Properties of Additives Molecules for Boundary Lubrication

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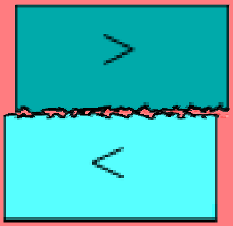
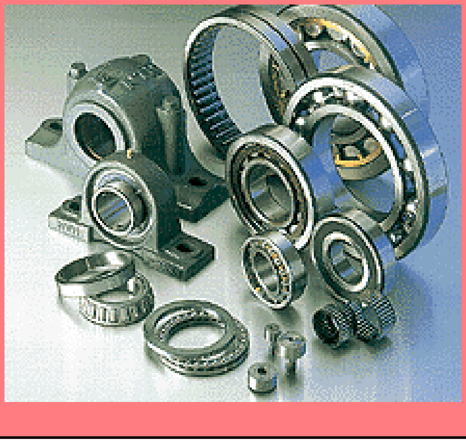
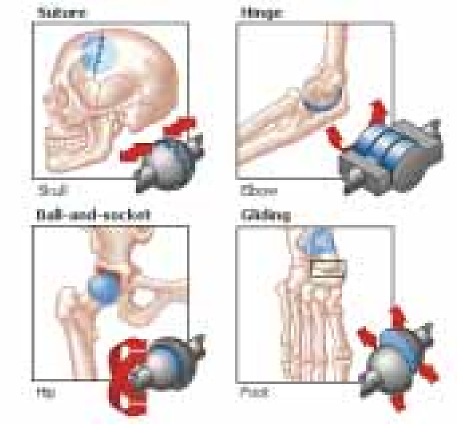
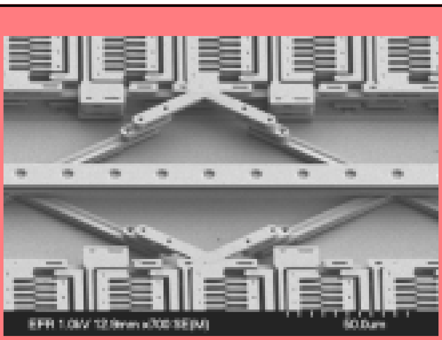
TRIBOLOGY



