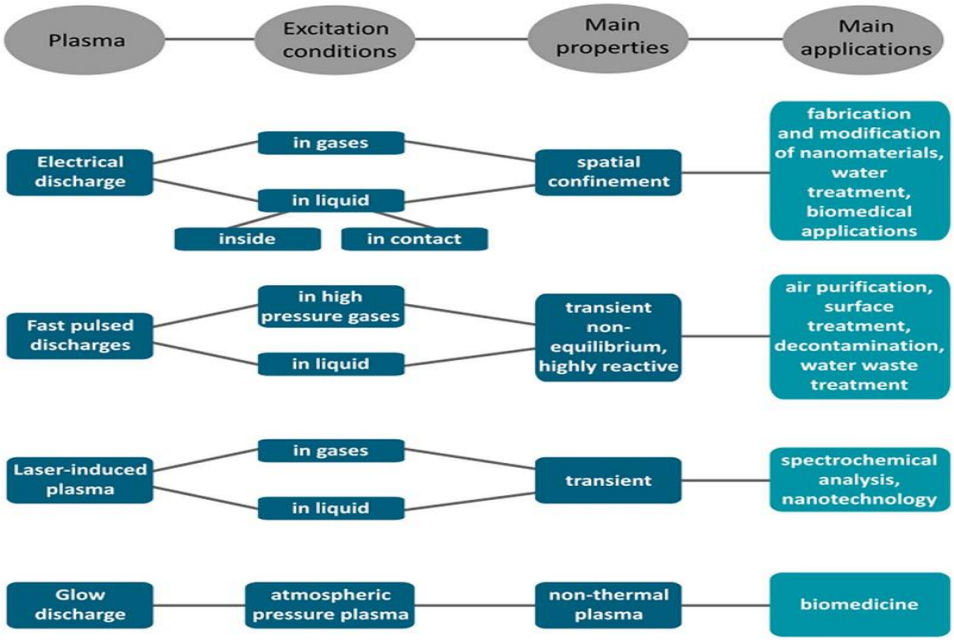
المجموعات والمشاريع البحثية بقسم الفيزياء

Plasma Research and Applications Group

Members	Prof. Dr. **Safwat Hassaballa**, Prof. Dr. **Wael M. Elshimy**, Dr. **M. Shaban**, Dr. M. **Tauqeer Khan, Dr. M. Imran Shakeir,** Dr. **Yasser Riyad** (Chemistry Dept.).
Description of the group research	- The term plasma is often referred to as the fourth state of matter. Starting with a gas at room temperature, as temperature increases, molecules become more energetic and dissociate to form a gas of atoms and then a gas of freely moving charged particles, electrons, and positive ions. This state is called the plasma state, it is characterized by a mixture of electrons, ions, and neutral particles moving in random directions that, on average, is electrically neutral. In addition, plasmas are electrically conducting due to the presence of these free-charge carriers. Nowadays, plasma science includes a variety of fields ranging from plasma physics to divisions of chemistry, atomic and molecular physics and materials science. - Plasmas are generated by supplying energy to a neutral gas causing the formation of charge carriers. The most commonly used method of generating and sustaining a low-temperature plasma for technological applications is by applying an electric field to a neutral gas. Plasma generators can be direct current (DC), alternating current (AC), pulsed, radio frequency (RF), or microwave (MW) plasma generators. The 2022 Plasma Roadmap: low temperature plasma science and technology "Journal of Physics D: Applied Physics" 

Plasma applications are attracting more interest and research activities. Plasma is useful in various types of modern industrial applications such as:

- Plasma deposition of thin films.
- Plasma processing of materials and surfaces and material functionalization.
- Plasma Synthesis of Nanostructures and nanomaterials
- Plasma wastewater treatment and pollution control.
- Plasma engineering of soft materials and biomaterials.
- Plasma Sterilization and Medical applications.
- Plasma agriculture and innovative food cycles.
- Plasma Electrification of chemical conversions

The Plasma Research and Applications Group welcomes all those having an interest in basic plasma research and applications

