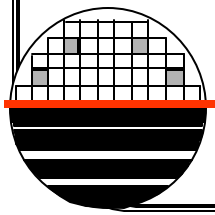
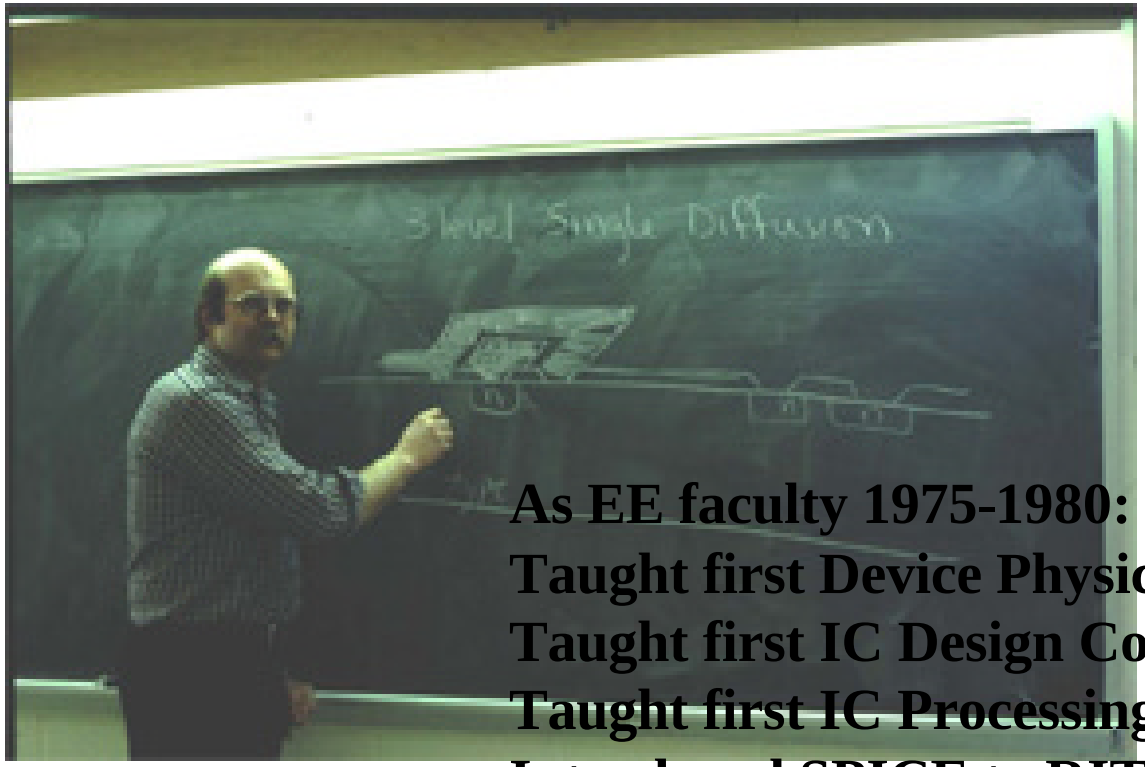
Firsts for Microelectronic Engineering

Dr. Lynn Fuller
Motorola Professor and
Founder of Microelectronic Engineering
Rochester Institute of Technology
82 Lomb Memorial Drive
Rochester, NY 14623-5604
Tel (716) 475-2035
Fax (716) 475-5041
LFFEEE@rit.edu
http://www.microe.rit.edu



DR. LYNN FULLER, FACULTY IN EE



As EE faculty 1975-1980:
Taught first Device Physics Courses
Taught first IC Design Courses
Taught first IC Processing Labs
Introduced SPICE to RIT
Made RIT's first transistors

HISTORY

1982 Start of BS Program in Microelectronic Engineering - Dr. Lynn Fuller, Director; 55 Freshman, 10-2nd and 5-3rd Year Students; Hire Department COO Sara Widlund; Professor Pearson and Facilities Manager Scott Blondell

1983 Hire Professor Turkman

1984 Start plans for new building

1985 Graduate first 5 students, Hire Professor Jackson

1986 Honorary PhD to Jack Kilby, Move into new building, Hire Professor Lane and Technician One

1987 ABET Accreditation of BS program, Graduate firs 5 year RIT Students, SRC Program for Micro Manufacturing Engineering Masters Degree, Hire Professor Kurinec

1988 Start student run factory, Graduate first Masters students, Hire Professor Smith and Technician Two

HISTORY

1989 Dedicate Perkin Elmer Laboratory for Electron Beam Lithography

1990 Imaging Science Ph.D. Program IBM CIM in Higher Education

1991 Dedicate Excimer Laser Laboratory, Ranked 1st in SRC Survey

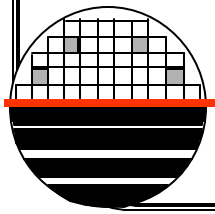
1992 10 Annual Conference, ABET Visit No. 2

1993 B.S. Program Curriculum Changes, Hire Professor Hirschman

1994 Dr. Lynn Fuller named Motorola Professor

1995 MSMME Program approved and started, First SEMATECH Research Contract

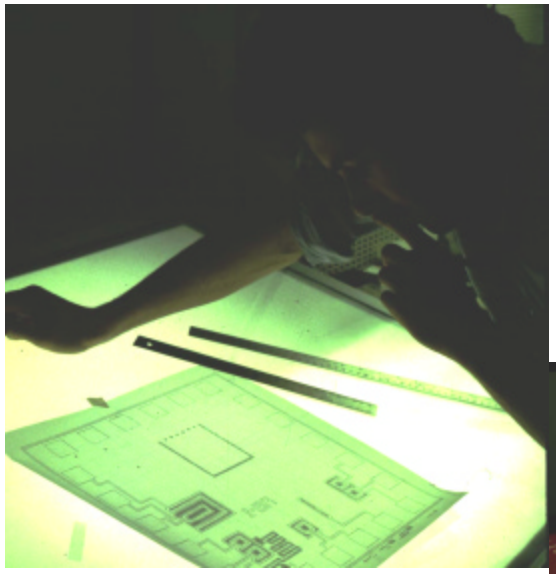
1996 Process first 6 inch wafers, Intel becomes affiliate member



HISTORY

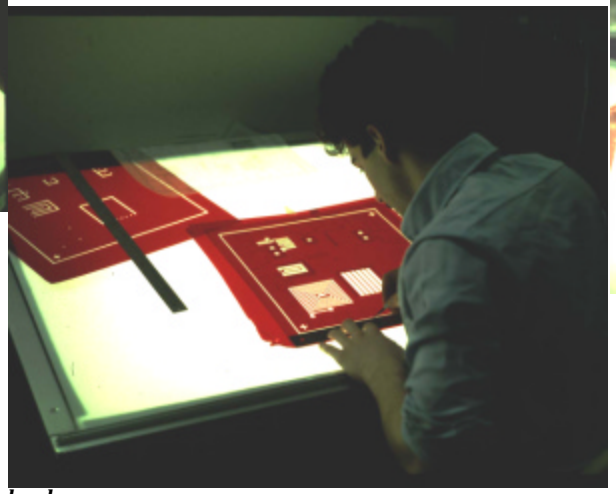
1997 NEC, Nikon, & Micron Become affiliate members
1998 Hire Professor Philip Rack, Start Distance Offering of Masters Program, ABET visit No. 3
1999 ABET Certification No 3
2000 ASM Lithography, Air Products and Photronics become Affiliates, Hire Professor William Grande, Dale Ewbank, Suraj Bhaskaran. Dr. Bruce Smith becomes the Intel Professor
2001 Dr. Santosh Kurinec becomes Department Head
2002 20th Year Celebration, Hire Professor Sean Rommel
2003 Start of Ph.D. Program in Microsystems Engineering
2004 Bruce Smith starts Amphibian Systems Inc.
2005 First Ph.D. Graduates in Microsystems Engineering
2006 Dr. Hirschman named Micron Professor
2007 25th Year

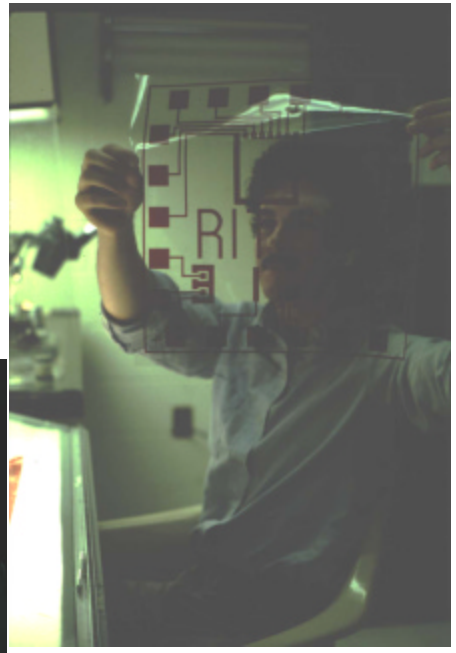
EARLY IC LAYOUT AT RIT



Drawing of Layout

Rubylith for each Layer





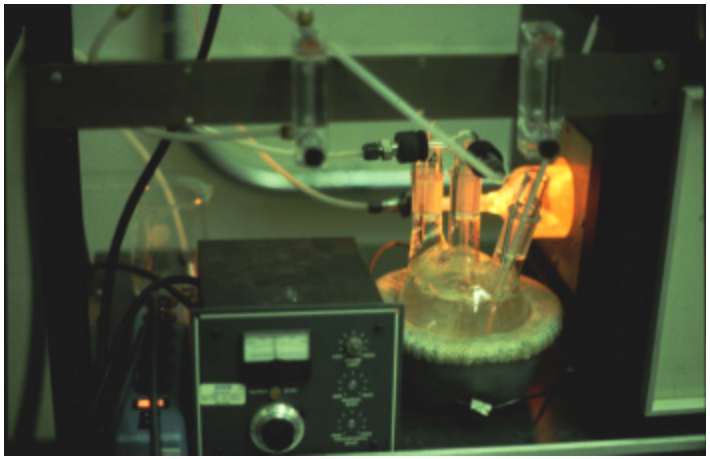
Design Rule Check

EARLY LITHOGRAPHY AT RIT

Kasper contact aligner on 2x4 blocks. Notice homemade reduction camera.

Hamilton Beech Blender Modified for spin coating resist on wafers. Purée gives coating thickness of ~1 µm

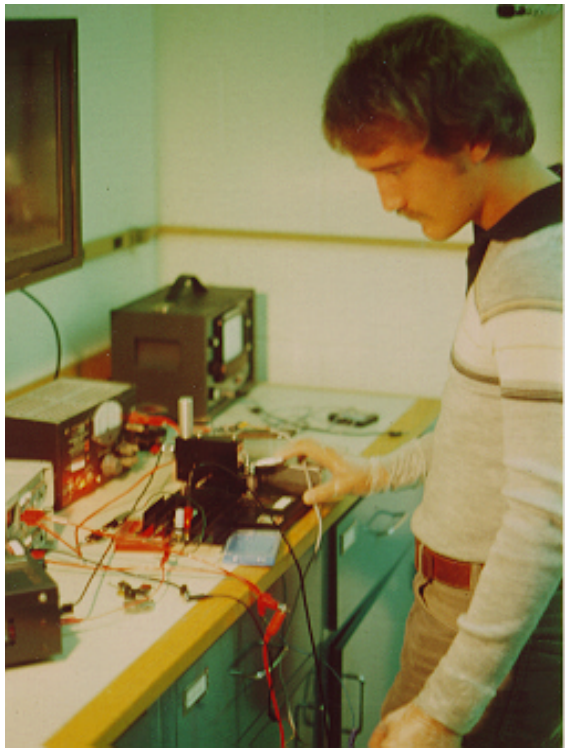
OXIDE GROWTH AND DIFFUSION AT RIT

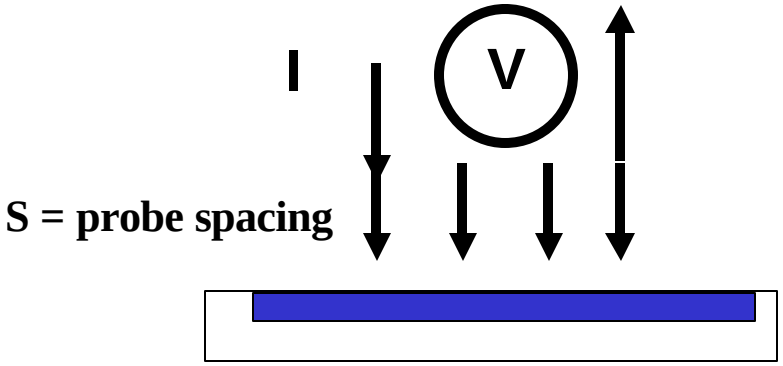


Gas flow and bubbler system

Students Jim Razzak and Rob Pearson do oxide growth on 2” wafers.

