: Spin devices Theme 2: Spin circuits Theme 3: Benchmarks & metrics	Task I: Novel state-variable devices Task II: Fab & Self-assembly Task III: Modeling & Arch Task IV: Theory & Sim Task V: Roadmap	Task 1: Logic devices with new state-variables Task 2: Materials & structs Task 3: Self-assembly & thermal mgmt Task 4: Interconnect & Arch Task 5: Nanoscale characterization	Broad work on various topics – also leverages other work in the centers

NRI-NSF Centers: 2006-2008

- Joint program established with NSF to fund NRI-related research at NSF centers

PI	Institution	Center	Center Name	Title of Supplement
Lundstrom, Mark	Purdue U	NCN	Network for Computational Nanotechnology	Exploratory Theory, Modeling, and Simulation for the NRI
Yardley, James T.	Columbia U	NSEC	Columbia Center for Electronic Transport in Molecular nanostructures	Non-equilibrium Quantum Coherent Devices in 1-D materials
Westervelt, Robert	Harvard U	NSEC	Science of Nanoscale Systems and their Device Applications	Ultrasmall Nanowire and Oxide Switches
Hawker, Craig	UCSB (Stanford, U Mass)	MRSEC	MRSEC at UCSB	Development of Next Generation Devices using Nanolithographic Techniques
Hull, Robert	U Virginia (Notre Dame)	MRSEC	Center for Nanoscopic Materials	Directed Assembly of Epitaxial Semiconductor Nanostructures for Novel Logic Switches
Johnson, Matt	U. Arkansas/ U Oklahoma	MRSEC	Center for Semiconductor Physics in Nanostructures	Nanoferroelectric Random Access Memory

New NSF-NRI Projects: 2007-2009

- NSF and NRI selected six new projects at NSF centers for 2007-2009

PI	Institution	NSF Center Type	Center Name	Title of Supplement
Tsymbal, Evgeny / **Sellmyer, David;** Belashchenko, Kirill; Sabirianov, Renat	U.Neb-Lincoln (U.Neb-Omaha)	MRSEC	Q-SPINS: Quantum and Spin Phenomena in Nanomagnetic Structures (www.mrsec.unl.edu)	"Multiferroic interfaces: new paradigms for functional switching"
Hull, Robert / Wolf, Stuart; Floro, Jerrold; Awschalom, David; Snider, Greg	U. Virginia (UCSB / Notre Dame)	MRSEC	Center for Nanoscopic Materials Design (www.mrsec.virginia.edu)	"Coherent Spin Dynamics in Single Ion doped Semiconductors: Towards a Coherent or Quantum Spin Switch"
Lundstrom, Mark / Alam, Muhamad; Datta, Supriyo; Klimeck, Gerhard; Roy, Kaushik	Purdue	NCN	The Network for Computational Nanotechnology (www.ncn.purdue.edu)	"Exploratory Theory, Modeling, and Simulation for the Nanoelectronics Research Initiative"
Ahn, Charles (**Tully, John**)	Yale	MRSEC	Center for Research on Interface Structures and Phenomena (www.crisp.yale.edu)	"Design and fabrication of magnetic-based devices with complex oxide materials"
MacDonald, Allan / DasSarma, Sankar (**Williams, Ellen**)	UMD (UT-Austin)	MRSEC	Materials Research Science and Engineering Center (http://mrsec.umd.edu)	"Pseudospintronics"
Kan, Edwin (**Buhrman, Robert**)	Cornell	NSEC	Center for Nanoscale Systems in Information Technologies (http://www.cns.cornell.edu/)	"Controlled Orbital Hybridization in the Carbon Nanotube Quantum Modulated Transistor (CNT-QMT)"

Environmental requirements for successful collaborative research

- Growth-oriented, technology-driven industry
- Sufficient industry revenue base to support research
- Common/congruent technical interests among industry participants
- “Can-do” attitude of industry participants to transform pre-competitive research into competitive advantage
- Benign government policies with respect to pre-competitive research collaboration
- Intersection of government program directions/interests with industry

Ground rules for operation

- Guaranteed influence by each participating company and government sponsors on research directions
- Equity with respect to participation costs
- Equal and rapid access to research results and intellectual property by all industry participants
- Hands-on industry involvement in the conduct of the research program
- Strong and relevant university researcher base