

**Research and Education in Mechanical
Engineering :
A Prospective View**

서 남 표 교수 (M.I.T.)

KSME Meeting in Seoul
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**"Research and Education in
Mechanical Engineering:
A Prospective View"**

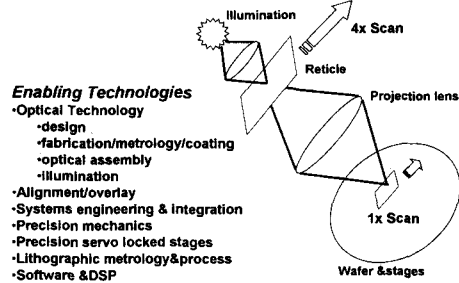
Nam P. Suh
The Ralph E. and Eloise F. Cross Professor
M. I. T.

Several powerful forces have been
changing the field of mechanical
engineering.

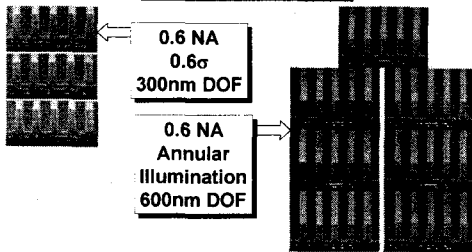
Several powerful external forces

- Information technology
- Communications -- the Internet
- Biology
- Nanotechnology
- Large distributed systems
- The Global economy
- Environmental issues

Lithographic Tool Drivers



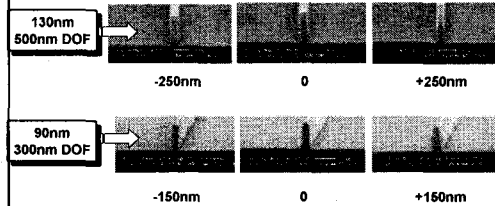
**Micrascan 193 Imaging
130nm Grouped Lines**



Binary Reticles

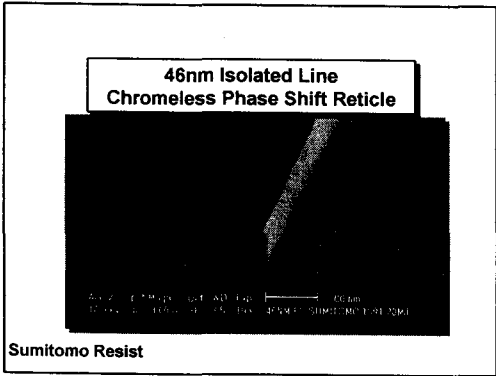
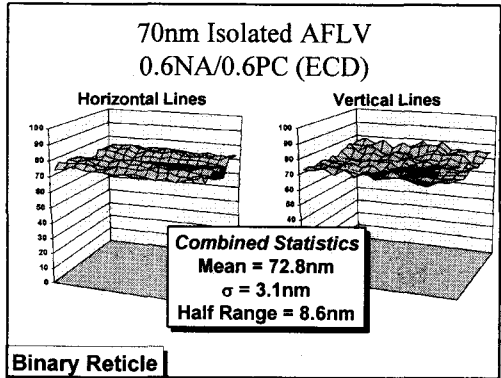
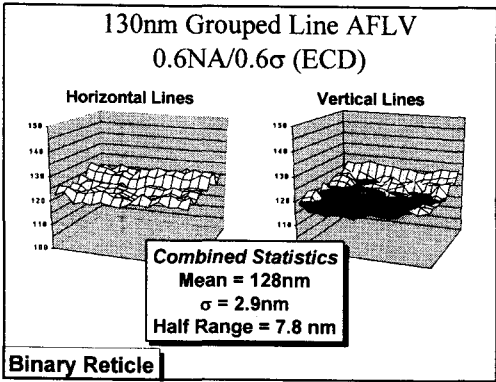
JSR AT-108 Resist