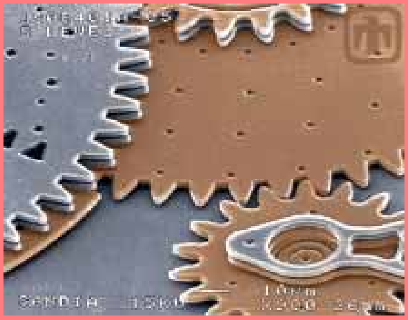


HUMAN JOINT

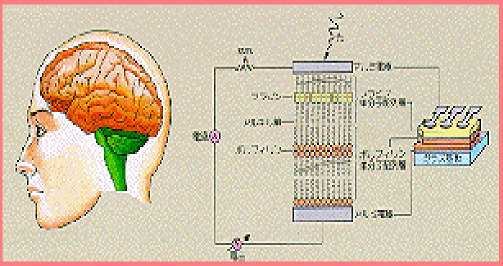




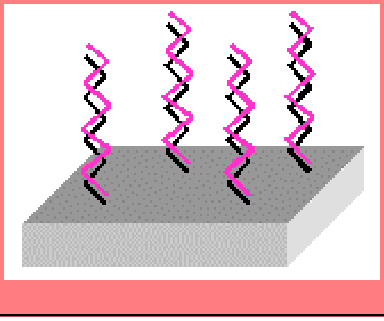
MEMS



DIAGNOSING AND SENSING

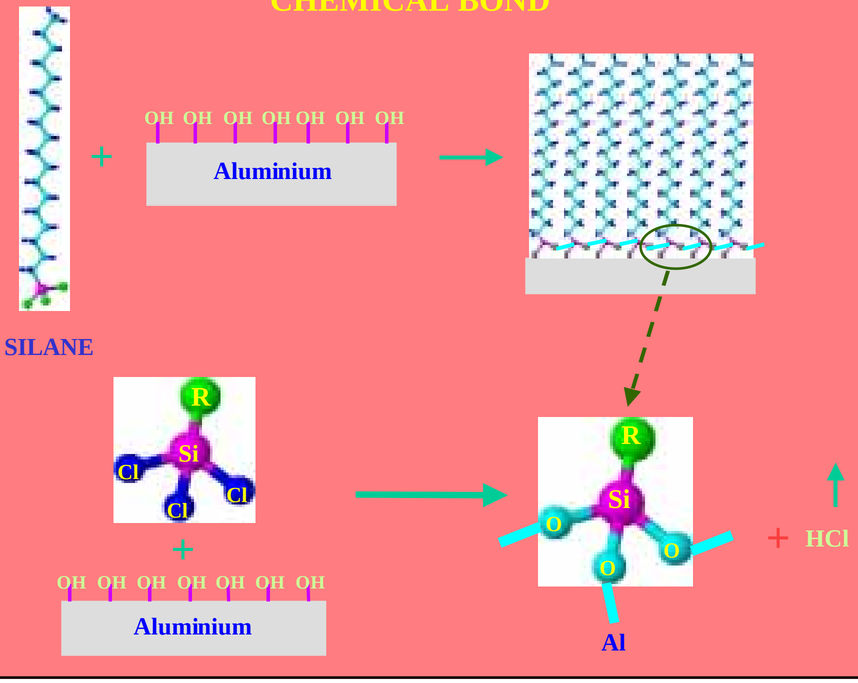


Bioelectronic devices



DNA SAMs

CHEMICAL BOND



SILANE

+

OH OH OH OH OH OH OH

Aluminium

R

Si

Cl Cl Cl

+

OH OH OH OH OH OH OH

Aluminium

R

Si

O O O

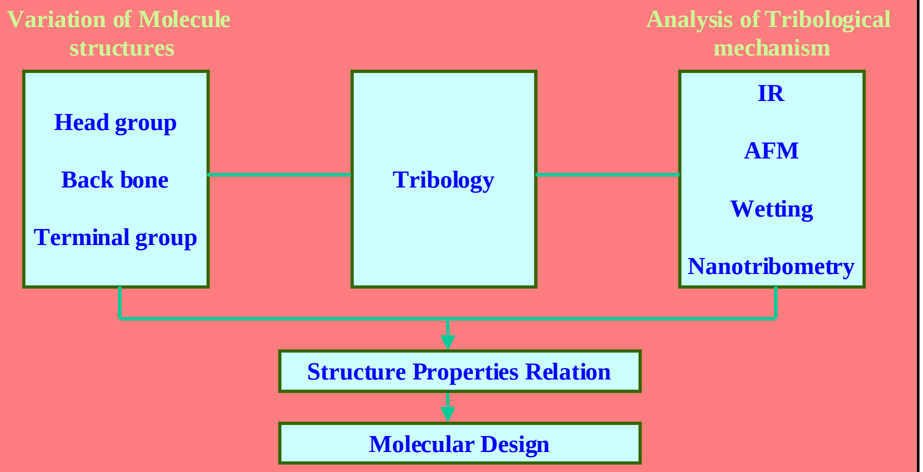
Al