FOUR POINT PROBE AT RIT





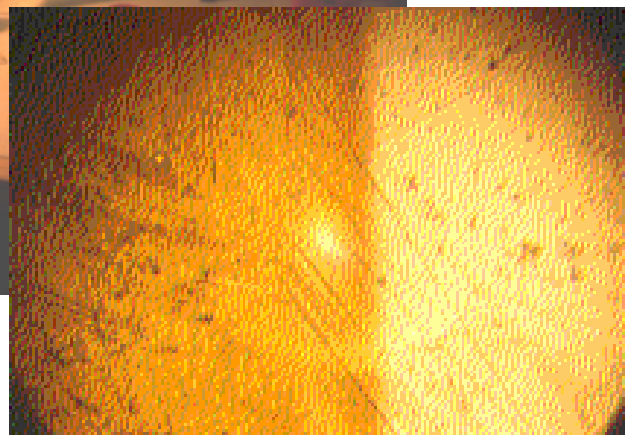
xj = Diffusion Layer Thickness

Rhos = p/ln2 x V / I = 4.532 V/I ohms/sq

,if S>xj

Use FORTRAN program on VAX
RUN USER:[MICROLIB.TOOLS]FOURPT

RIT'S FIRST ANGLE LAP AND STAIN XJ MEASUREMENT

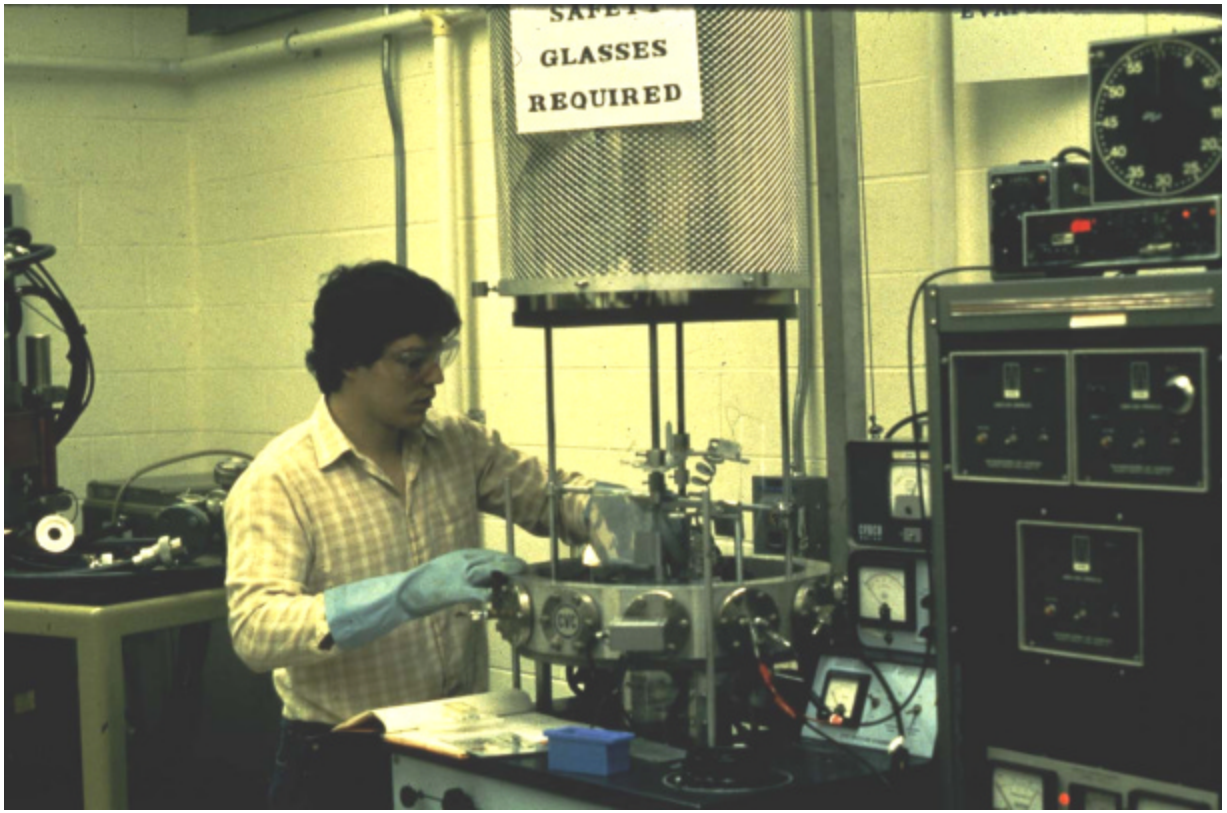


Chris Knaus

Rochester Institute of Technology

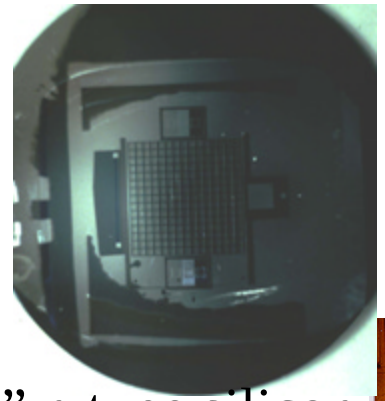
Microelectronic Engineering

RIT'S FIRST METALLIZATION SYSTEM



Summer 1979

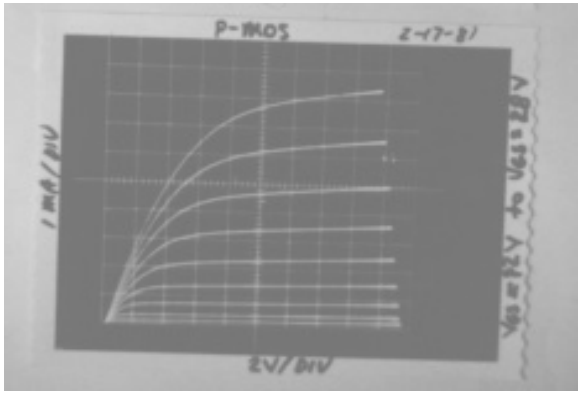
FIRST RIT PMOS TRANSISTOR

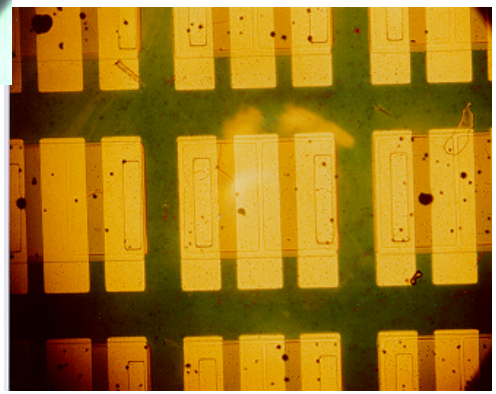


2” n-type silicon wafer

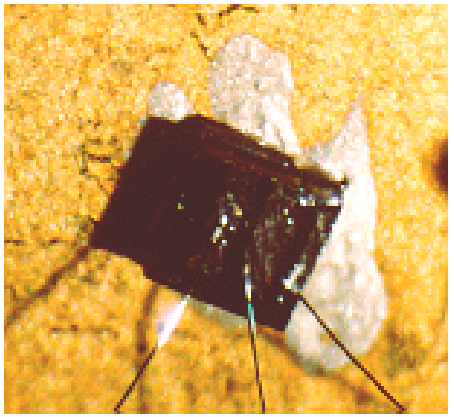
2-17-81

Vt = 12 volts



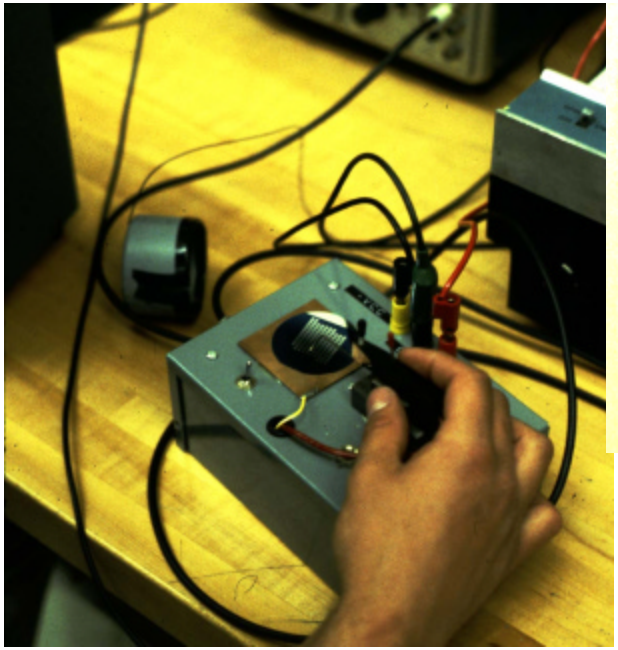


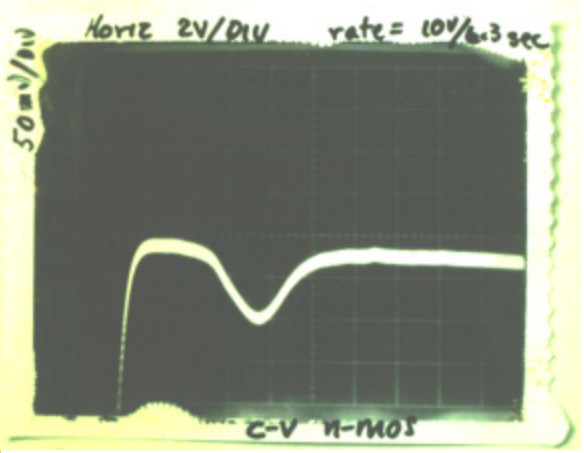
PMOS Transistors



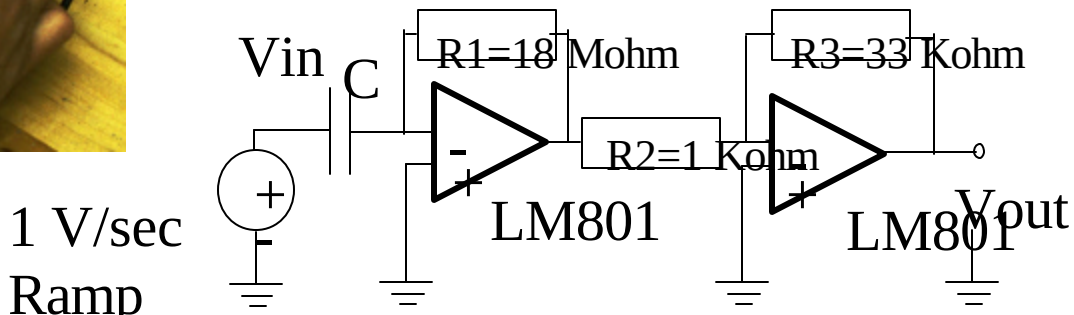
Packaged Device
Aluminum wire bonds

LOW FREQUENCY CV MEASUREMENTS





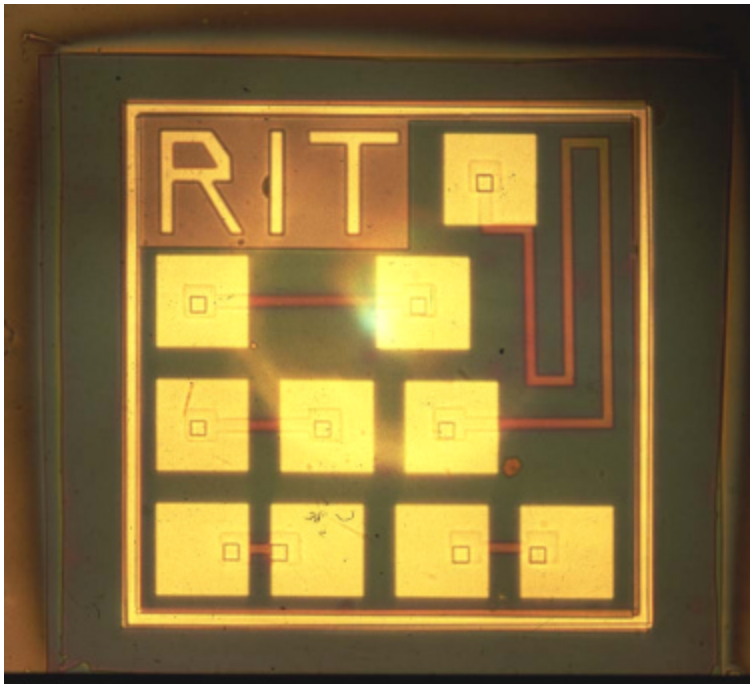
Homemade C-V Measurement System



Vout = (C R1 R3 / R2) (dVin/dt)

RIT'S FIRST DIFFUSED RESISTORS

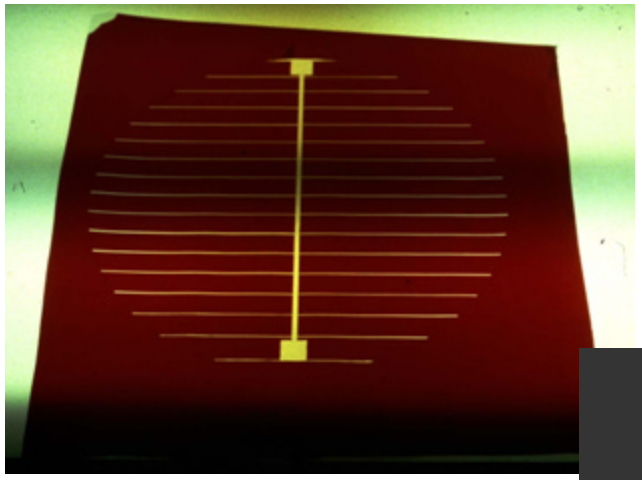
P-type diffused resistors in an n-type wafer.



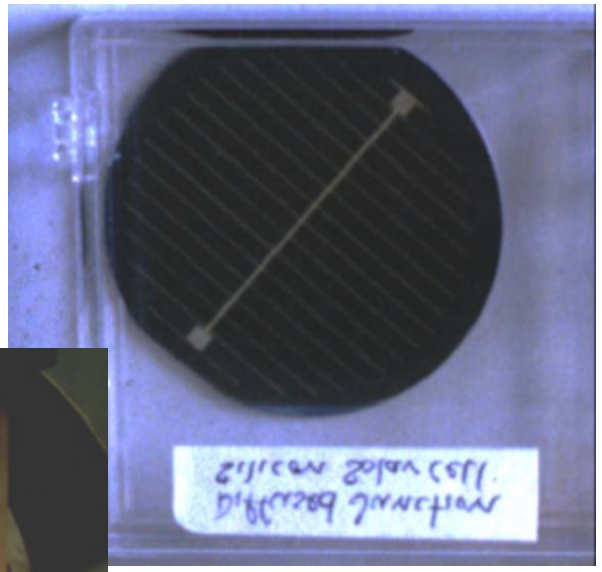
Completed chip.