Research Facilities

Dual Head Magnetron Sputtering Coater

50 (mg/h) Ozone Generator for water treatment

Research Projects related to the group

Plasma Technology for Wastewater Treatment

Duration	**18 months, start (2020/10/25) end (2022/4/24)**

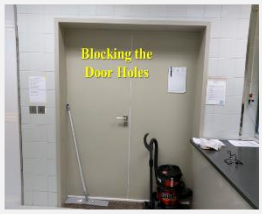
	Brief description of the project	- Industrial wastewater containing organic pollutants and others is one of the most important environmental issues. Therefore, there is an urgent need for effective treatment technologies that enable the reuse of this water. Plasma technology can address the problem of wastewater pollution by direct production of highly reactive agents (UV, O, H2O2, O3, OH) that attacks and decompose pollutants. - In this project, we used plasma technology to implement a wastewater treatment plant for industrial wastewater remediation. The design of the treatment reactor will allow the highest possible surface/ volume ratio of water in direct contact with the plasma. The effectiveness of plasma processing is determined by measuring the rates of elimination of chemical contaminants and elimination of microorganisms. This reactor is characterized by low energy consumption and can be easily scaled to handle large amounts of industrial wastewater. - The proposed treatment method showed good efficiency in decontaminating industrial wastewater from both the chemical and biological contaminations.
	Plasma Deposition of Photocatalytic Thin Films for Hydrogen Production	
	Duration	**18 months, start (2020/10/25) end (2022/4/24)**
	Brief description of the project	- Green hydrogen, an alternative fuel generated with clean energy, is experiencing a global resurgence and has been identified as the clean energy source that could help bring the world to net-zero emissions in the coming decades. - Photocatalysis is the process of light-induced redox reactions upon the surrounding molecules to produce radical species for the subsequent utilization in the water splitting for H2 and O2 production, various pollutant degradations, CO2 conversion into hydrocarbon fuels, disinfection of microorganism. Photocatalysis allows the direct conversion of water into hydrogen and oxygen by light. Various photocatalytic thin films were used for evolution of H2 such as TiO2, Ag/TiO2, Fe2O3, WO3, ZnO etc. However, most photocatalysts require UV light activation. This research project will develop visible light photocatalysts, allowing efficient hydrogen production using only sunlight. - In this research proposal, we use plasma thin film deposition technique, the magnetron sputtering device, to deposit and study

		different photo-catalysts During the thin film deposition process the structure and/or morphology of the films will be varied to allow variations in the optical, electrical and morphological properties to enhance the visible light absorption and/or limit the recombination rate of charge carriers.
Contact	Prof. Dr. Safwat Hassaballa safwat.hassaballa@iu.edu.sa Tel: 0540094815	

(Solar Cells Fabrication and Characterisation) Group	
Members	**Abdullah Almohammedi**, Yasser Abdelrady Masoud Ismail, Mohamed Benghanem, Mohd Taukeer Khan,
Description of the group research	The group is concerning to the research in the new ideas of the emerging solar cell research which is identified as "Third Generation of Solar Cells" The priorities are: 1. Organic Solar Cells 2. Perovskite Solar Cells 3. Encapsulation of Solar Cells 4. Solar Cell Concentrators
Research Facilities	

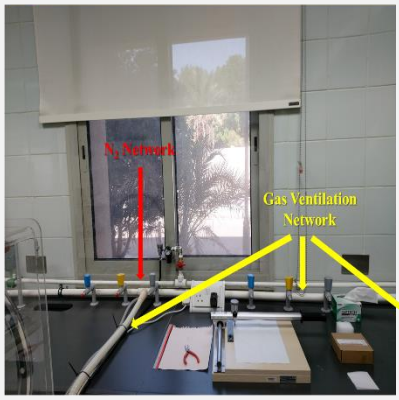
Infrastructure in the Lab

For Clean Environment



For Clean Environment

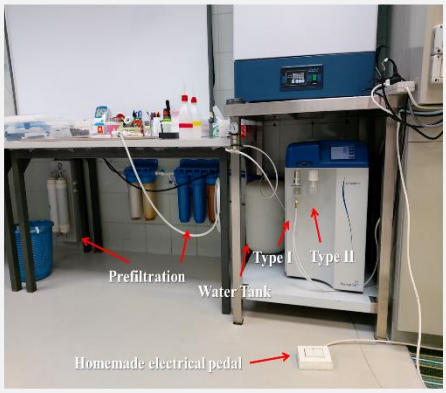
N_2 Gas Network & Gas Ventilation Network