+ HCl

Methodology

Design of additive molecules for aluminium Tribology

***Approach*: Find the relation of molecular structure with Tribology**


Variation of Molecule structures

Analysis of Tribological mechanism

Head group

Back bone

Terminal group

Tribology

IR

AFM

Wetting

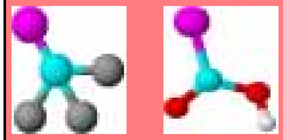
Nanotribometry

Structure Properties Relation

Molecular Design

➢ Head Group

R-$SiCl_3$ **R-COOH**

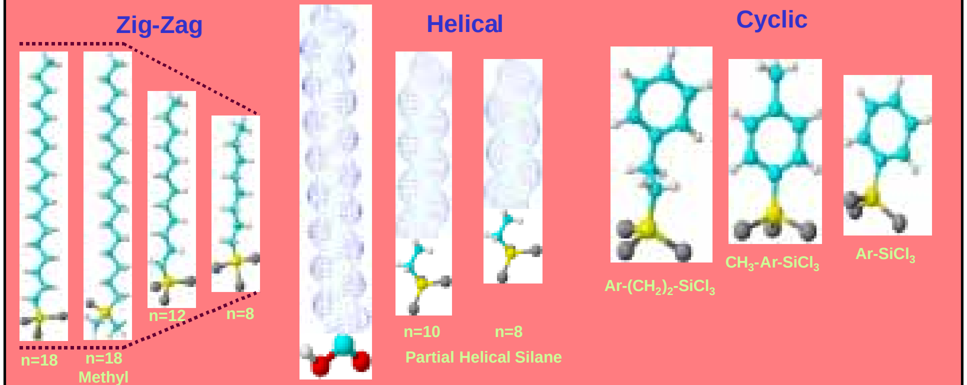


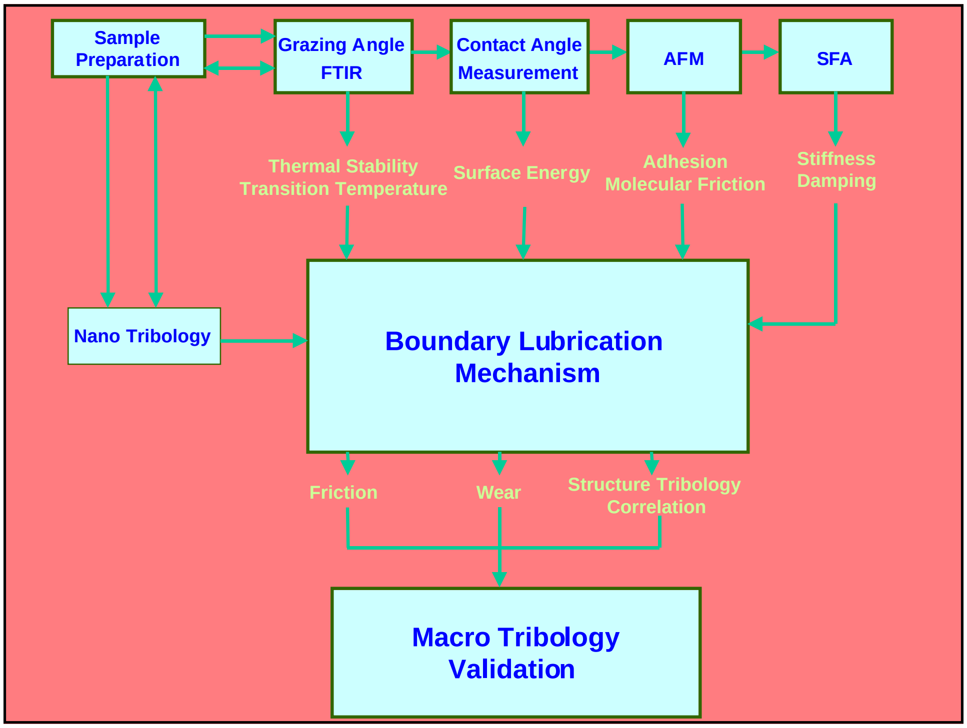
➢ Terminal Group

Alkyl Group **Fluoro Alkyl Group** **Aryl Group**

➢ Back Bone

Zig-Zag **Helical** **Cyclic**





Sample Preparation

Grazing Angle FTIR

Contact Angle Measurement

AFM

SFA

Thermal Stability
Transition Temperature

Surface Energy

Adhesion
Molecular Friction

Stiffness
Damping

Nano Tribology

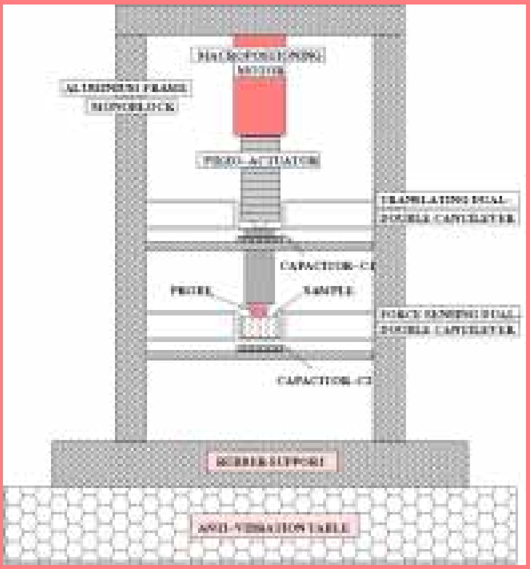