Maskmaking

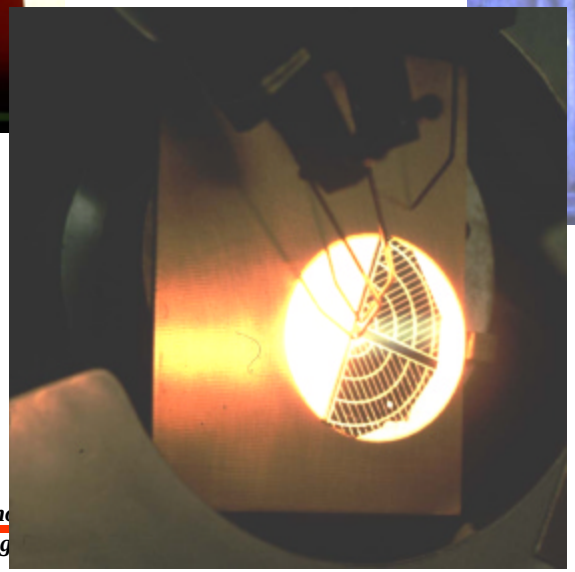
RIT'S FIRST SOLAR CELLS



Layout

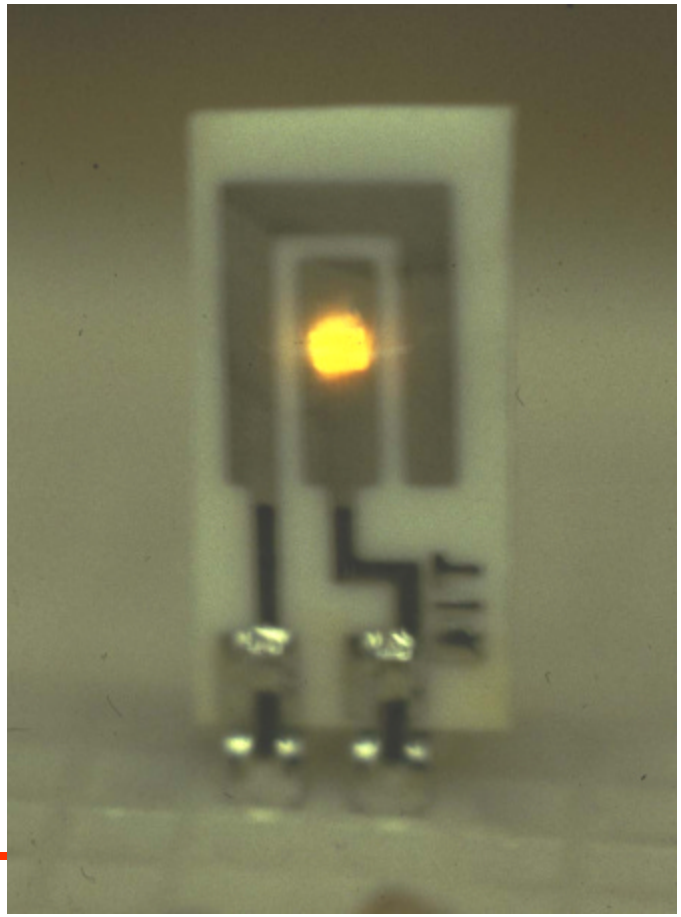


Completed device.



Testing

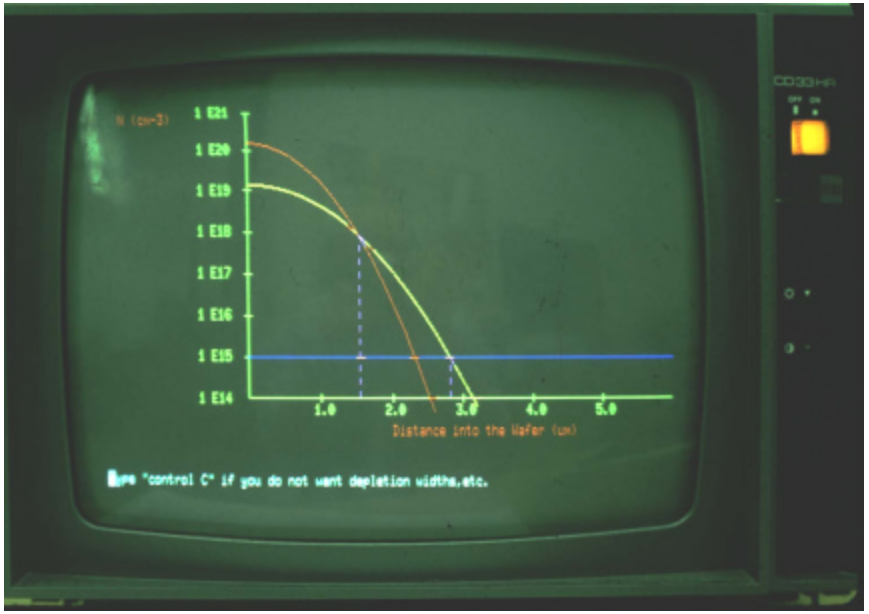
RIT'S FIRST GALLIUM PHOSPHIDE LED



GaP wafers with n-type epilayer, add gold metal, dice and wire bond to RIT thick film ceramic package.

RIT FIRST TO OFFER MICRO MAJOR

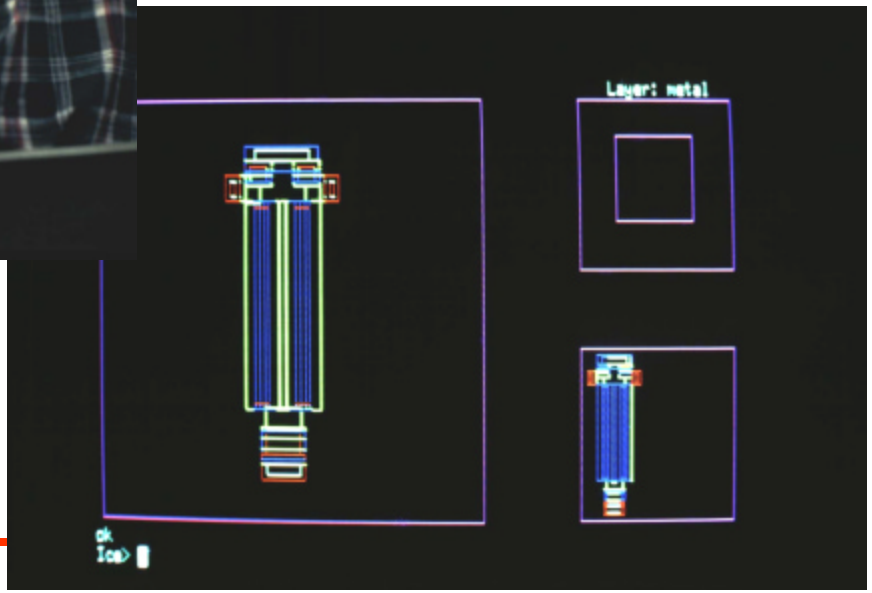
RIT BISIM PROCESS SIMULATOR



Chris Ludden wrote a FORTRAN program for simulation of diffusion and calculation of space charge layer thickness, sheet resistances and transistor current gain. This software was equivalent to SUPREM being developed at Stanford University at the same time.

RIT ICE LAYOUT EDITOR

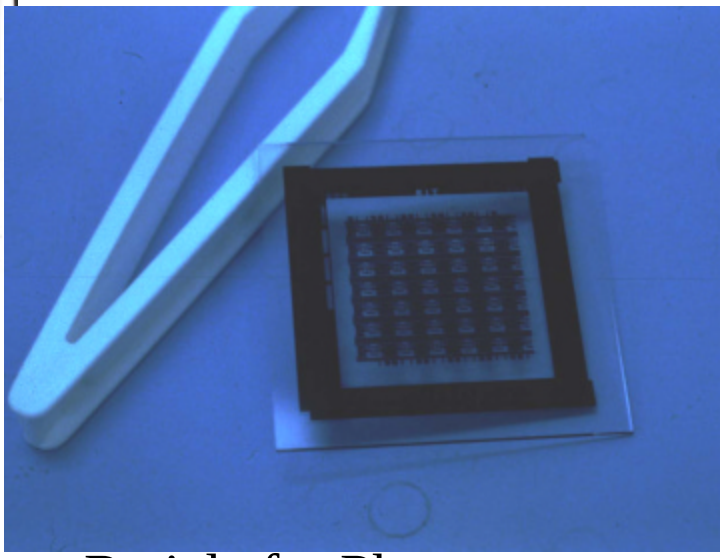
Taylor Hogan created a “C” program for layout of integrated circuits. Output in Mann 2000 format for our optical pattern generator.



RIT'S FIRST OPTICAL PATTERN GENERATOR

Mann 2000 PG

Ed Barry was the department technician for the 1st year of the program.

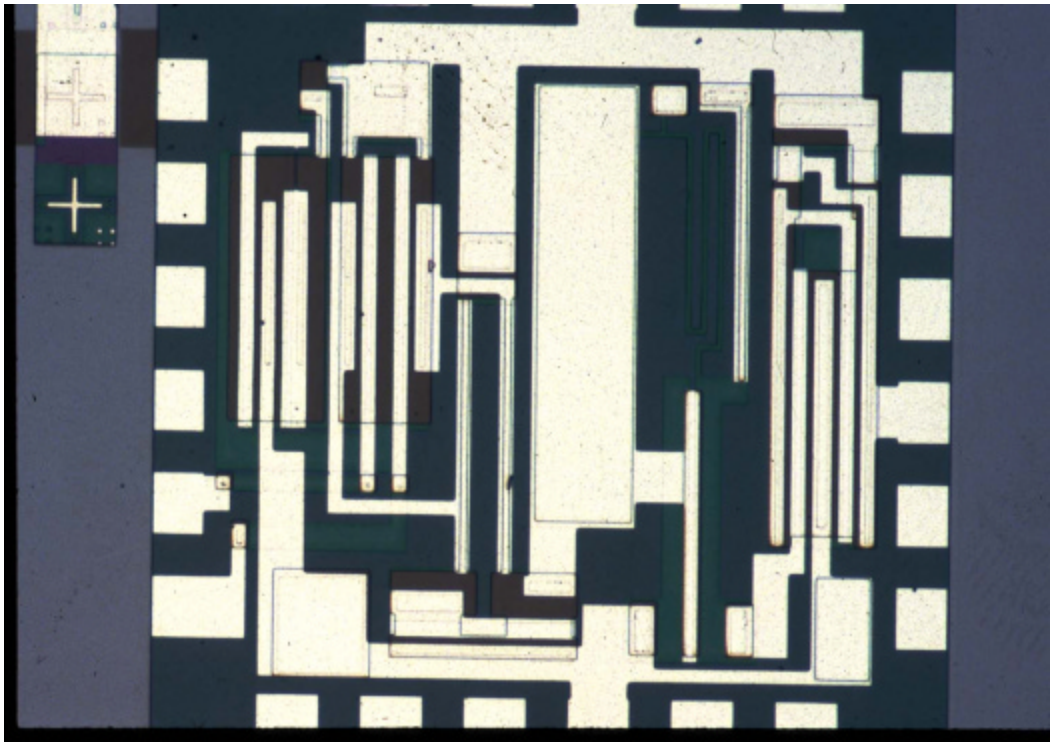


Reticle for Photorepeater

RIT'S FIRST PHOTOREPEATER

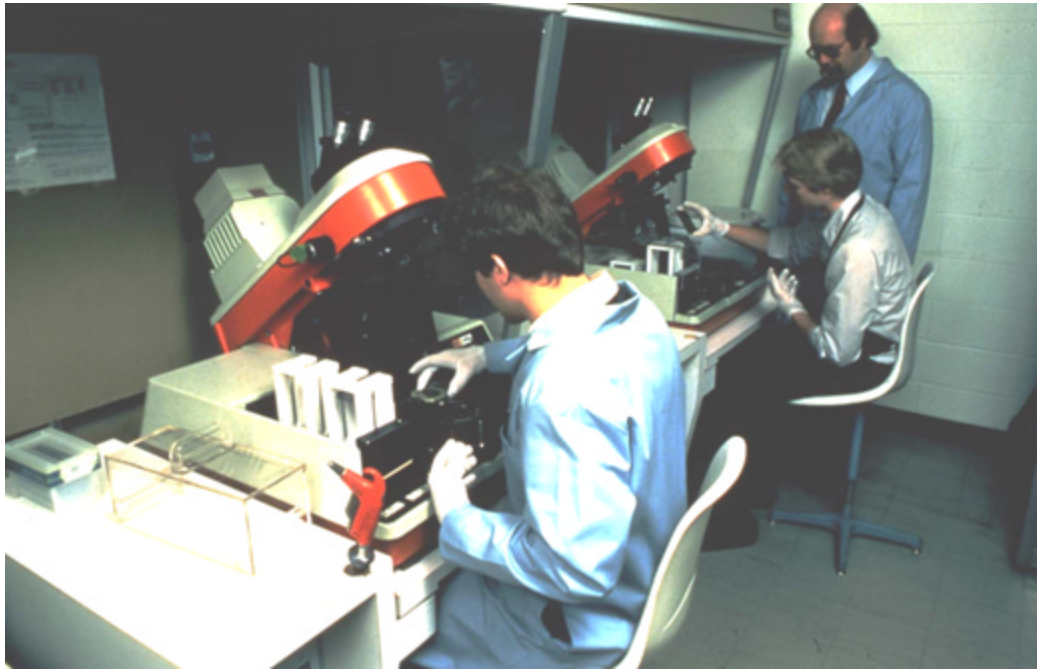
Jim Kawski makes 1X Photomask using RIT's photorepeater. The 1X masks were emulsion on glass.