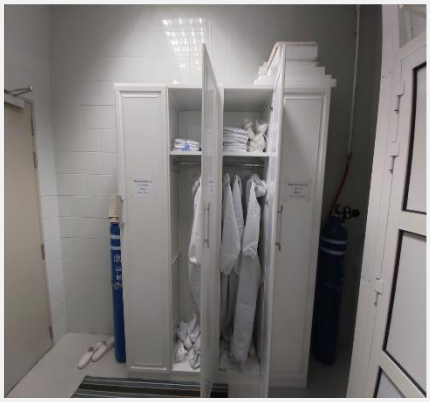
Yellow Light for Solution and Organic Film Preparations

Fume Hood for Cleaning of ITO-Glass Substrates

Water Purification System (for Type I & II water)



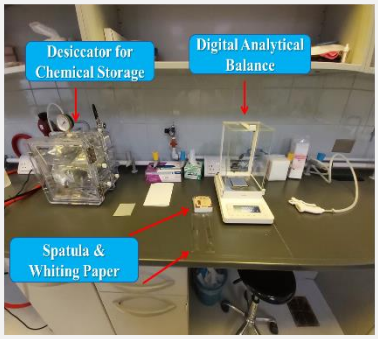
Wearing Lab Suit and Interring into the Lab



Consumables in Storage Shelves and Refrigerator

Facilities for Solar Cell Preparation

Preparation of Organic Solutions under Yellow Light



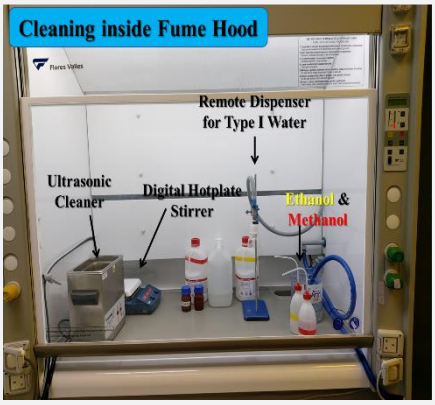
Cleaning of ITO-Glass Substrates

ITO-Substrate Cutter

ITO-Substrate Holder

Cleaning of ITO-Glass Substrates

Cleaning inside Fume Hood



Cleaning of ITO-Glass Substrates

Vacuum Oven

Plasma Cleaner

Research Projects related to the group	***Project1 (Encapsulation of Low-Cost and Highly Efficient Perovskite Solar Cells using Low-Cost Polyurethane for Outdoor Application)***	
	Duration	- *9/10/1441*
	Brief description of the project	*In the present research proposal, an easy and cheap encapsulation technique is used for perovskite solar cells through the complete immersing of the cells inside the polyurethane melt prepared from low-cost castor oil and 2,4-toluene diisocyanate. Therefore, the entire covering of solar cells is ensured against outdoor weather by using little encapsulation procedures and low-cost materials for (1) increasing the lifetime of the perovskite solar cells, (2) reducing the production costs of the solar cells commercially and, also, for (3) application of low-cost solar cells in the outdoor conditions. This study will be carried*

		out under conditions of the outdoor weather of Madinah prefecture in Saudi Arabia, as a study for a first time. Therefore, the present investigation may illustrate and highlight the effect of Madinah outdoor weather on the encapsulated perovskite solar cells for outdoor application, in addition to the effect of Madinah outdoor weather on physical properties of polyurethane material, as an important applicable polymer.
	Project2 (Fabrication of New Low-Cost Organic Solar Cells for High Efficiency Generation of Electricity and Reducing Air Pollution)	
	Duration	- 18/9/2022
	Brief description of the project	*Through the present research, we try to prepare new organic solar cells using new liquid-crystalline molecules as non-fullerene-based organic solar cells. The non-fullerene-based organic solar cells have received great interest recently due to their higher performance and greater potential compared with fullerene-based solar cells. Different new and innovative liquid-crystalline molecules can be synthesized and characterized in our lab for the optimization towards solar cell applications. Nowadays, liquid-crystalline molecules are applicable materials because they can be used for producing solar cells with high efficiency as well as they can be used in different optoelectronic applications such as sensors and light emitting diodes for displays. It is possible to synthesize different types of liquid-crystalline molecules having different and useful physical properties towards solar cell applications. Several researchers from different scientific departments (physics and chemistry) in Islamic University will cooperate and share through this project. From such collaboration, we are looking for accomplish the aspired tasks and objectives to fabricate*