Boundary Lubrication Mechanism

Friction

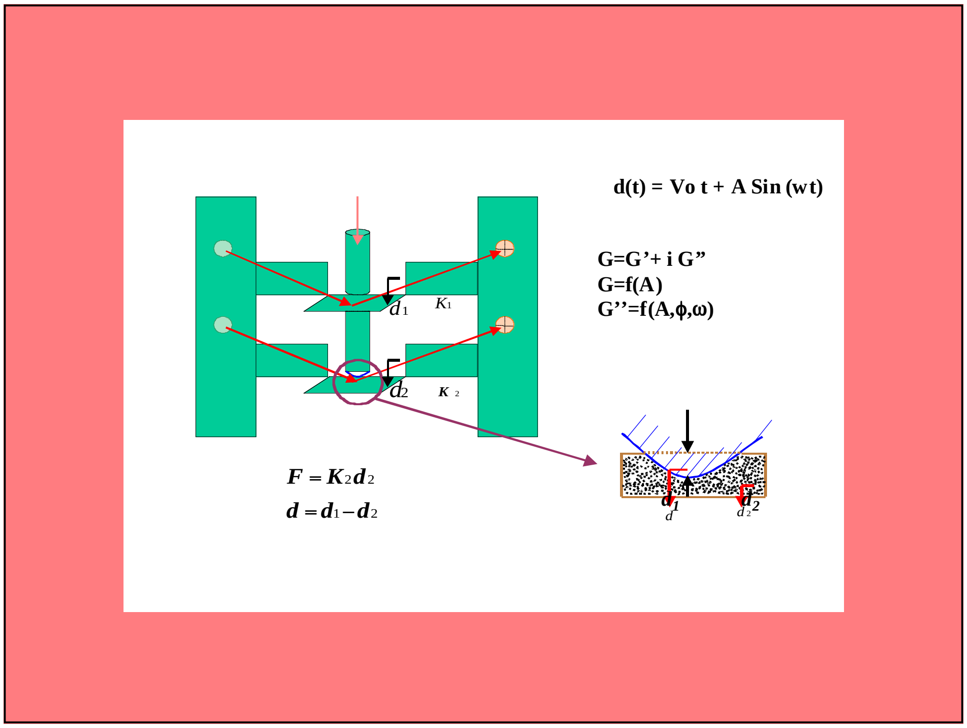
Wear

Structure Tribology Correlation

Macro Tribology Validation



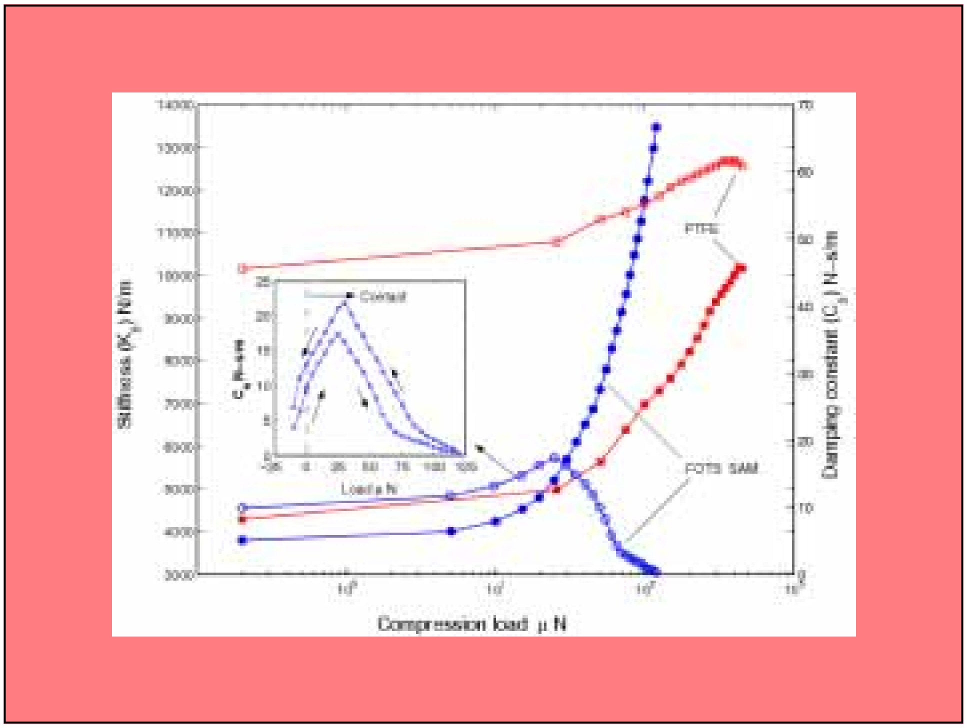
Surface Force Apparatus : Design

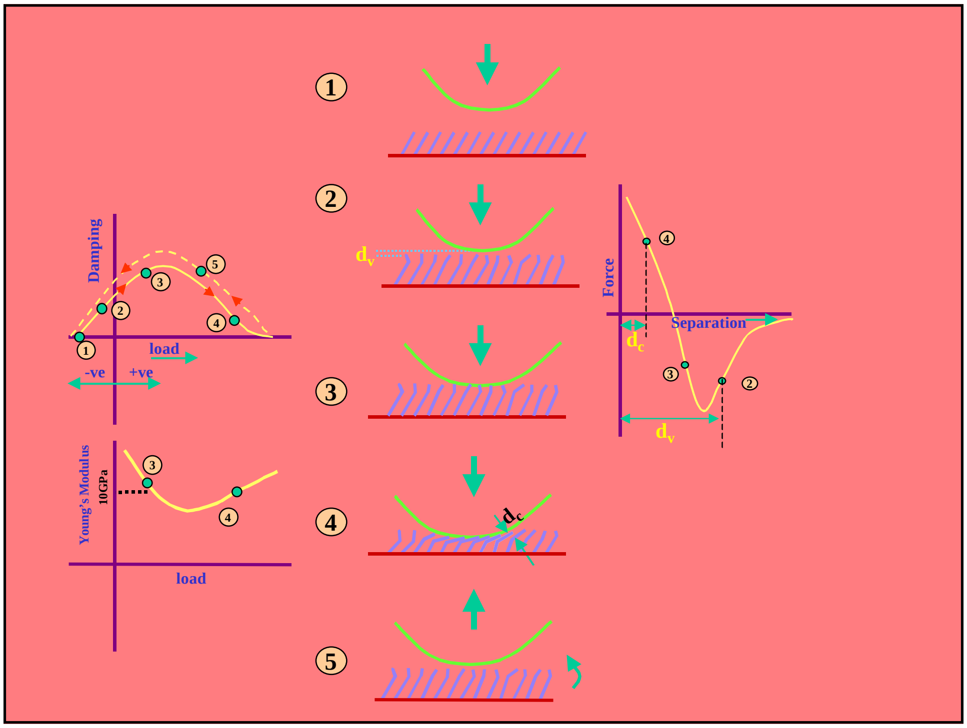


$$d(t) = V_o\, t + A \sin(wt)$$

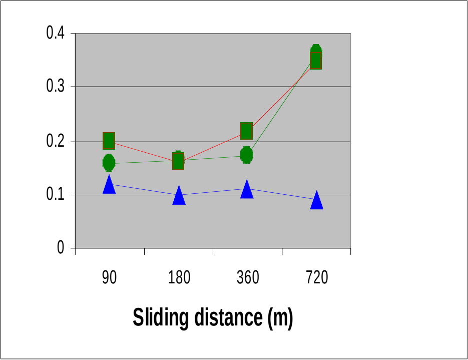
$$G = G' + i\, G''$$
$$G = f(A)$$
$$G'' = f(A, \phi, \omega)$$