RIT'S FIRST ALL PMOS OP AMP DESIGN



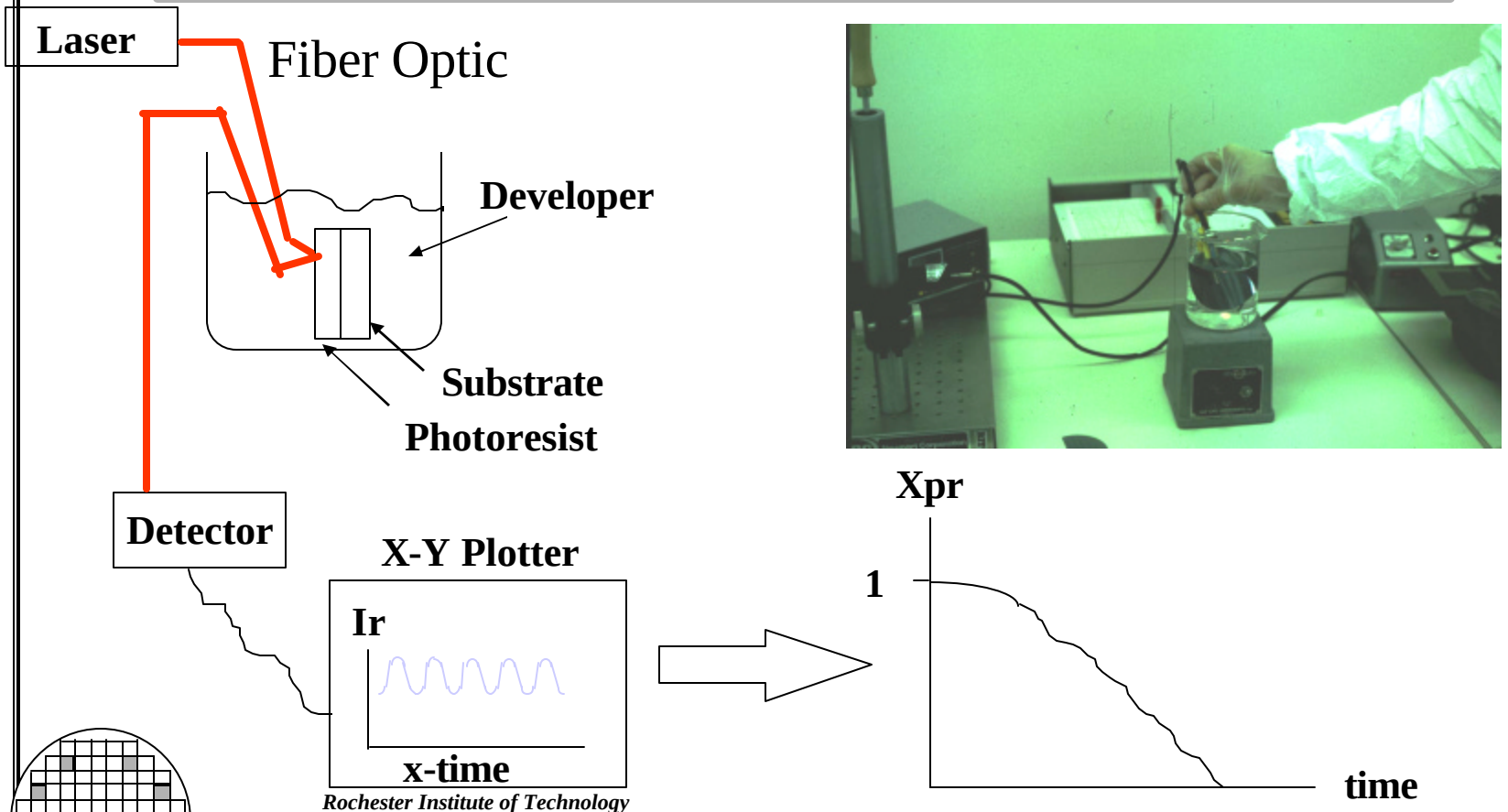
Jonathan Littlehale

RIT'S FIRST LITHOGRAPHY COURSES

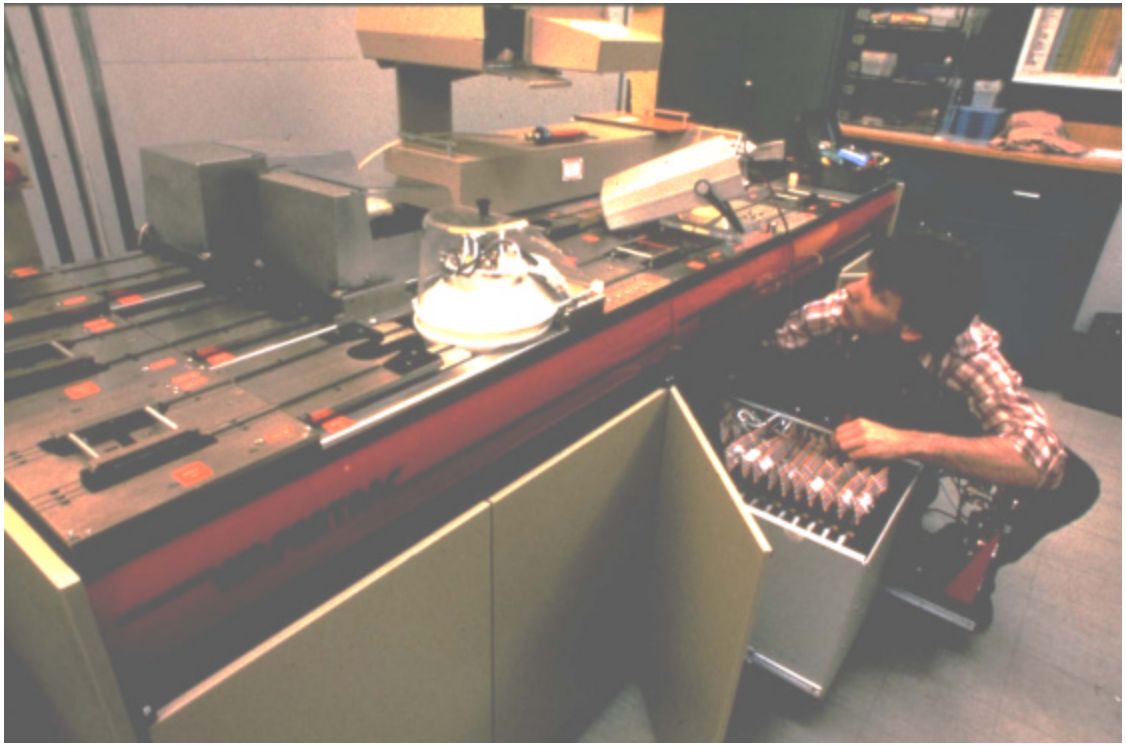


RIT was the only university to teach undergraduate lithography courses. UC Berkeley taught some courses at the graduate level. Even today few universities teach lithography courses.

RIT'S FIRST DEVELOPMENT RATE MONITOR



RIT'S FIRST GCA WAFER TRACK

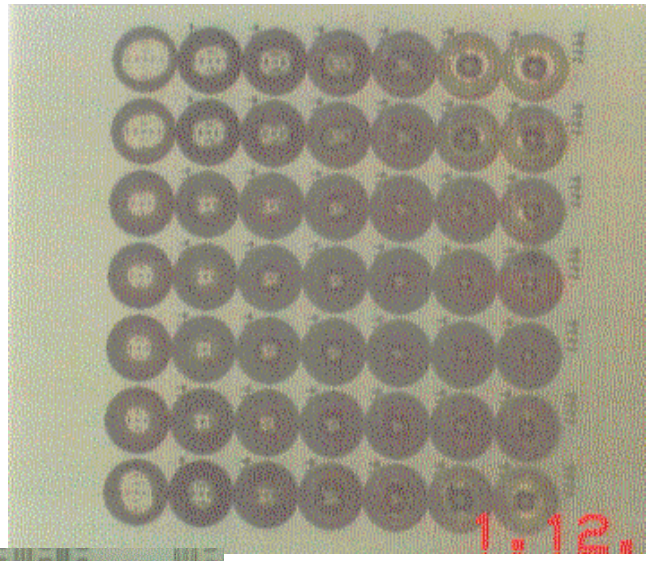


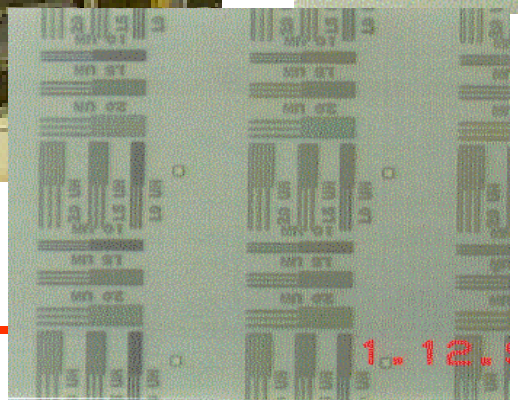
Used for process development and characterization laboratory.

Rochester Institute of Technology
Microelectronic Engineering

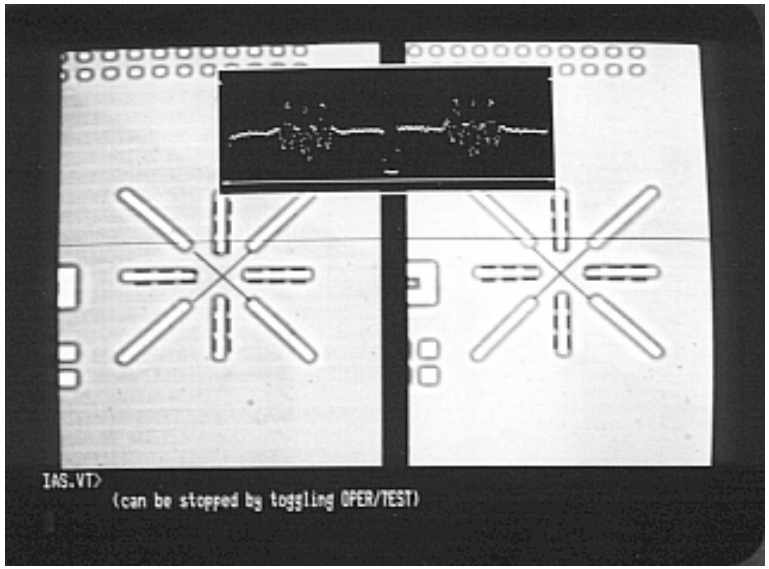
Scott Blondell

RIT FOCUS AND EXPOSURE LAB

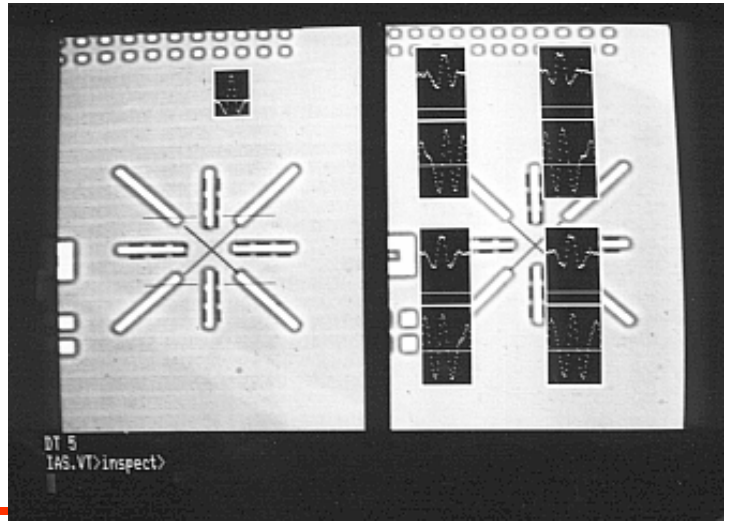




AUTOMATIC OVERLAY LAB

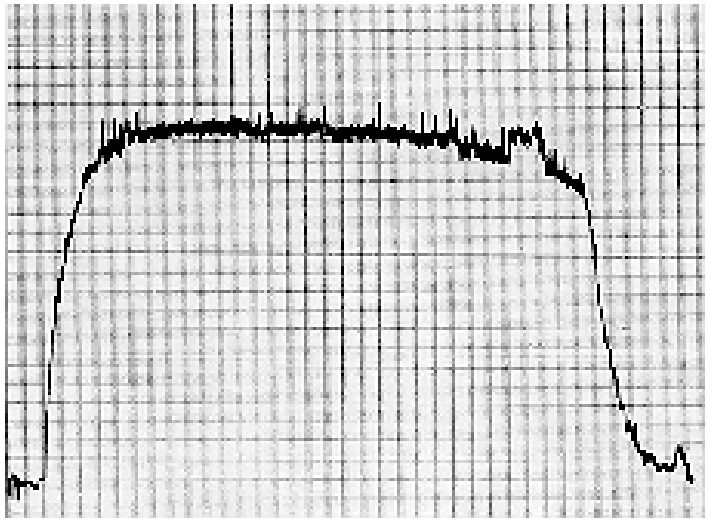


GCA 6700 Overlay Setup Images



FIRST END POINT DETECTION AT RIT

O2, 30 sccm, 50 watts, 300 mTorr

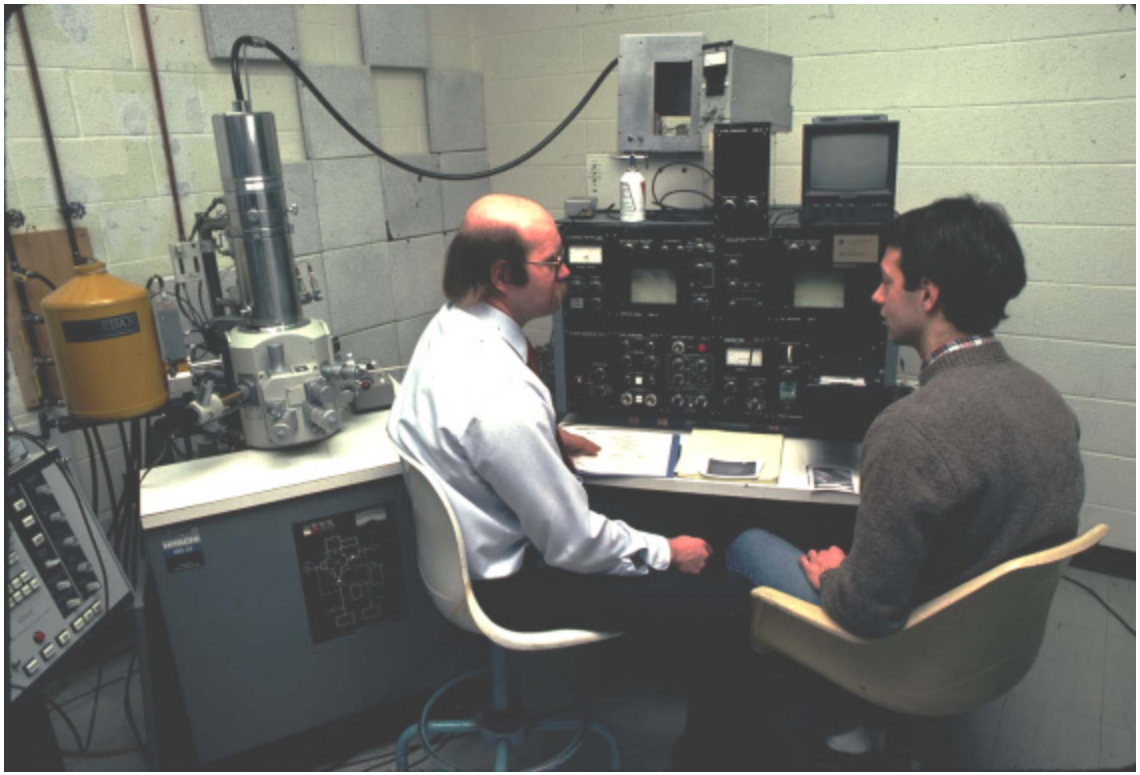


0.0 TIME (min) 8.0

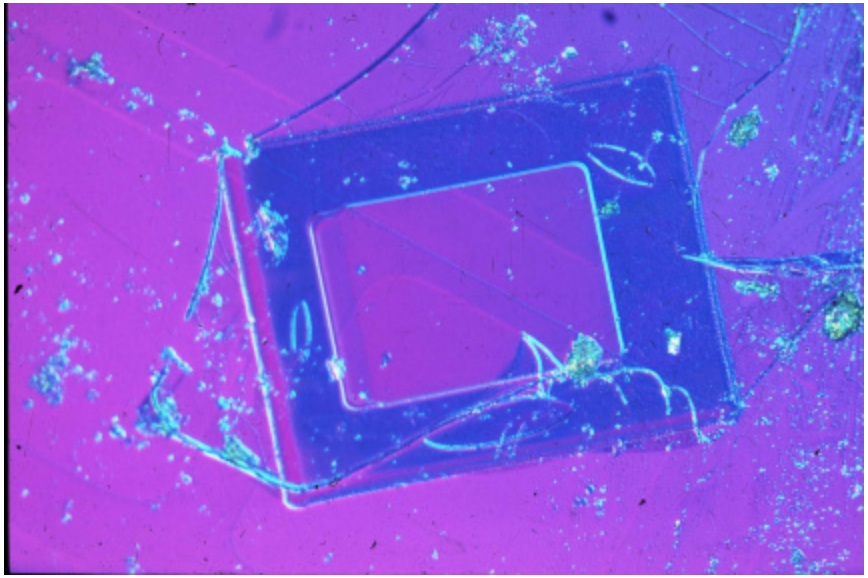
Monitor the CO peak at 483.5 nm. During photoresist stripping there are large numbers of CO molecules. At end of Photoresist stripping the number of CO molecules is reduced.