		and characterize new organic solar cells using new liquid-crystalline molecules for low-cost electricity generation and for contributing to reduce air pollution.
Contact	arda@iu.edu.sa & yasser.ismail@iu.edu.sa	

Nanophotonics and Applications (NPA) Group	
Members	Prof. Dr. Mohamed Shaban (PI), Dr. Abdullah Almohamedi, Prof. Dr. Safwat Hassaballa, Dr. Taukeer Khan, Abdelaziz A.A. El-Sayed

Description of the group research	This group focuses on the design of nanomaterials including nanopowders, nanoarrays, thin films, nanocoatings, nanoporous membranes, RO and FO membranes and their applications in the field of energy (PEC hydrogen production, solar cells, supercapacitor, and fuel cells, smart windows), water treatment and desalination, and environmental applications (Sensors, catalysts, antimicrobials, solid wastes and plastic wastes recycling).
Research Facilities	CHI electrochemical station (CHI-660E) Shimadzu GC [GC230] UV/Vis spectrophotometer [Agilent technologies (G9825A)] Ultrasonic cleaner [USC 500-TH] Hotplate magnetic stirrer [VELP Scientifica(AREC-T)] Liquid N2 Maker [IMTEK Cryogenic (CN-Lab 20)] Muffle Furnace [DAIHAN LABTECK, LEF-130P-1] Tube Furnace [Nabertherm, R151C2AN] Magnetron Plasma sputtering coater [CY Scientific instrument, CY-600-2HD-PL]  


VWR


CRLAB 10


Nabertherm

<table>
<tr><td></td><td colspan="2"> 
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<tr><td rowspan="3">Research Projects related to the group</td><td colspan="2">Project1 (Nanometric zeolite/metal oxides compound for hydrogen fuel production and dyes removal from wastewater)</td></tr>
<tr><td>Duration</td><td>Mohamed Shaban (PI), Hamd Alomhamdi, AbdelAleem Hefny, Ashour Mohamed, Deanship of Scientific Research (Research Groups Program: Grant no. (904/1443AH)), Islamic University of Madinah, Saudi Arabia, 2022/2023.