**Micrascan 193 Imaging
0.6NA/0.6PC**

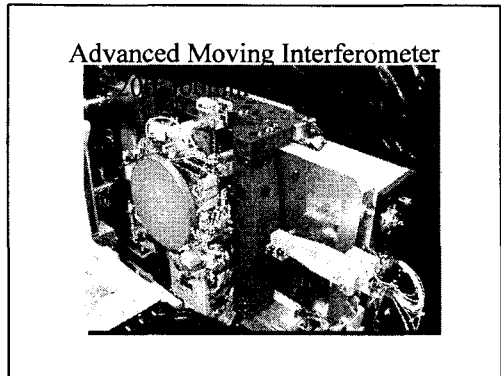
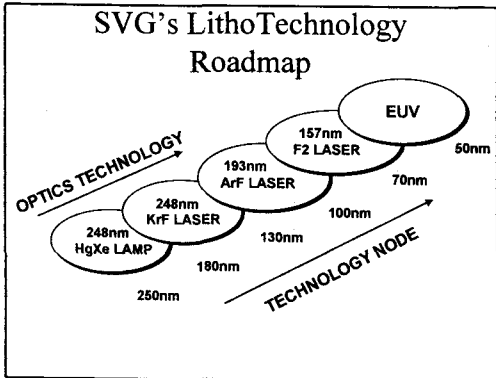


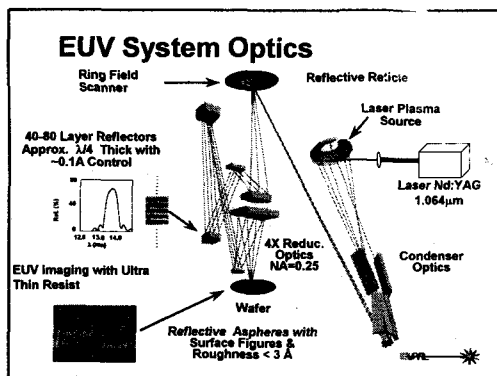
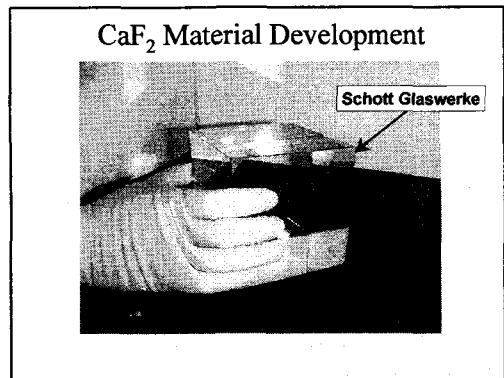
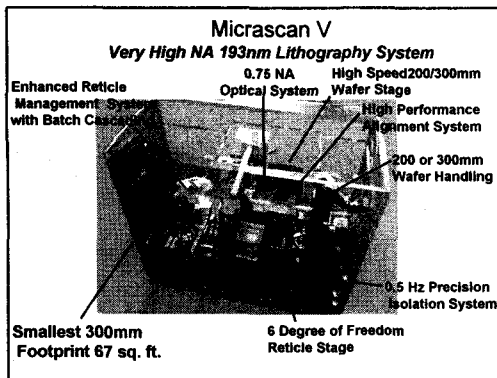
Binary Reticles

Sumitomo Resist



Where is Lithography Headed?





Characteristic of Academic Research

Academic research often deals with
"legitimate, well-understood problems within their disciplines"
 rather than
"the exceptional, unorthodox work that creates revolutions" in science and technology"

- From Class by Jane Glack -

A Historical Perspective on Mechanical Engineering

• The heyday of mechanical engineering was during the growth period (1930-1960) of the automobile industry.

A Historical Perspective on Mechanical Engineering

• Mechanical engineering missed the boat during the electronic and computer growth period, although the engineering tasks in these fields involve machines, mechanical systems, etc.

**A Historical Perspective
on Mechanical Engineering**

- **The problem lies in the conservative nature of engineers and the outdated mode of engineering education.**

**Changes I tried to make to bolster engineering in
the United States**

National Science Foundation (1984-1988)

- Created new support structure for new areas
 - MEMS
 - Optoelectronics
 - Design science
 - Bioengineering, etc.

**Changes I tried to make to bolster engineering in
the United States**

National Science Foundation (1984-1988)

- Created systems oriented support programs
 - ERC
- Eliminated the grip of entrenched interest groups that prevented NSF from being a forward looking organization

**The effort I have made to change the field of
mechanical engineering education in the United States**

MIT Mech Engineering Department (1991-to date)

The transformation of the field of mechanical engineering from a discipline that has been primarily based on physics into one that is based on physics, information, and biology, while maintaining a strong foundation on design.

Why change?

- **Nanotechnology is changing many fields such as heat transfer, machine design, telecommunications, etc.**

Why change?