Dick Lane

RIT'S FIRST SEM



FIRST E-BEAM LITHOGRAPHY AT RIT

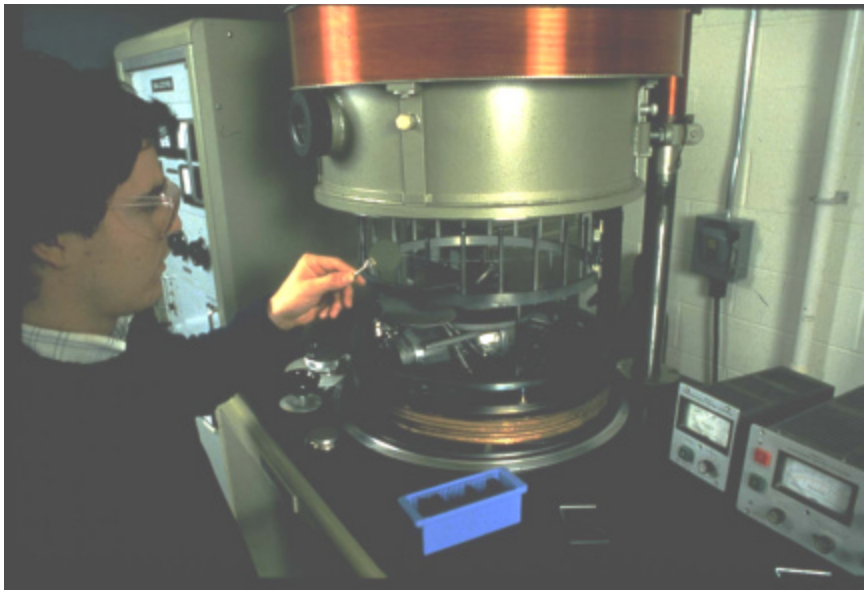


Using a SEM we obtained thickness log dose curves.

FIRST RIT IC PROCESSING SHORTCOURSE

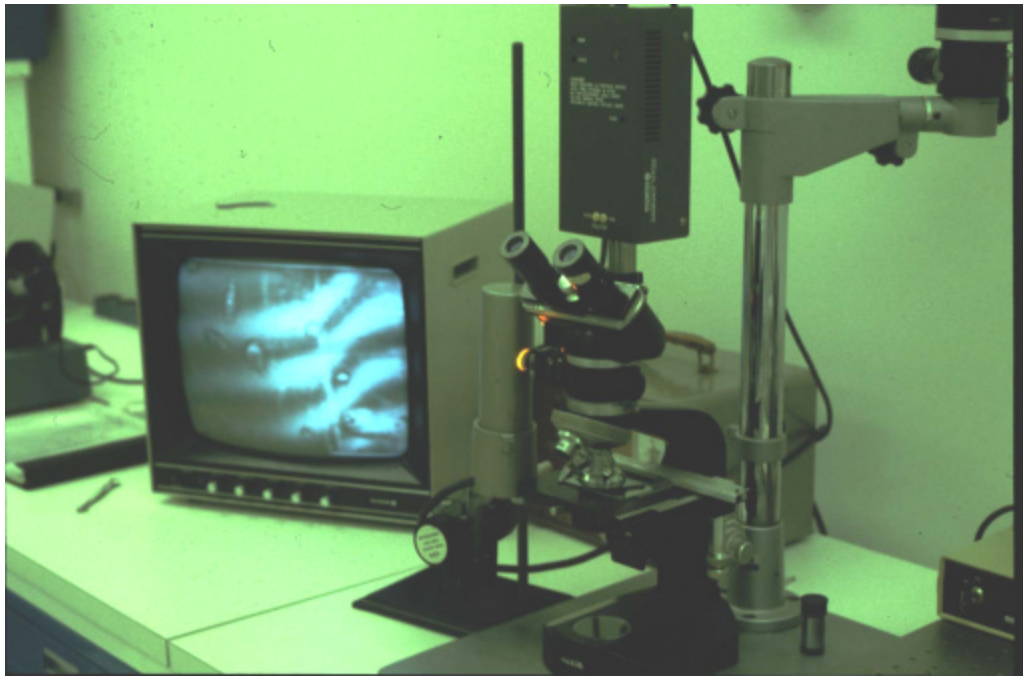
Students in first RIT IC processing short course. 1000's of students have taken our short courses over the years.

FIRST SPUTTERING AT RIT



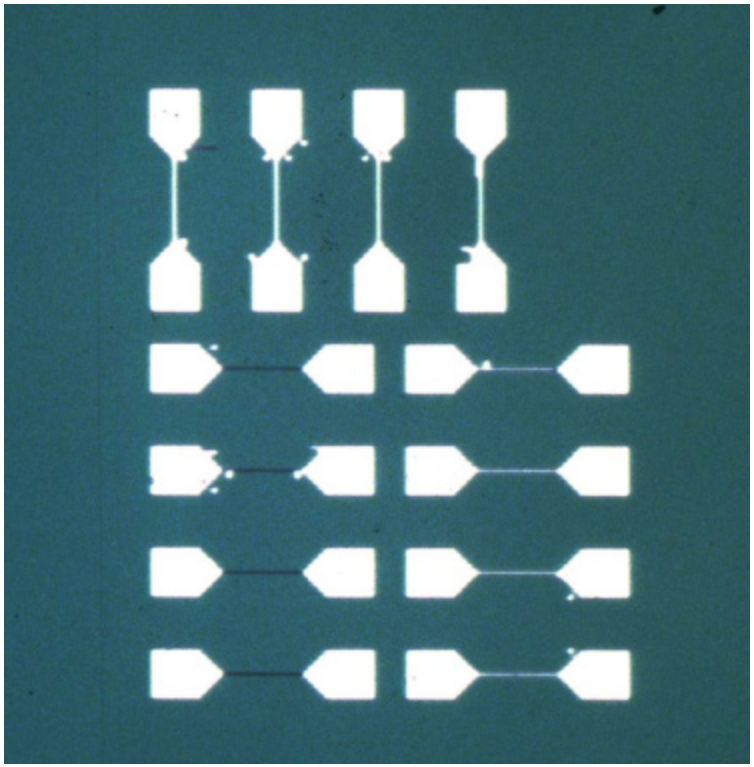
Juan Becerra sputtering in Balzars sputter tool.

RIT'S FIRST THICKNESS MEASUREMENT

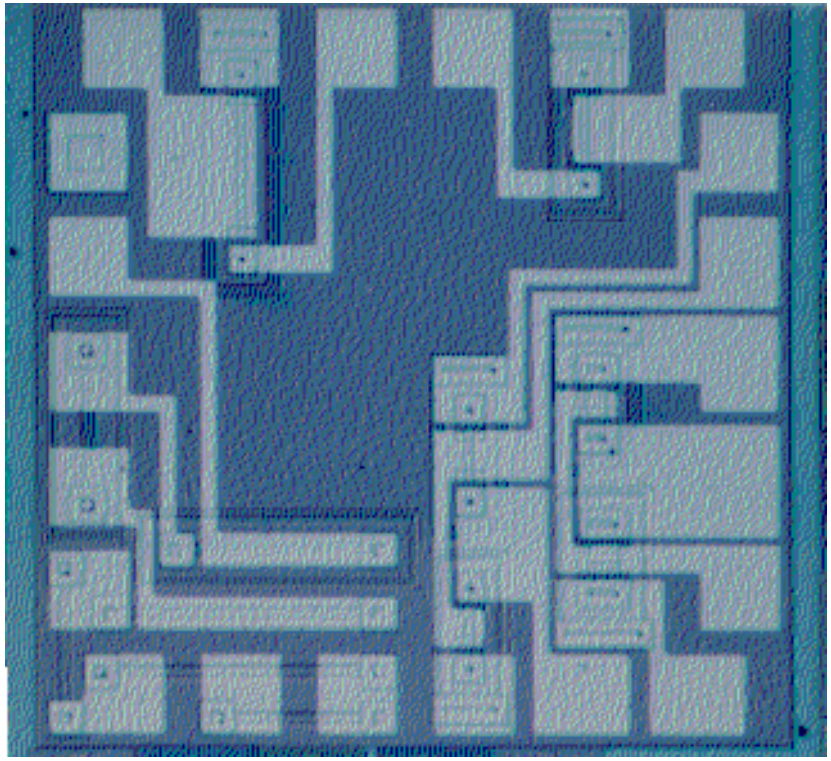


Interference microscopy for thickness measurement of opaque films.

FIRST ELECTROMIGRATION STUDY RIT



FIRST METAL GATE CMOS



Jim Pollard builds first metal Gate CMOS, 1987

FIRST $50,000 OF MOTOROLA'S $2,000,000

Dick Kenyon
Roger Hewett
Lynn Fuller
Fred Tucker

$50,000

THE NEW BUILDING

The department faculty and staff.
Dr. Turkman, Lynn and Sara missing.

Affiliate representatives

RIT'S FIRST ION IMPLANTER

Varian 400 ion implanter.