(18 months)</td></tr>
<tr><td>Brief description of the project</td><td>Tis project focuses on the design of zeolite/metal oxides compound and their applications of green hydrogen using the photoelectrochemical technique and photocatalytic dyes removal from wastewater.</td></tr>
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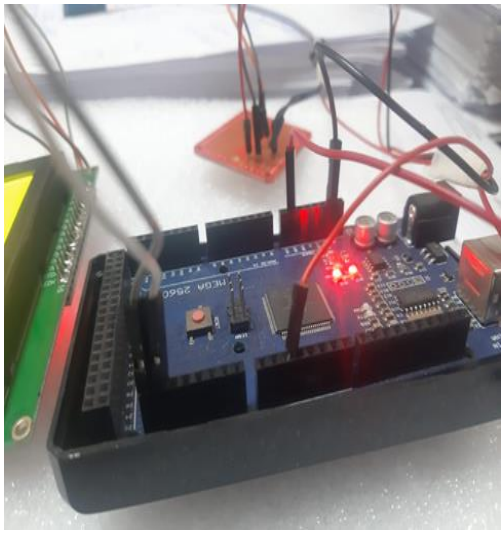
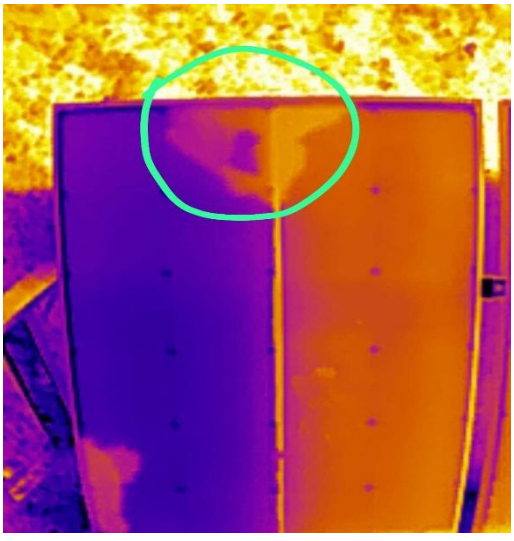
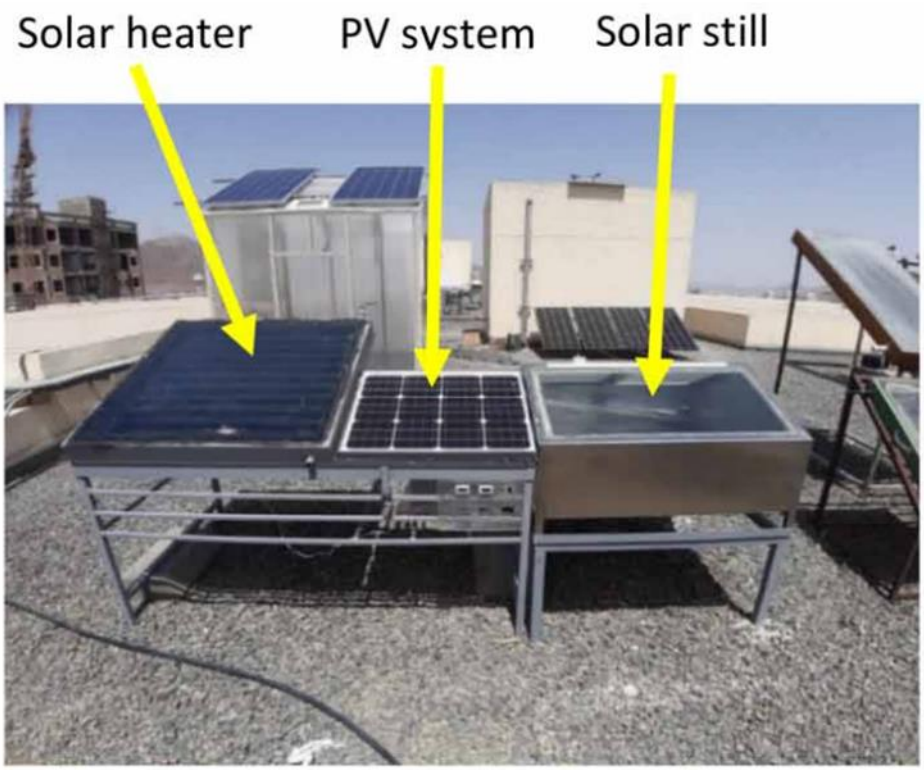
	Project2 (title)	
	Duration	
	Brief description of the project	
	*******Please include more cells in the table if you have more projects**	
Contact	e-mail: mssfadel@iu.edu.sa mssfadel@aucegypt.edu arda@iu.edu.sa	

(Renewable Energy Applications) Group	
Members	Mohamed Benghanem, Abdullah Almohammedi, Mohd Taukeer Khan, Yasser Abdelrady Masoud Ismail,
Description of the group research	The group is concerning to the applications of Renewable energy such as Solar Energy and wind Energy. The different applications are: 1. Photovoltaic system for electricity generation. 2. Solar water desalination system. 3. Smart solar cooling greenhouse. 4. Hydrogen production using PV system. 5. Wind Energy system

