대한기계학회 2000년도 추계학술대회논문집 A pp. 3~11

Research and Education in Mechanical Engineering : A Prospective View

서 남 표 교수 (M.I.T.)

KSME Meeting in Seoul
November 3, 2000

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

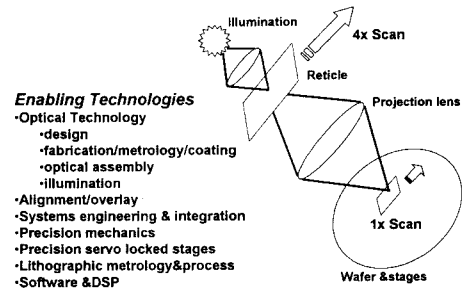
Nam P. Suh
The Ralph E. and Eloise F. Cross Professor
M. I. T.

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

Several powerful external forces

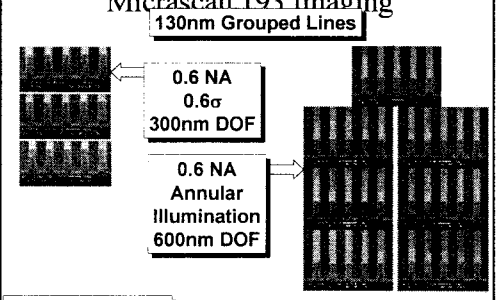
- Information technology
- Communications -- the Internet
- Biology
- Nanotechnology
- Large distributed systems
- The Global economy
- Environmental issues

Lithographic Tool Drivers



Enabling Technologies
- Optical Technology
  - design
  - fabrication/metrology/coating
  - optical assembly
  - illumination
- Alignment/overlay
- Systems engineering & integration
- Precision mechanics
- Precision servo locked stages
- Lithographic metrology&process
- Software &DSP

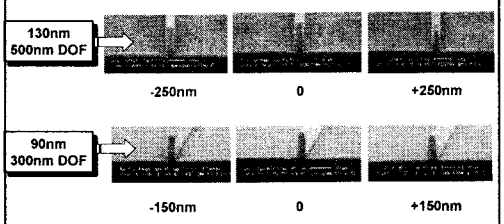
Micrascan 193 Imaging



Binary Reticles

JSR AT-108 Resist

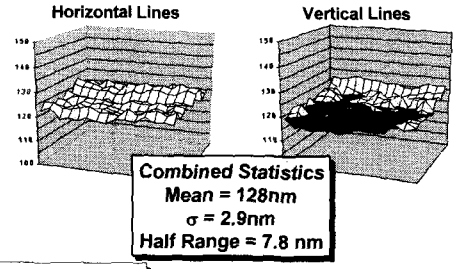
Micrascan 193 Imaging
0.6NA/0.6PC



Binary Reticles

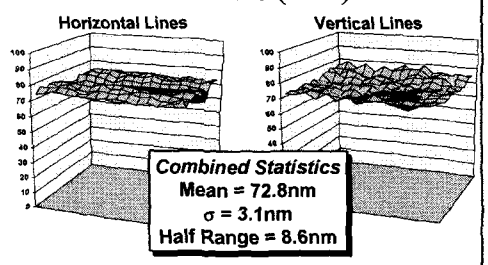
Sumitomo Resist

130nm Grouped Line AFLV
0.6NA/0.6σ (ECD)



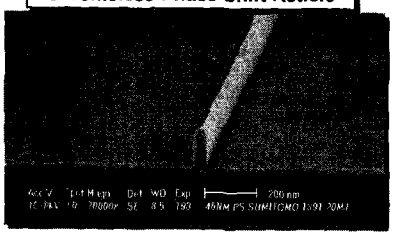
Binary Reticle

70nm Isolated AFLV
0.6NA/0.6PC (ECD)



Binary Reticle

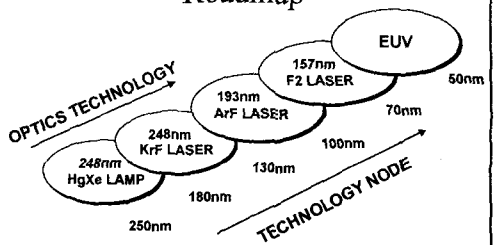
46nm Isolated Line
Chromeless Phase Shift Reticle



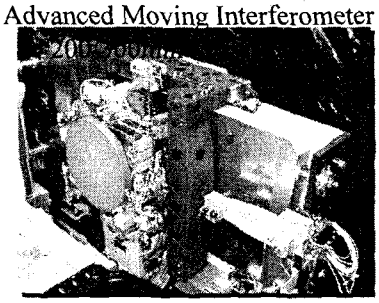
Sumitomo Resist

Where is Lithography Headed?

SVG's LithoTechnology Roadmap

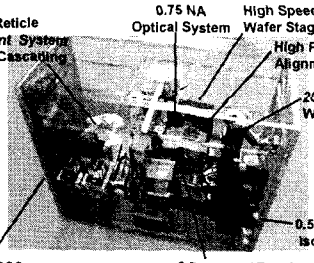


Advanced Moving Interferometer

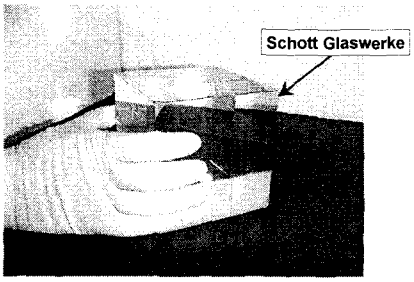


Micrascan V

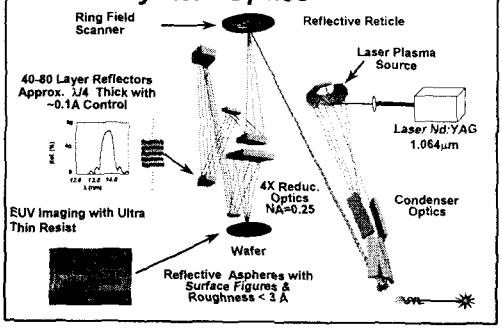
Very High NA 193nm Lithography System



CaF_2 Material Development



EUV System Optics



Characteristic of Academic Research

Academic research <u>often</u> deals with
"legitimate, well-understood problems within their disciplines"

rather than

"the exceptional, unorthodox work that creates revolutions" in science and technology"

-- From Chaos by Jame Gleick --

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 trenched 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?

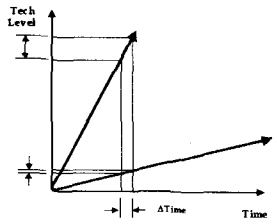
To *lead*

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

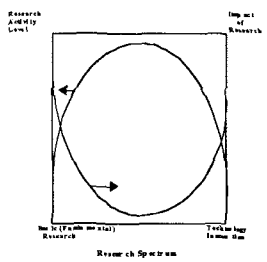
- **Graduate Program -- Strengthening of Traditional sub-disciplines of ME**
  - **Manufacturing**
  - **Design**
  - **Control**
  - **Mechanics**
  - ***Thermal and Fluid science and engineering***
  - **Materials**

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'Arbeloff 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.**