Rochester Institute of Technology
Microelectronic Engineering

Lynn Fuller
Scott Blondell

RIT'S FIRST LPCVD POLY AND NITRIDE

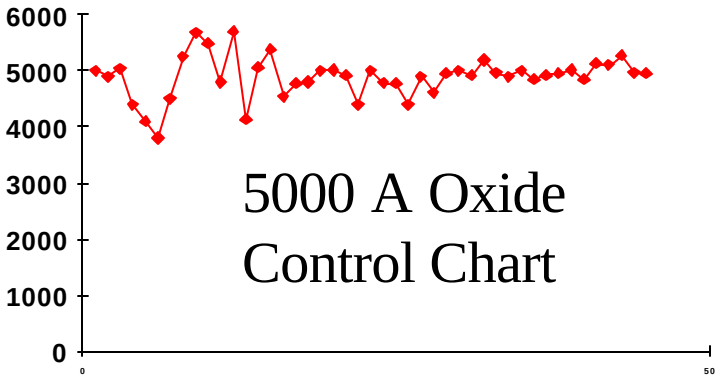
RIT'S FIRST POLY AND NITRIDE ETCH TOOL

Rochester Institute of Technology
Microelectronic Engineering

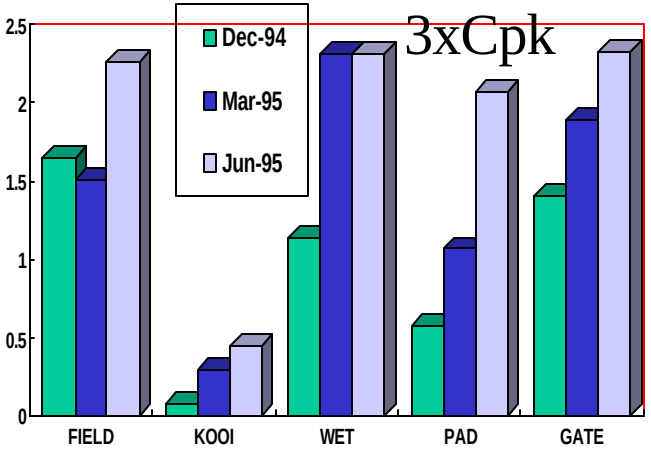
Dick Lane
Tom Grimsley

RIT'S MESA WIPTRACKING SYSTEM

MESA Software
AS/400 Hardware

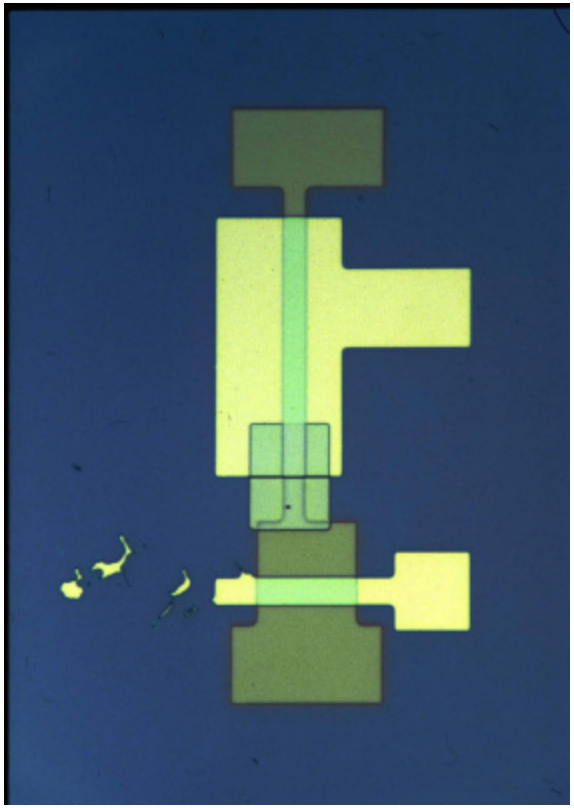


5000 A Oxide
Control Chart

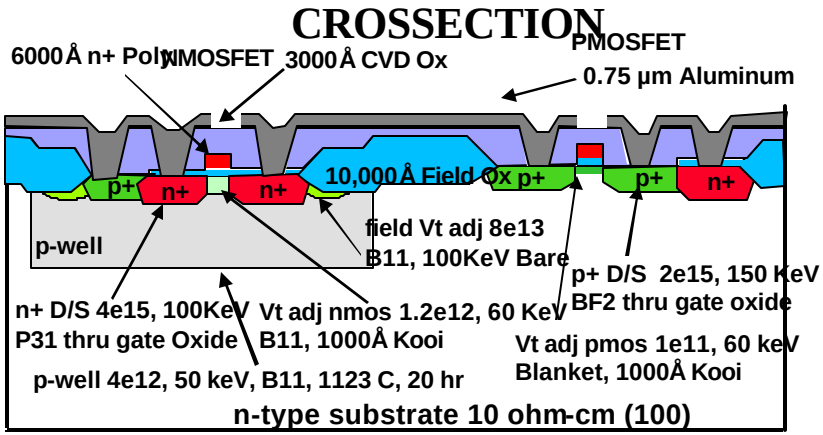


3xCpk

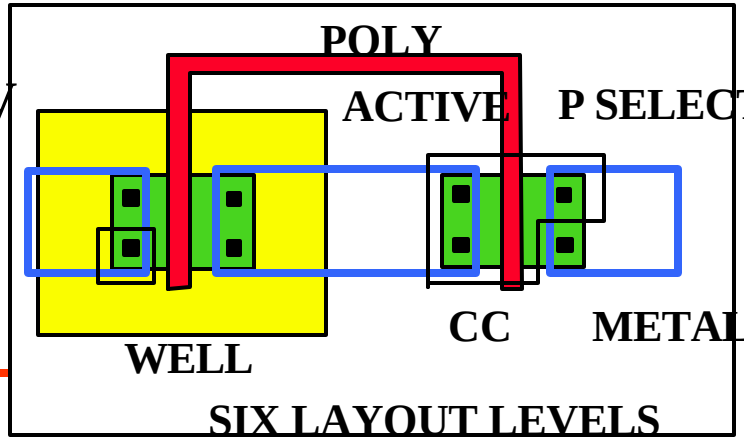
RIT'S FIRST NMOS INVERTER

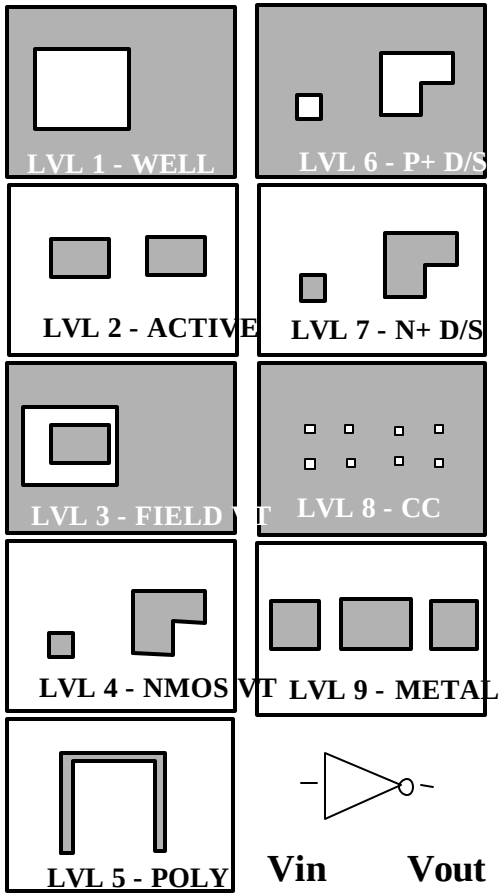


RIT'S FIRST CMOS PROCESS

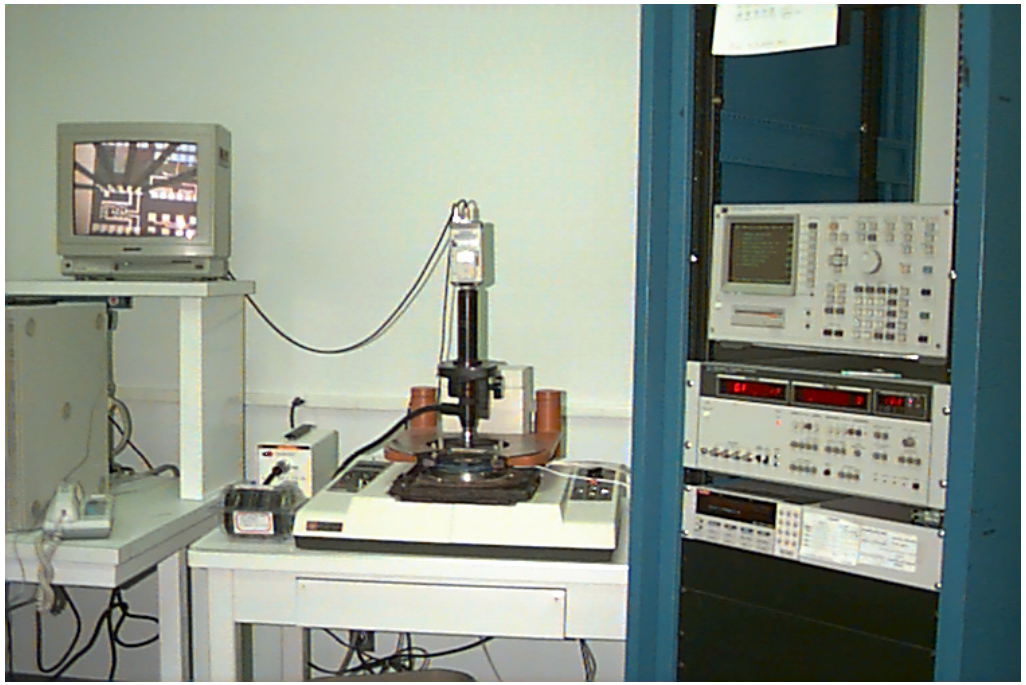


PLAY BACK NEXT



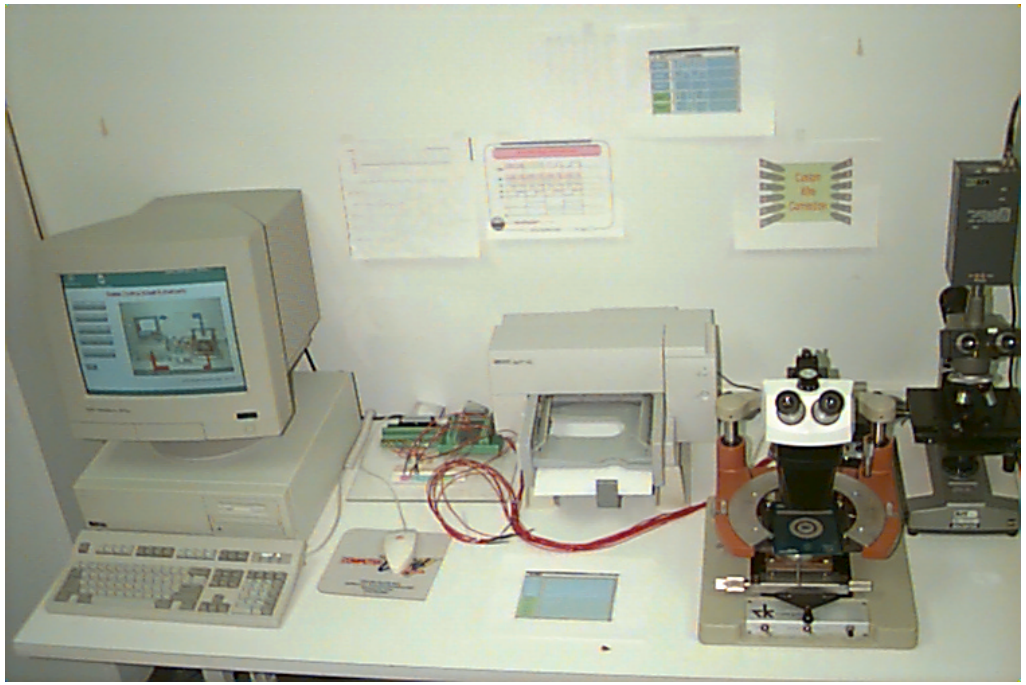


RIT'S FIRST ANALOG PARAMETRIC TESTER



Rob Pearson

RIT'S FIRST DIGITAL TEST SYSTEM

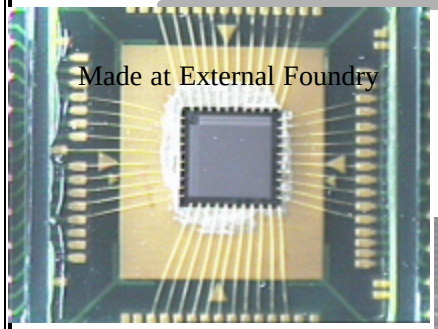


Suphong Yunrudee
Joanna Kiljan

Rochester Institute of Technology
Microelectronic Engineering

MEBES MASKMAKING 1990

RIT'S FIRST CID IMAGER CHIP

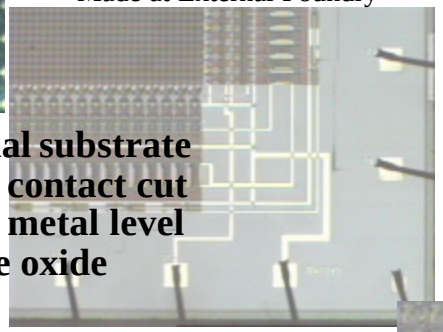


Made at External Foundry

PMOS on n-type epitaxial substrate
6 micron gate, 4 micron contact cut
Double poly-silicon, one metal level
15 V process, 50 nm gate oxide

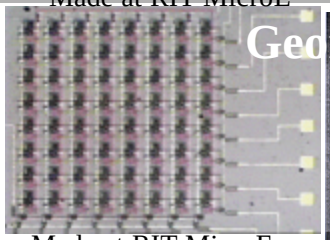
8 Photo levels
- **Active**
- **Poly-1**
- **Poly-2**
- **p+ D/S Implant**
- **n+ Substrate Contact**
- **Pinning Implant**
- **Contact Cut**
- **Metal**

Made at External Foundry

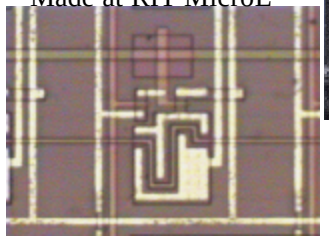


800

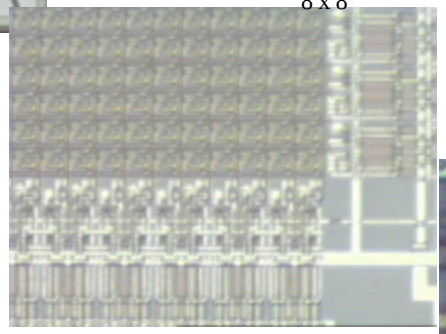
Made at RIT MicroE



Made at RIT MicroE



8 x 8

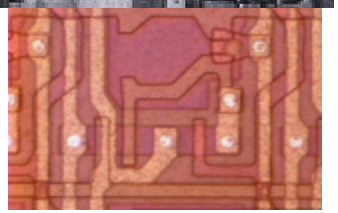


128 x 128

100,000

Made at External Foundry

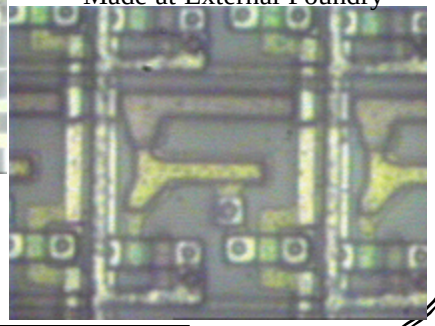
George Lungu



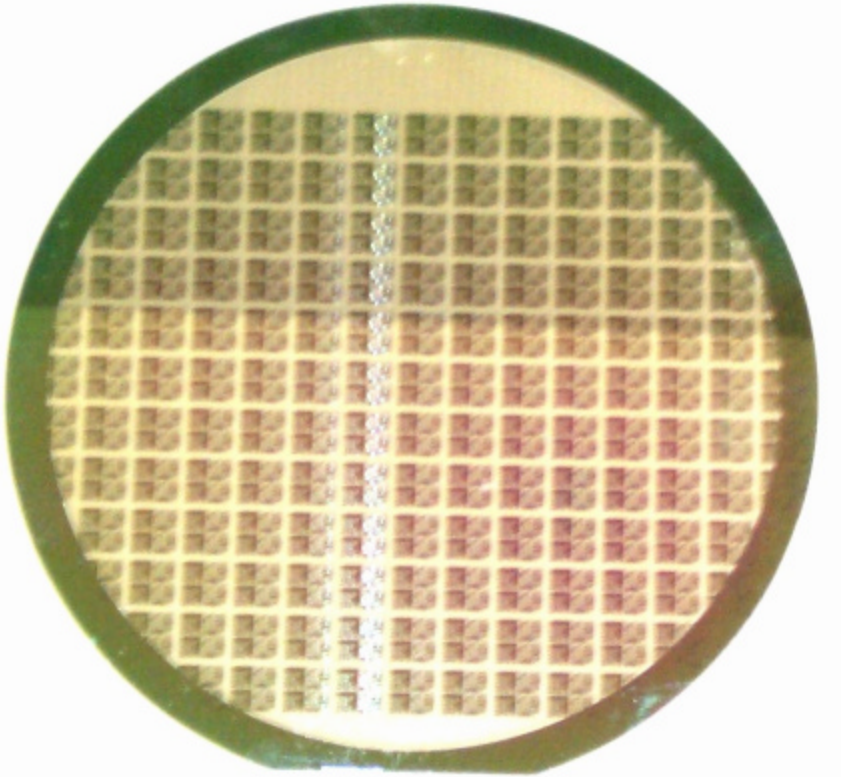
54 x 40

10,000

Made at External Foundry



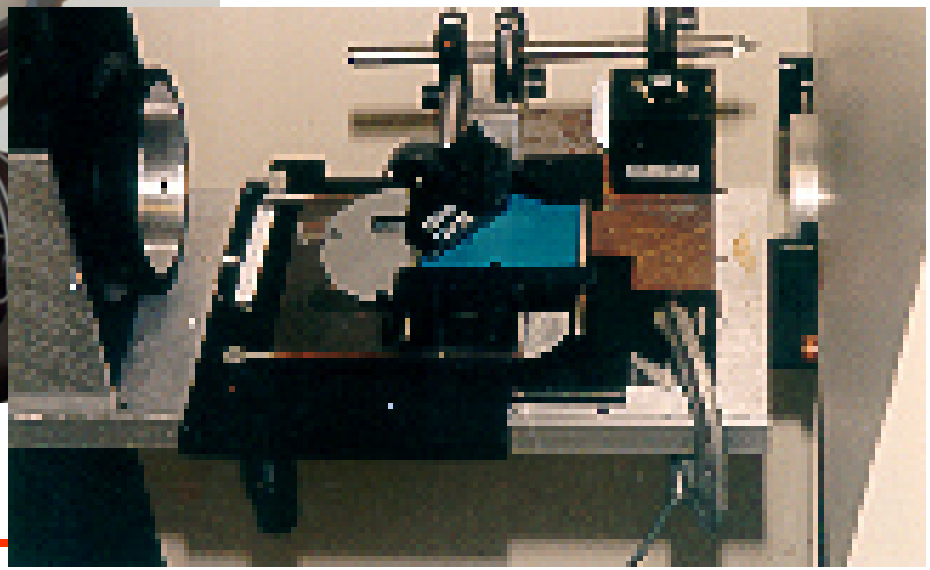
1996 RIT'S FIRST 6" WAFERS



Karl Hirschman and his EMCR 350 Class

FIRST EXCIMER LASER LITHOGRAPHY

Laser light plus optics on a bench.