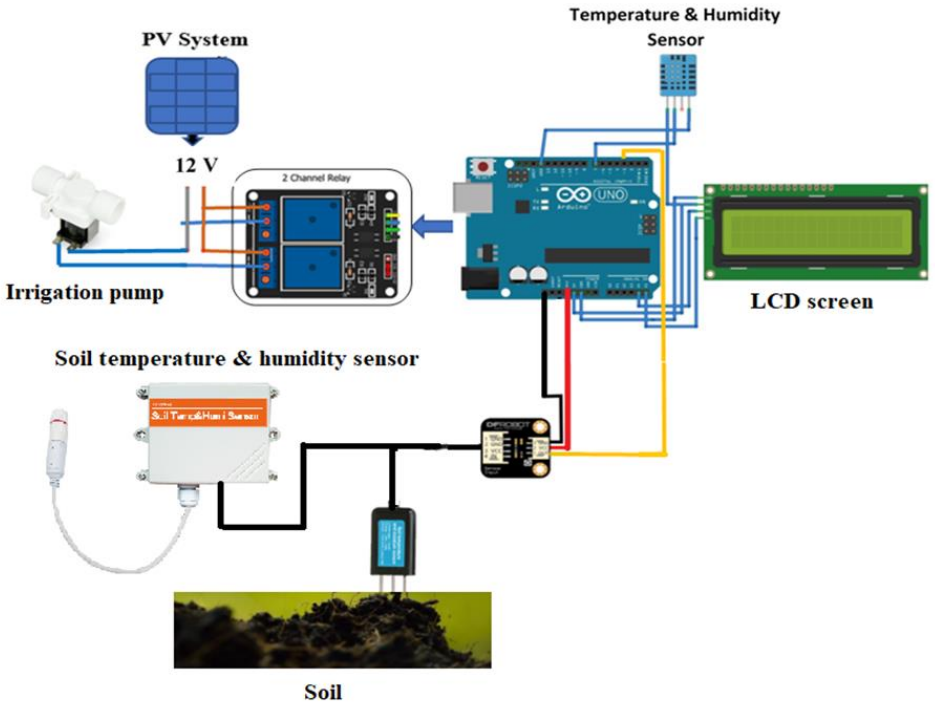
Research Facilities	PVPM 2530C for I-V Characterization of PV panels Agilent Data Logger. Keithley instruments Sources meters 2400 Weather station. Experimental unit for Greenhouse measurement. Prototype of Solar desalination unit. 






Solar heater
PV system
Solar still

Different sensors used in the Renewable Energy Lab:

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Reverse Osmosis System Controller


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Forever Pure

Research Projects related to the group	***Project1 (Optimization and Performance Management of Photovoltaic system Powered Electrolysis for Hydrogen production)***	
	Duration *18 Months*	**Mohamed Benghanem** (PI), Islamic University of Madinah, **KSA** Adel Mellit, Trieste University, **Italy,** Sofiane Haddad, Jijel University, **Algeria** Nadia Chetibi, Research Centre of Advanced Techniques, **France.** Grant no. (809/1443AH)), Islamic University of Madinah, Saudi Arabia, 2022/2023.
	Brief description of the project	This project focuses on the design and setting of photovoltaic system to supply an electrolysis for hydrogen production. An optimization of a PV-Hydrogen generation system by both PV module and hydrogen cell has been elaborated. It is recommended to use Potassium Hydroxide (KOH) over Sodium Chloride (NaCl) as an electrolyte and fixed some distances between electrodes to produce a higher hydrogen flow rate.
	Project1 (Combined Water desalination systems powered by Hybrid solar energy systems)	
	Duration *18 Months*	Mohammed Emad (PI), Islamic University of Madinah, **KSA** **Mohamed Benghanem** (Co-PI), Islamic University of Madinah, **KSA** Khaled Harbi, Taibah University**, KSA** Khaled. Almohammadi, Taibah University**,** Madinah, **KSA** Abdulrahman Aljabri, Islamic University of Madinah, **KSA** Abdulmohsen Alsaiari, King Abdulaziz University, Jeddah**, KSA**. Grant no. (1030/1443AH)), Islamic University of Madinah, Saudi Arabia, 2022/2023.
Contact	e-mail: mbenghaneml@iu.edu.sa emad@iu.edu.sa arda@iu.edu.sa	