$$F = K_2 d_2$$
$$d = d_1 - d_2$$

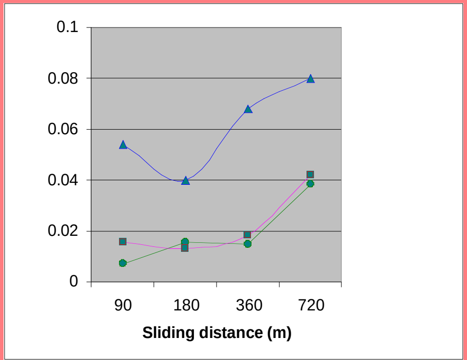




Friction Coefficient



WEAR



The Nature of Contact Induced Deformation and Fracture in TiN Films on Steel

S. K. BISWAS and V. JAYARAM

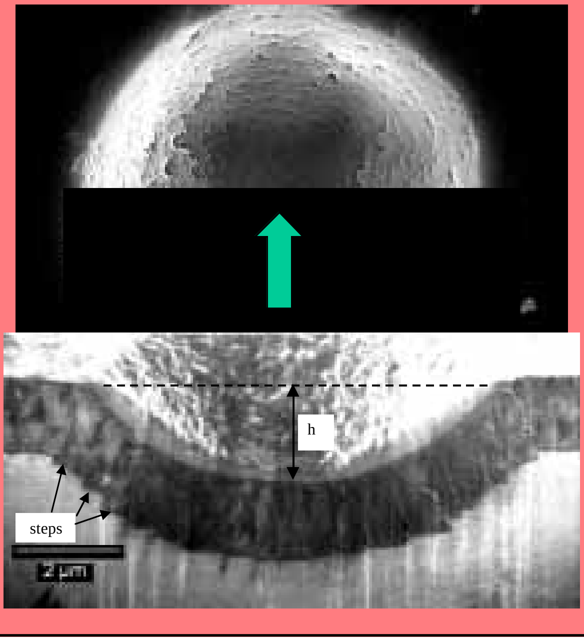
Indian Institute of Science

Sanjith Bhowmick **S.J. Suresha**	*Indian Institute of Science* *India*
Dr. Mark Hoffman **Z -H. Xie**	*University of New |South Wales* *Australia*

Material detail

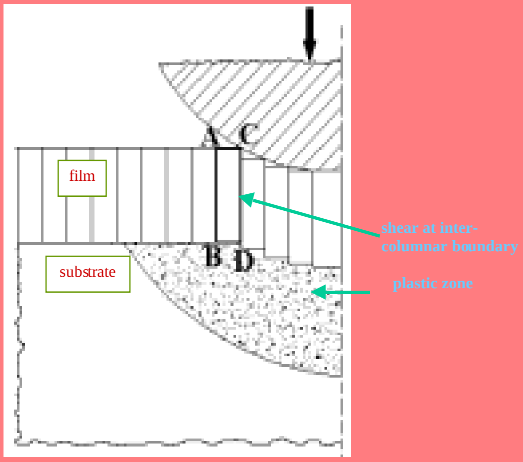
Cross section view

Thin film on SS



A model on coating damage

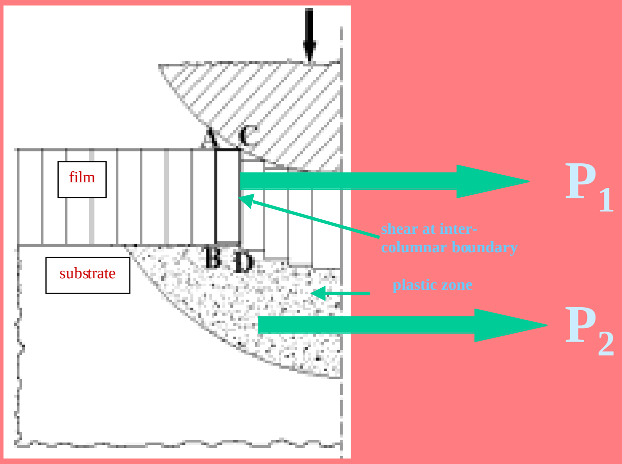
At high loads



Schematic of the partitioning of load between the TiN annulus, ABCD, and the expanding cavity in the steel substrate.

A model on coating damage

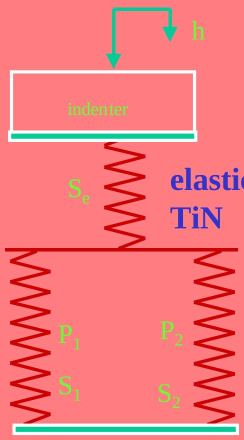
At high loads



Schematic of the partitioning of load between the TiN annulus, ABCD, and the expanding cavity in the steel substrate.