Bruce Smith

Rochester Institute of Technology
Microelectronic Engineering

RIT EARLY MEMS DEVICE

US005357803A

United States Patent [19]

Lane

[11] **Patent Number: 5,357,803**

[45] **Date of Patent: Oct. 25, 1994**

[54] **MICROMACHINED MICROACCELEROMETER FOR MEASURING ACCELERATION ALONG THREE AXES**

[75] Inventor: **Richard L. Lane**, Penfield, N.Y.

[73] Assignee: **Rochester Institute of Technology**, Rochester, N.Y.

[21] Appl. No.: **866,667**

[22] Filed: **Apr. 8, 1992**

[51] **Int. Cl.**[5] **G01P 15/13**

[52] **U.S. Cl.** ..... **73/517 B**; 361/280

[58] **Field of Search** ..... 73/517 B, 517 R, 516 R; 361/280, 283.1; 310/309; 384/439

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Primary Examiner—John E. Chapman

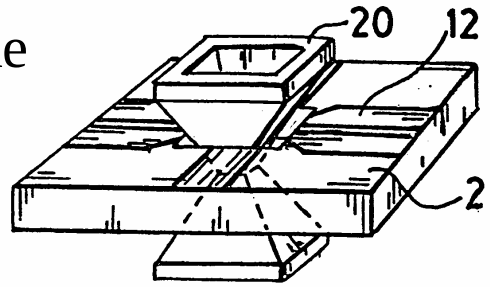
Attorney, Agent, or Firm—Nixon, Hargrave, Devans & Doyle

[57] **ABSTRACT**

The present invention relates to a microaccelerometer employing a single free-mass and capable of measuring acceleration along three coordinate axes, and a process for fabricating through micromachining and microelectronic techniques a microaccelerometer employing a free-mass. A microaccelerometer preform is constructed by chemically coating and etching a silicon wafer to form a support member and a free-mass surrounded by the member. The free-mass is movable with respect to, but constrained by the silicon support member. Acceleration measurements are obtained by circuits which sense changes in the position of the free-mass with respect to an equilibrium position, induced by a change in the rate of acceleration of the accelerometer, and the electromagnetic force required to restore the free-mass to its equilibrium position.

18 Claims, 6 Drawing Sheets

Dick Lane



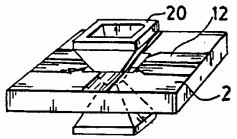


FIG. 15

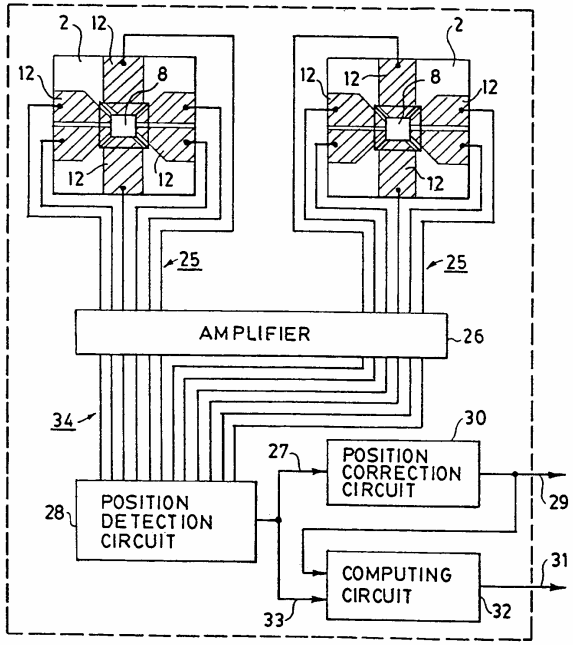
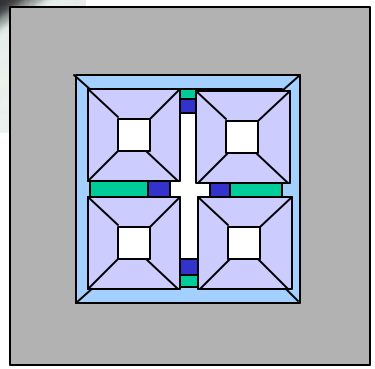
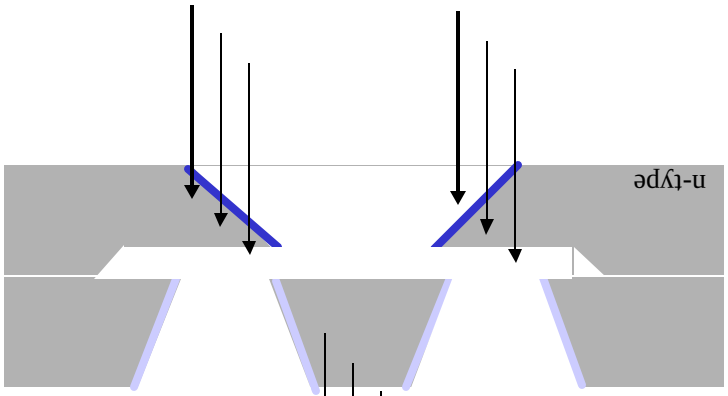
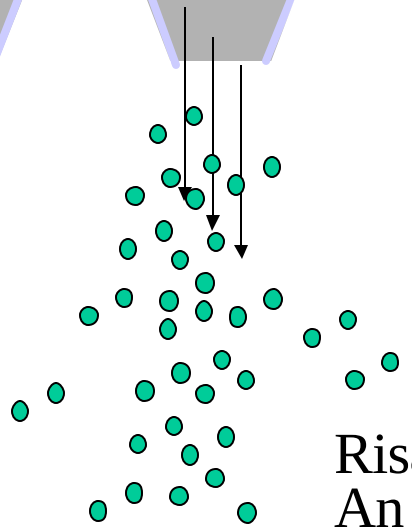


FIG. 16

OTHER RIT MEMS DEVICE





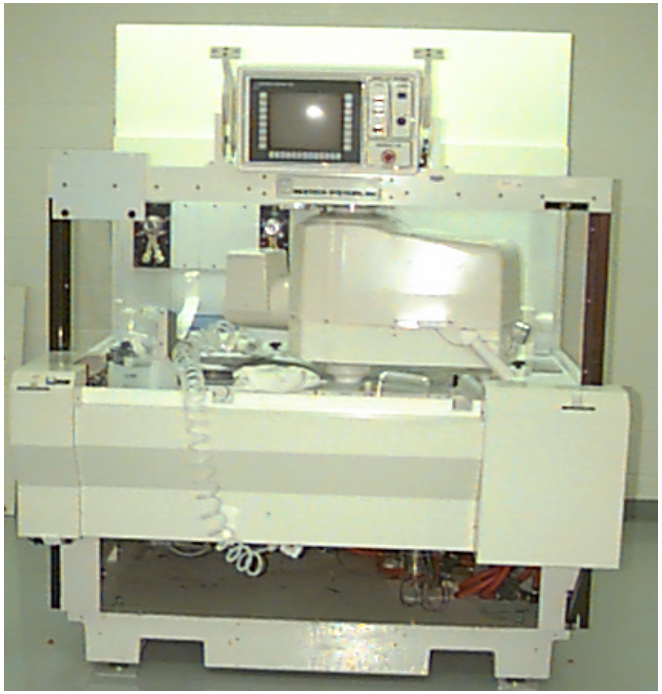


Risa Robinson
An Pham
Lynn Fuller

Rochester Institute of Technology
Microelectronic Engineering

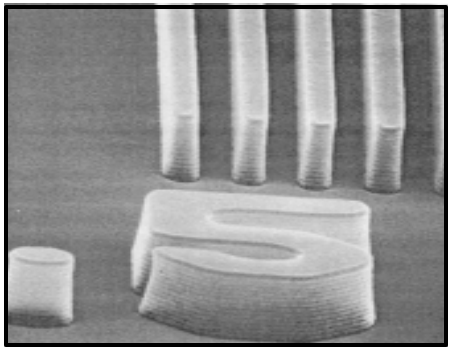
RIT'S FIRST RTP TOOL

RIT'S FIRST CMP TOOLS



Westech/Speedfam CMP Tool

RIT'S ADVANCED LITHOGRAPHY TOOLS

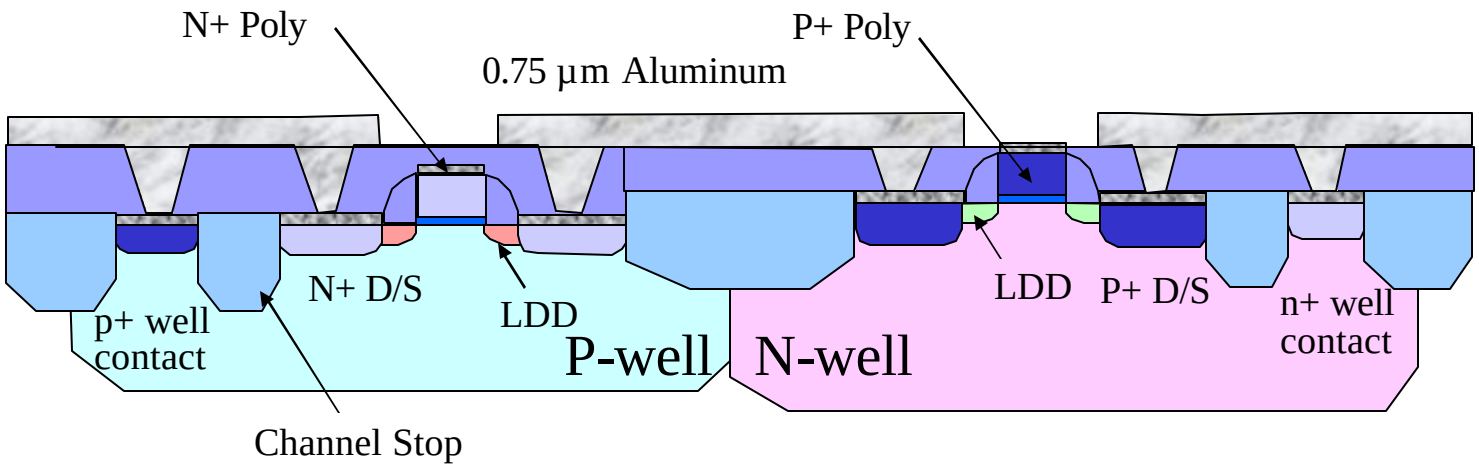


RIT'S ADVANCED ETCH TOOL & CD SEM

Quad Plasma Etch Tool

Hitachi 6780 CD SEM

RIT'S ADVANCED CMOS PROCESSES



0.5 µm Poly Gate Length CMOS

RIT'S 1ST, 2ND & 3rd ABET ACCREDITATION

MASTERS DEGREES OFFERED IN µE

Master of Engineering in Microelectronics Manufacturing Engineering
Master of Science in Microelectronics Manufacturing Engineering

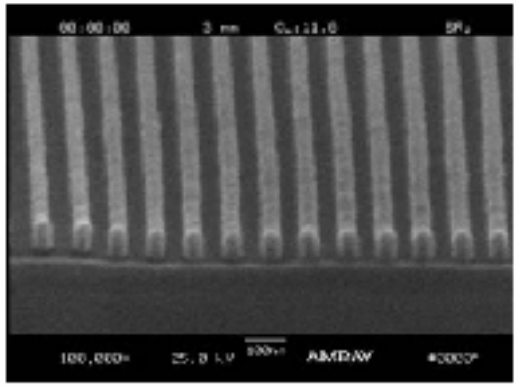
MEMME OFFERED BY DISTANCE LEARNING

Video Tapes for Each Module, ~30/course
Paper Copies of Each Module Presentation ~1000 pages/course
Special Simulation Software Server, Textbook, WEB Based Help

BRUCE SMITH - INVENTOR OF THE YEAR 2000

At a first-ever celebration of RIT inventors, professors Bruce Smith, Richard Lane and Joseph Hornak (left to right) stand with President Albert Simone holding patent plaques that bear drawings and descriptions of their inventions.

DR. BRUCE SMITH – STARTS AMPHIBIAN SYSTEMS INC.



193i resist images 45nm resolution

STEVE CARLSON – MICROE BS GRAD 1987, IMAGING SCIENCE MS GRAD 1990

Distinguished RIT alumni receiv

Alumni-award winners, left to right, Donald Naylor, Philip Rosenzweig, Steven Carlson, Philip Jacob, David Foy, Donald Lehmbeck and Michael Ramsager (absent: Daniel Carp, Mark Conboy)

Rochester Institute of Technology
Microelectronic Engineering

Senior VP Technology, Photronics, Inc.

NEWS AND PUBLICITY

Solid State Technology
December 1999

"There is a shortage of engineering graduates, especially those from the pioneering and renowned IC manufacturing program at the Rochester Institute of Technology", Stanley Wolf, author and professor at UCLA.