- **System level issues are becoming more important.**

**I will illustrate the changes we have
made at MIT.**

Introduction to M. I. T.
(The Massachusetts Institute of Technology)

- About 920 professors
- \$1.3 Billion a year budget
- 4,000 undergraduate students
- 6,000 graduate students
- About \$7 billion endowment
- Research budget of approximately \$800 million

**Introduction to the Department of
Mechanical Engineering**

- About 60 professors
- 400 undergraduate students
- 400 graduate students

“MIT has the tradition of having strong
departmental system.”

Goals of the Department

To produce
future leaders
in engineering, industry, academia,
research and other professions

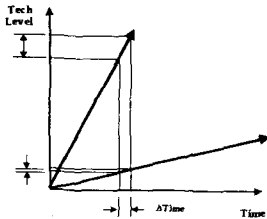
Goals of the Department

To lead in advancing the field of
mechanical engineering through
knowledge generation
and
technology innovation

Why?

To lead
the profession of mechanical engineering
into a new era
of more rapid technology change

Implications of the Rate of Technology Change



Specific Goals of the Department

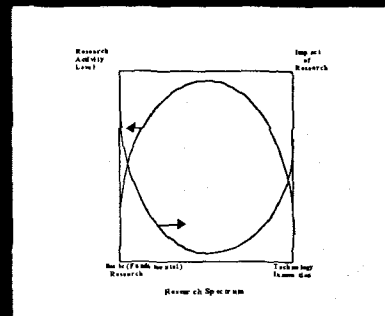
- Graduate Program -- Strengthening of Traditional sub-disciplines of ME
 - Manufacturing
 - Design
 - Control
 - Mechanics
 - Thermal and Fluid science and engineering
 - Materials

Specific Goals of the Department

Research Emphasis

Near the Two Ends of the Research Spectrum

Research Emphasis of the ME Department



Collective actions taken by the ME faculty

- Create a IT focused research group
- Hired outstanding new faculty members with degrees in CS, EE, physics, and applied math
- Created laboratory facilities through renovation of space
- Established the d'Arbeloff Laboratory for Information Systems

Collective actions taken by the ME faculty

- Redirected bioengineering activities to concentrate in BioInstrumentation
- Hired outstanding new faculty members with degrees in physics and other fields
- Created laboratory facilities through renovation of space
- Established the Laboratory for BioInstrumentation

Collective actions taken by the faculty

- **Hired some of the best faculty members in more traditional areas such as manufacturing, mechanics, design and others**

Results

- **The strongest and the most creative faculty in the history of the Department of Mechanical Engineering at MIT**

State of the Department

- **Research contributions in fundamental areas by young and “new” faculty**
 - **Mechanics (Mahadevan, McKinley)**
 - **Bio-Instrumentation (So)**
 - **Networking (Siu, Sarma)**
 - **Information (Lloyd, Hart)**

State of the Department

- **Research contributions in technology innovation by young and “new” faculty**
 - **DOME (Wallace)**
 - **PIV Algorithm (Hart)**
 - **Auto ID Center (Siu, Sarma)**
 - **Seals (Hart)**
 - **Quantum mechanical computers (Lloyd)**
 - **Two-photon microscopy (So)**
 - **Haptic systems (Sarma)**
 - **Design of manufacturing systems (Cochran)**

State of the Department

- **Research contributions in technology innovation by young and “new” faculty**
 - **Next Generation Internet (Siu)**
 - **Mechanical “Linux” Project (Nayfeh)**

State of the Department

- **Information Technology in ME**
 - **D’Arbelloff Laboratory**
 - **Leading research activities in IT in ME**
 - **Auto ID Center**
 - **Gateway subjects**
 - **Special collaboration with EECS (?)**
 - **Ph.D. in ME and S.M. EECS**

State of the Department

- **Bio-Instrumentation, Bioengineering, and Biomechanics**
 - Fund raising activities
 - Strong and growing research activities

State of the Department

- **Manufacturing**
 - Largest funding base
 - Leading manufacturing research
 - 3-D Printing
 - DBM
 - Sheet Metal Forming
 - Manufacturing Systems
 - Microcellular Plastics
 - Composites
 - Large Systems – CMP machine
 - New machines and machine elements

State of the Department

- **Design**
 - CIPD
 - Leading design research
 - DOME
 - Axiomatic design
 - System design

State of the Department

- **Mechanics and Materials**
 - Rheology and new silk-like materials
 - Classical physics
 - Computational engineering
 - PIV
 - DBM
 - Fracture mechanics
 - High temperature plasticity
 - Deformation of polymers

Slides of Current Research Projects

- **There are many exciting projects being undertaken in the Department of Mechanical Engineering of MIT, which will be shown next.**