A model on coating damage

A spring-model to estimate entire loading part



$S = dP/dh$

elastic deformation of TiN

shear fracture in TiN

elasto-plastic deformation of steel

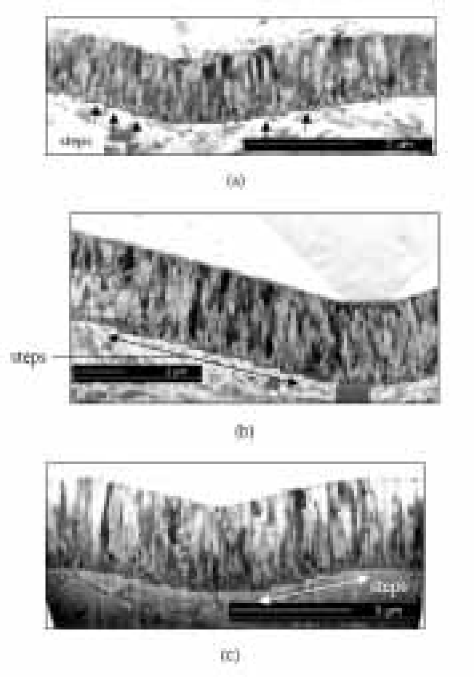


Fig. : FIB images of cross section of indentations of TiN films of thickness (a) 1.6 µm (0.5 N load), (b) 4.9 µm (5 N load) and (b) 5.9 µm (2N load) on HSS showing steps at the film-substrate interface.

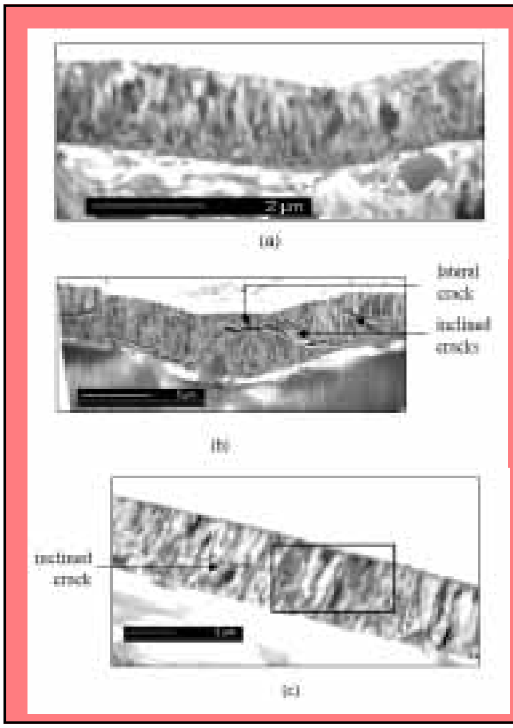


Fig. : Cross section FIB images of indentations of films of thickness (a) 1.6 µm (0.3N), (b) 4.9 µm (1N) and (c) 4.9 µm (5N), on MS showing inclined cracks. Shear steps in the thin film in (a) are replaced by inclined and lateral cracks in (b). The boxed region in (c) reveals lateral displacement of columns across the inclined cracks, consistent with shear.

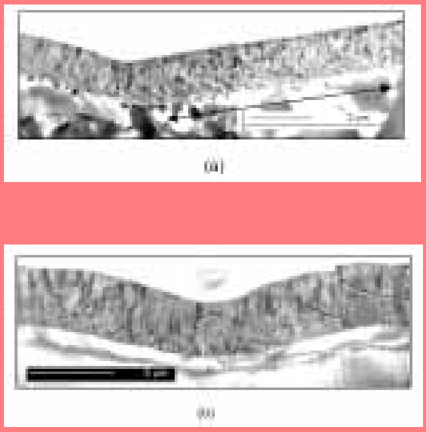


Fig. : Cross section FIB images of TiN films on Al; (a) 1.6 µm film (0.3 N) showing array of inclined cracks near the inter- face, (b) 4.9 µm film (1 N) displaying inclined cracks and lateral cracks under indentation.

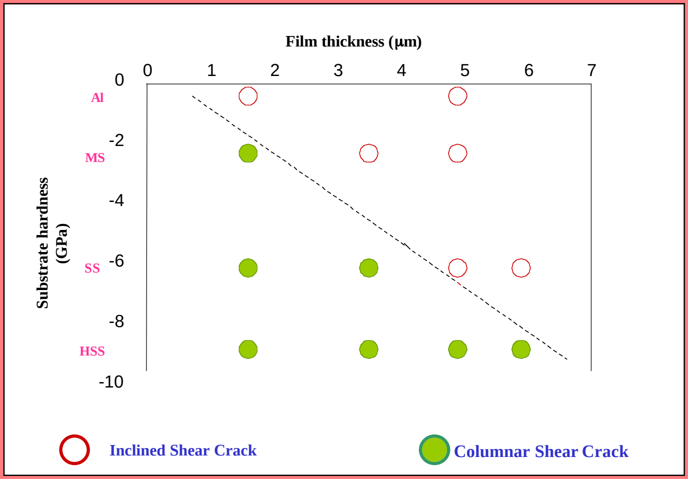


Fig. : A schematic diagram showing the change in failure modes with film thickness and substrate yield stress.