INDUSTRY INSIGHTS

Stanley Wolf

Needed: Cohesive education programs for IC manufacturing

At the height of the last boom in the semiconductor industry, we heard an industry-wide cry about the lack of properly educated and trained people entering the industry at all levels. Part of the concern was that US academia was not turning out enough engineers in general and, more specifically, with a few exceptions, was not offering programs with a strong emphasis in IC manufacturing.

Now, we've gone through a classic downturn and are entering what we anticipate is another boom. But it appears that IC manufacturing education at the university level in the US today has not changed appreciably. While engineers and scientists are well educated in specific disciplines, such as electrical engineering, chemistry, physics, materials science, mechanical engineering, and optics, they still enter the industry untrained for IC manufacturing. By-and-large, even at the engineering level, training in IC manufacturing is still occurring on the job. There has been no fundamental change in engineering education to support what is a cornerstone industry in today's society.

My best perspective of this trend comes from seeing the shortage of recent, up-to-date semiconductor textbooks.

Only ~2000 textbooks specifically about semiconductor manufacturing are delivered to university bookstores each year and ~15% are returned because they are not purchased. Yearly enrollment in such classes is about 1500. IC fabrication courses are offered at about 100 US universities, with an average enrollment that sells 15–20 books/year at each school. (This number may be skewed to the low side because at some schools, such as Stanford University, professors use their own notes as the course text.) Since 1986, Lattice Press has sold 20,000 copies of the book *Silicon Processing for the VLSI Era, Vol. 1: Process Technology* (co-authored by myself and R. Tauber). A small percentage of these are being used in classes at MIT, UC Berkeley, UCLA, the University of Michigan, UT Austin, etc. But the widest use of this book has been for self-education, OTJ training, or an internal program at IC manufacturers. The book's second edition has just been published (October 1999), but this has been long overdue.

By-and-large, even at the engineering level, training in IC manufacturing is still occurring on the job, not at the university.

Four of the five top IC manufacturing textbooks, which constitute most of the 2000 mentioned above, have copyright dates circa 1990. This indicates that book publishers do not see a demand to keep these books up-to-date with the rapid pace of IC manufacturing technology. The current edition of Sze's *VLSI Technology* (McGraw Hill), which originated as notes for an internal training program at Bell Labs, was published in 1988. Sze, who is now at National Chiao Tung University, Hsinchu, Taiwan, republished his book in 1996 as *ULSI Technology* (McGraw Hill), but this volume eliminated chapters on oxidation, diffusion, and ion implantation, reducing its effectiveness as a textbook.

Other older textbooks include Runyan and Bean's *Semiconductor Integrated Circuit Processing Technology* (Addison-Wesley), published in 1990, and Gandhi's *VLSI Fabrication Principles* (Wiley), which was reissued as a second edition in 1994, although 90% of its references still pre-date 1985. Campbell's *Science and Engineering of Microelectronic Fabrication* (Oxford) was published in 1996 and currently owns ~35% of the textbook market. However, it contains almost no references more recent than 1991 and therefore does not describe the hottest process technologies of the 1990s, such as CMP, copper metallization, dual-damascene interconnects, step-and-scan alignment, and phase-shift masks.

Despite the fact that ~90% of IC manufacturing is CMOS-based, there is no single textbook in print today on CMOS technology. Chen's *CMOS Devices and Technology for VLSI* (Prentice-Hall, 1990) is out of print. This may be because only a very small number of classes are available at universities on the device physics of MOSFETs — offered by excellent professors such as Chenming Hu at UC Berkeley and John Brews at the University of Arizona.

There is a shortage of engineering graduates, especially those from the pioneering and renowned IC manufacturing program at the Rochester Institute of Technology (RIT). Numbering about 35–55/year (approximately 30 BS, 10 MS, and 3 PhDs), the RIT graduates are only a small fraction of the engineers entering IC manufacturing every year. A few other similar programs have emerged, for example, at Boise State University and the University of Illinois at Chicago, but not enough to meet the need.

continued on page 87

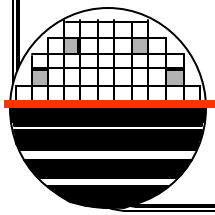
Stanley Wolf is the author of the three-part series *Silicon Processing for the VLSI Era* and owner of Lattice Press, PO Box 352, Sunset Beach, CA 90742, ph 714/840-5010, fax 562/592-1976, e-mail stanwolf@home.com.

SRC #1 RANKING

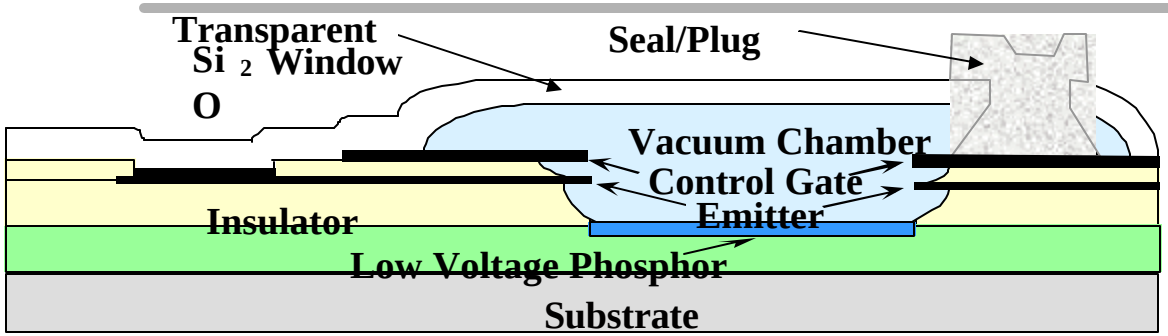
1991 Semiconductor Research Corp. survey results published in Semiconductor International:

RIT is number 1 (tied with University of Illinois) in education of engineers for the semiconductor industry.

Ranked below RIT: Texas A&M, MIT, Purdue, UC Berkeley, RPI, Arizona State, Cornell, Murray State, Rice, Stanford, UT Austin

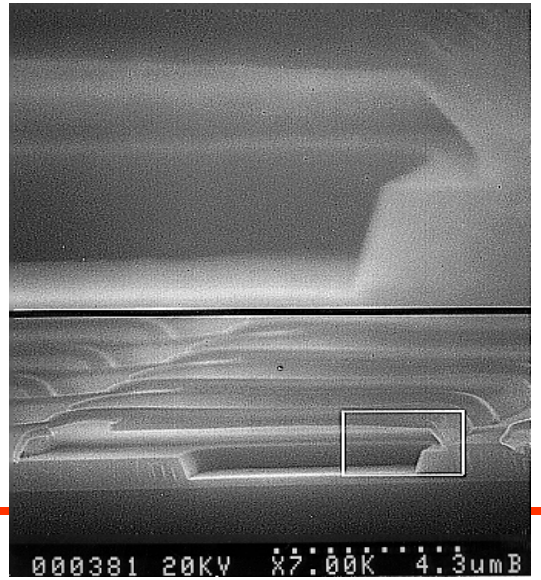


INCUBATOR - ADVANCED VISION TECHNOLOGY INC.

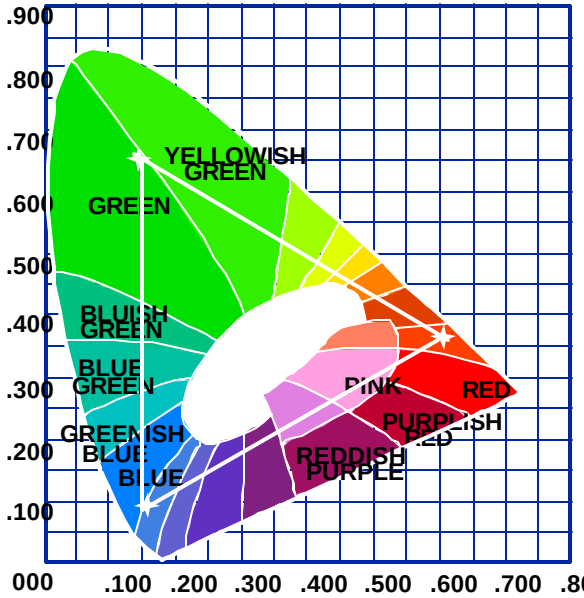


Integrated Phosphor Field Emission Device

Micro-encapsulated Chamber



Color Chart of AVT Phoshors



μE FACULTY

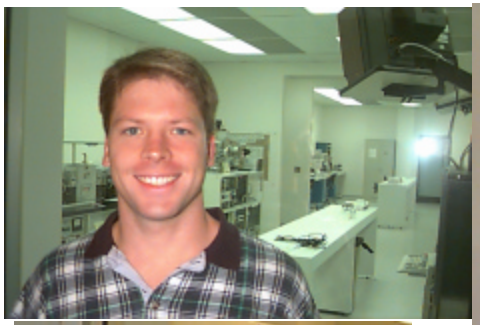
Lynn Fuller
Bob Daly
Joe Altman
Cem Karacal
David Sumberg
Nassar Darweesh
Karl Hirschman

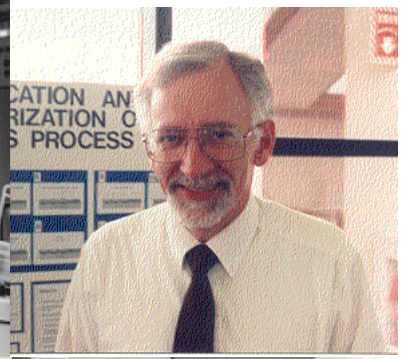
Bruce Smith
Mike Jackson
Renan Turkman
Philip Rack
Bill Grande
Santosh Kurinec
Dale Ewbank
An Pham

Richard Lane
Jim Scanlon
Suraj Bhaskaran
Pamela Obiomon

Rob Pearson

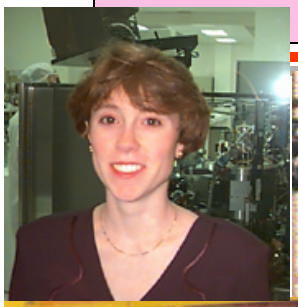
μE FACULTY



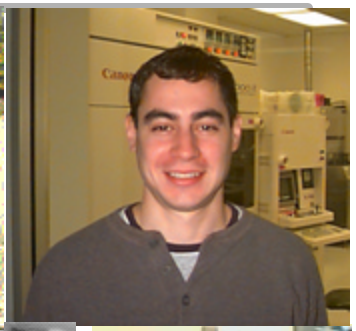


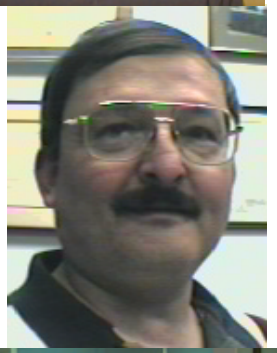

μE STAFF

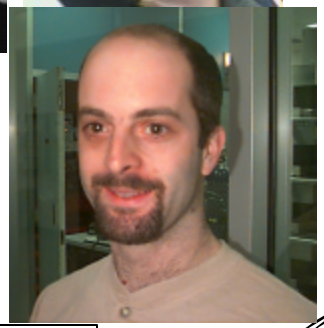




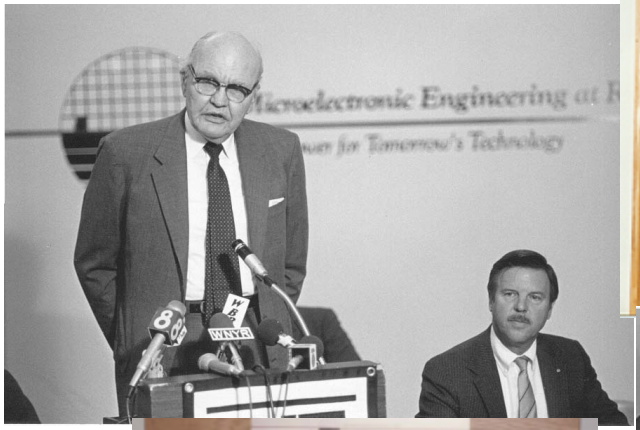


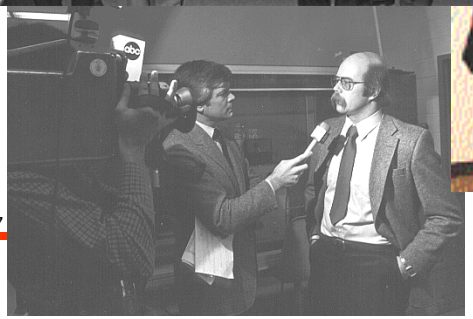


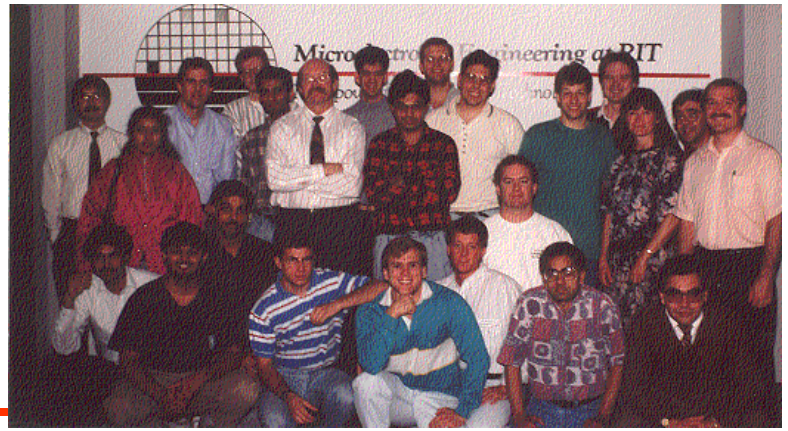


VISITORS and GUESTS

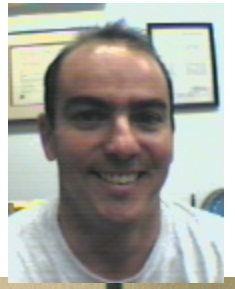


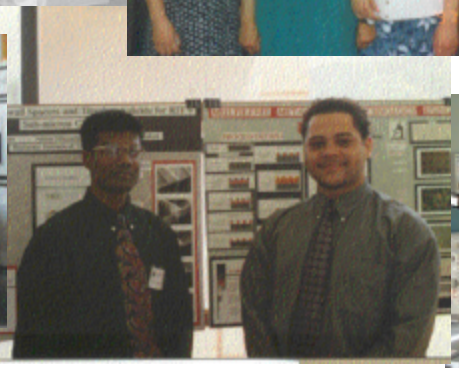


THE STUDENTS



THE STUDENTS





THE STUDENTS