(Functional Nanomaterials Group (FNG)) Group		
Members	Imran Shakir	
Description of the group research	At the Functional Nanomaterials Group, our focus lies in the development of novel nanomaterials featuring diverse compositions and structures. Our research delves into exploring a range of promising functionalities, including redox activity, catalytic activity, and ionic conduction properties. Our primary objective is to selectively and efficiently synthesize metal oxides nanowires, nanotubes and nanosheets and their composites CNTs and graphene to generate breakthrough applications in optoelectronics, photocatalysis, and renewable energy.	
Research Facilities	Write the main available research facilities, you many include pictures of the devices	
Research Projects related to the group	***Project1 (Efficient Utilization of Kingdom's Industrial Waste (Sulfur) For the Design and Synthesis of Layered Metal Sulfides Nanostructures for Energy Storage Devices)***	
	Duration	*15-12-2021*
	Brief description of the project	*Green and efficient utilization of industrial waste into useful form of energy is one of the most challenging task for the researchers and scientist all over the world as the current available resources may soon outshine. During last few decades, many energy storage and conversion technologies such as supercapacitors, lithium ion batteries, electro and photo-assisted water splitting and solar cells have been under research, the efficiencies of these devices have been limited as they already reached the intrinsic limit of most of the known materials used in these technologies. In order to improve the performances of these devices by utilizing industrial waste, it is essential*

		to investigate new materials with various architectures that display best performances while exploiting their unique features such as high surface area, good electronic and ionic conductivity and unusual size effects along with compositional variants. In this regard, recently, metal sulfides gained considerable attention as new materials for energy storage devices due to their high electronic conductivity as compared to their crossponding metal oxides. The major objective of the current project is to efficiently utilize the sulfur produced as one of the major industrial wastes in the Hydrocarbon based industry in the Kingdom of Saudi Arabia. The technical focus of the proposed project will be to design and synthesized various architectures of metal sulfides systems by utilizing sulfur waste, which will not only be very cost effective, but also have the potential as efficient electrochemical energy storage materials. We believed that the synthesized metal sulfides nanostructures with optimum morphology can accommodate large strain without pulverization, and can also display fast electron transport, fast ion diffusion making them an excellent choice as electrode materials for various kind of energy storages devices. Moreover, we believe that their electrochemical performance will be further enhanced by synthesizing their nanocomposites with various highly conductive metal oxides and high surface area carbon based materials like carbon nanotubes and graphene. For the synthesis of desired material architectures of metal sulfides and its composites, we will adopt a number of solution based approaches such as sol-gel, solvothermal and hydrothermal methods. We believe that these synthesis approaches will provide us with the unique opportunity to produce

		bulk amounts with a precise control over composition, morphology and electrochemical properties.
	Project2 (Design and fabrication of high-performance, flexible energy storage devices via the layer-by-layer assembly of graphene and ultra-thin metal hydroxide films deposited onto multiwall carbon nanotubes)	
	Duration	01-09-2019 to 31-08-2022
	Brief description of the project	One of the greatest challenges of the modern world is the increasing demand for energy, which may soon exceed the amount of usable energy obtainable using currently available technologies. Although there are many promising technologies for energy conversion and storage, such as solar cells, photo-assisted water splitting, lithium ion batteries, and supercapacitors, the efficiencies of these devices have already reached the inherent limits of the available materials. To further improve the performance of these devices, the design of new material architectures with optimum performance that exploit high surface area, novel size effects, and compositional variations is imperative. Recent developments in nanotechnology and materials science offer potential solutions to questions on how to improve both performance and safety while enhancing the reliability of portable, flexible electronic devices. However, the development of lightweight and flexible energy storage devices, such as batteries and supercapacitors, with high performance still remains a challenging task because the poor conductivity of metal hydroxides limits the charge/discharge rate at high energy/power densities and the specific capacitance severely decreases at high currents. To improve flexible energy storage device performance, we proposed a unique, simple, and cost-effective layer-by-layer (LBL) assembly technique to fabricate multilayer thin film electrodes in which

		multiwalled carbon nanotubes (MWCNTs) coated with ultrathin metal hydroxide films are uniformly sandwiched between graphene layers. