The Iby & Aladar Fleischman Faculty of Engineering

The Materials Science and Engineering Department

Website: http://materials.tau.ac.il

Prof. Noam Eliaz
Founding Chairman

July 2017
The mission of the DMS&E

• To conduct cutting-edge research in MS&E, thus gaining international reputation and collaborations
• To become a center of excellence within Tel-Aviv University for education and R&D in MS&E
• To support the Israeli industry, government and defense organizations, either by R&D or by consultation services
• To educate world class engineers that will lead the next technological breakthroughs. The DMS&E fills a national strategic need by operating the only focused MS&E academic programs in the Center of Israel, close to many relevant companies, research centers, government and defense organizations
The strengths of the DMS&E

We do things different!

• The Core and Affiliated Faculty are world leaders in their research fields and have won many prestigious international awards
• The unique diversity of departments at Tel-Aviv University and the institutional spirit encourage multidisciplinary R&D projects
• Young and vibrant department where students will learn in a warm and supportive environment
• The curriculum was carefully planned and constructed with reference to curricula in leading institutions in the field worldwide
• The School of Chemistry, with which the B.Sc. Program was constructed, is internationally acclaimed and is known for excellence both in teaching and in research
The strengths of the DMS&E – Contd.

• Education of students for excellence and many achievements. Graduate students advised by our faculty have won several prestigious awards such as the Israel Security Award, Chief of Staff Award, Promotion of Women in Science Award, SAMPE Israel, outstanding presentations at international conferences, etc.

• Most of the DMS&E faculty have been collaborating with industry and defense organizations and contributing to the development of technologies and products that have an impact on homeland security, health, environment, and economy

• Close vicinity to industrial companies, defense organizations and R&D centers
1. Prof. Noam Eliaz, DMS&E Chair
2. Prof. Ilan Goldfarb
3. Assoc. Prof. Shachar Richter
4. Assoc. Prof. Amit Kohn
5. Dr. Oswaldo Dieguez
6. Dr. Ariel Ismach
7. Dr. Brian A. Rosen
8. Dr. Noa Lachman
9. Dr. Semen Gorfman

And keep growing…
Additive manufacturing (3D printing)
Electrocryostallization of hydroxyapatite and other calcium phosphates for orthopedic and dental implants.
Bio-Ferrography (osteoarthritis, efficacy of drugs, wear of artificial implants, cancer).
Electroless and electroplating of functional alloys.
Materials durability in space-simulating environments.
Corrosion in different environments (e.g. aircraft, navy, nuclear reactors, \textit{in vivo}).
Failure analysis.
Metal-Oxides for Memristor Technology

Cross-bar array device
Surface science
Epitaxial growth
Self-(assembly, organization, ordering) of nanostructures on surfaces

UHV Microlab

Reciprocal lattice geometry (LEED, RHEED)

Nano-magnets, Nano-contacts

TMS

IV / IV

Ge/Si(001)

In/CdZnTe(110)

TiSi$_2$/Si(111)

In/CZT(110) camel-hump

Quantum ring

Use of Nature Resources for Development of Advanced Materials

Blood absorbent

Plastics

Pads

Anti-bacterial

Assoc. Prof. Shachar Richter
The Bio- and Molecular-Electronics Group
Prof. Amit Kohn

- Information storage devices
  - Magnetic Tunnel Junctions for Random Access Memory
    - Collaboration with Hitachi Global Storage Technologies

Spin Light Emitting Diodes
Transmission Electron Microscopy

Electron holography for nanoscale mapping of electric and magnetic fields

Collaboration with Micron Technology

Academic supervisor – TEM facilities at the Wolfson Applied Materials Research Center

Materials characterization service to TAU, Israeli academia and Industry
Atomistic Simulation of Materials Group
Department of Materials Science and Engineering at Tel Aviv University
Head: Dr Oswaldo Diéguez (dieguez@tau.ac.il)

- All materials are made of atoms
- The equations of quantum mechanics tell us how atoms interact
- We can solve these equations using powerful computers
- With this information we understand materials, simulate materials, and design new materials

Search for New Multiferroics
Ferroelectric Domain Walls
Understanding Solar Cells
2D Materials Lab – Dr. Ariel Ismach

I. Synthesis and characterization of 2D materials
II. Direct-growth of 2D heterostructures/ superlattices; Novel 3D structures
III. Tuning the physical and chemical properties

New 2D materials (how do they grow?)
- Growth mechanisms
- Single layer level (possible?)

Possible Applications
- Electronics
- Optoelectronics
- Transparent conductors
- Flexible electronics
- NEMS

New Properties
- Structure
- Electronic
- Optical
- Mechanical
- Thermal

Commercial and few home-built CVD systems

Micro-Raman Spectrometer
When 2D meets 3D: Graphene and h-BN foams

- **Graphene**: Ni G/Ni foam GF
- **h-BN**: 50 mm size single-crystal WS$_2$ monolayer domain

**Novel nanostructures**

**Graphitic Carbon Nitride**
Ongoing **Gas-to-Liquid (GTL) Research Projects:**

1. Shape control of LNO Perovskites for methane reforming (Israeli Ministry of Energy)
2. Effect of substitutions and defects on GTL performance
3. Synthesis of ultra-high surface area catalysts via combustion synthesis (MOMENTUM Fund)

**Shape-controlled performance**

**Defect engineering** of catalyst structure

Ni-alloy nanofoams from **energetic materials**
Ongoing Electrochemistry Research Projects:

1. Microtexture control of Pd catalysts for Alkaline Fuel Cells (AFC)
2. Fuel cell failure analysis, interfacial kinetics with scanning electrochemical microscopy (SECM) - (INREP2, pending)

Materials for improved fuel cell operation

Microtexture dependent performance

Scanning electrochemical microscopy (SECM) study of fuel cell components
**Major Interests:**

- Composite materials, focusing on carbon nanotube (CNT)/polymer composites.
- Surface treatments and nano-thin coatings.
- Mechanical and electrical properties of materials and their governing mechanisms.
- Nano-scale morphology characterization, focusing on quantitative SEM and TEM techniques.
Going Multidisciplinary!

DMS&E 11 Affiliated Faculty

Biomed Eng
Meital Zilberman

Mech Eng
Rami Haj-Ali
Dov Sherman

Electrical Eng
Yossi Rosenwaks
Yosi Shacham

Physics
Yoram Dagan

Enabling Technology

Chemistry
Gil Markovich
Fernando Patolsky

Molecular Microbiology and Biotechnology
Ehud Gazit
Tal Dvir

Cell Research and Immunology
Dan Peer
The Colloidal Nanostructures and Nanomaterials Group

- Metal nanowire films
- Nano-chirallity
- Magneto-transport in magnetic nanoparticle films
- Properties of nanoscale ferroelectric crystals

Prof. Gil Markovich
School of Chemistry
http://chemistry.tau.ac.il/markovich/
The group is focused on R&D in the field of 1D semiconducting nanomaterials, nanowires and nanotubes, for example:
1. The development of novel methods for the synthesis of nanowires and nanotubes.
2. The chemical and physical characterization of nanowires and nanotubes.
3. The large scale assembly of nanowires for the creation of nanowire arrays.
4. The applications of nanowires and nanotubes in a broad range of fields, from medical diagnosis to homeland security.
Nanoscale Electronic Devices and Characterization:

- Semiconductor nanowires (NWs): Nanowire transistors, dopant distribution, sensors, GaN NW optoelectronics, poly-Si nanowires.
- Electrostatically formed nanowires.
- Kelvin probe force microscopy (KPFM): Tip-sample electrostatic interaction.
- Organic transistors and solar cells
Research and development of materials, technologies and integrated processes for micro- and nano-scale system fabrication.

- Metallization methods for Very Large Scale Integration (VLSI) of Integrated Circuits (IC) and Micro-Electro-Mechanical Systems (MEMS).
- Electrochemical metallization: electroplating and electroless plating, electrophoretic deposition.
- MEMS bio-sensors and actuators.
- Polymer microprocessing: electro-active polymers, conjugate polymers, silicon nanowire integration, etc.
Multi-Scale Global-Local Mechanical Simulations

Impact and Penetration of Composite Armor

Experimental and Computational Damage of Composite Materials

3D brick element

Material point

Representative sublaminate

Dynamic Simulation-Prediction

Image correlation optical method

Bio-composites

Soft Coral Collagen Fibers

Coupled Mechanical-Electrical Piezo-resistive Composites

Micromechanical model

Fiber Matrix

Macro-Scale

Bio-Composite

Collagen-Algenate Composite PCT - WO 2013118125 A1

Micromechanical modeling of fiber-matrix unit-cell: Coupled electrical current density (left) and mechanical stress (right)

Prof. Rami Haj-Ali, School of Mechanical Engineering
http://www.eng.tau.ac.il/~rami98/
Active Implants and Scaffolds for Tissue Regeneration

- Synthetic and natural bio-polymers
- Biodegradable structures with controlled release of bioactive agents
- The effects of process parameters on the structure and properties

1. Wound dressings with drug controlled release
2. Soy-protein structures for various medical applications

3. Hemostatic soft tissue adhesives with controlled release of bioactive agents
Associate Professor Tal Dvir
Laboratory for Tissue Engineering and Regenerative Medicine
Faculty of Life Sciences
http://www.dvirlab.tau.ac.il

- Biomaterials for regenerative medicine
- Microfluidic devices for tissue engineering
- Nanoelectronics/engineered tissue hybrid (cyborg tissues)
- Targeted delivery systems for tissue regeneration
- 3D-printing of tissues and organs
- Bio-inspired materials
- Engineering 3D cellular microenvironments
• Bio-nanomaterials
• Supramolecular polymers of unique mechanical, optical, electronic and piezoelectric properties
• Peptide-based composites
• Convergence of peptide nanotechnology and DNA nanotechnology
• Organic semiconductors
Research interests:

- Nanomaterials
- Probing and manipulating the immune system with nanomaterials
- Developing novel strategies for targeted drug delivery
- Developing tools to study immuno-nanotoxicity
- Polysaccharides as building blocks for nanotherapeutics
Oxide interfaces
Superconductivity, magnetism and ferroelectricity at oxide interfaces
Deposition by RHEED-controlled pulsed laser
Quantum transport effects at topological insulators and superconductors
Scanning Tunneling Microscopy (STM)
Mesoscopic phenomena in low-dimensional electronic systems

SdH measurements of Cu$_{0.25}$Bi$_2$Se$_3$
Thank you for your attention!