THIN FILM FOR CHEMICAL AND MECHANICAL PROTECTION

THICKNESS – 1nm → 100_m
(10^{-9}) (10^{-4}m)

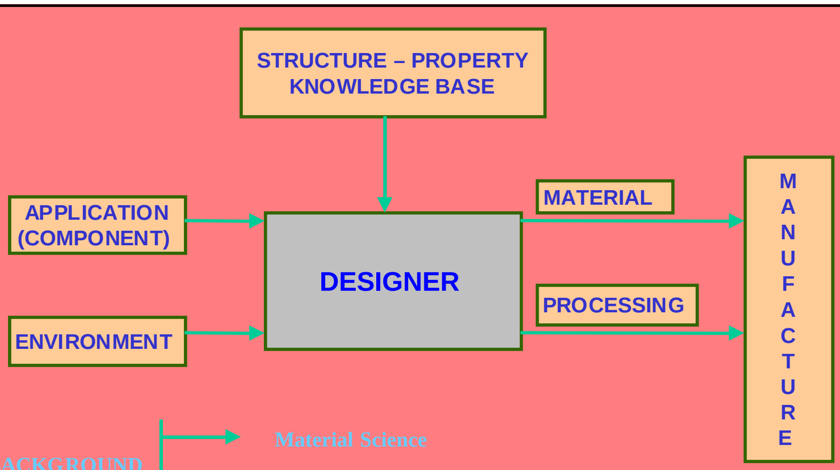
APPLICATION – MECHANICAL MACHINERY
HUMAN JOINTS (BIOLOGICAL)
ELECTRONIC (PACKAGING, DISK)

PROTECTION FROM – MECHANICAL DAMAGE IN POWER TRANSMISSION , CHEMICAL ATTACK

MATERIALS – ORGANIC MOLECULES ↓
HARD CERAMIC

PROCESSING – SELF ASSEMBLY ↓
SPUTTERING
PVD
HIGH ENERGY ION BEAM

PROPERTIES – STIFFNESS / HARDNESS
DAMPING
FRICTION / WEAR
THERMAL STABILITY



BACKGROUND KNOWLEDGE
- Material Science
- Mechanics
- Inorganic and Physical Chemistry
- Instrumentation

UNDERGRADUATE

INTRODUCTION TO NANOTECHNOLOGY

Pre requisite

12th Standard
Physics
Chemistry
Mathematics
Biology

- **Nanoscale S&T Implication**
  for Physics and Engineering
  for Chemistry and Biology

Nano structured materials
Nano particles
Quantum Dots
Ultrathin films – Multilayers
Molecular Self Assembly

Properties	**Mechanical**
	Electronic
	Optical
	Magnetic
	Thermal

5th Semester

(50 Hours Inc. Lab)

Compulsory

- **Preparation Routes**
  - **Precipitation**
  - **Milling**
  - **Colloidal Assembly**
  - **Vapour Phase Deposition**
  - **Molecular and Atomic epitaxy etc.**
  - **Lithography**

- **Preparation Environments**
  - **Clean Rooms**
  - **Vibration**
  - **Working Practices**

- **Characterisation Techniques**
  - **Diffraction**
  - **Spectroscopy**
  - **Electron Microscopy**
  - **SPM**

MSc in Nanoelectronics and Nanomechanics (2 Semester)

Semester 1

Generic methodologies for nanotechnology	(15 credits)
Semiconductor Nanotechnology	(15 credits)
Nanoscale Magnetic Materials and Devices	(15 credits)
Next generation silicon technologies	(15 credits)

Semester 2

Microfluidics	(15 credits)
Micro-and nano-electromechanical systems	(15 credits)
Electronic and Photonic Molecular Materials and Devices	(15 credits)
Molecular Electronics	(15 credits)
Quantum Computing	(15 credits)

PROBLEMS OF AN INTERDISCIPLINARY MASTERS COURSE IN NANOTECHNOLOGY

* Diversity
Prerequisites
Flexibility

* TEACHERS TRAINING

* LABORATORY INFRASTRUCTURE
DIVERSE
EXPENSIVE
NO PREVIOUS EXPOSURE

*AVAILABILITY OF SCIENCE
BASEDINDUSTRIAL EMPLOYMENT

Thank You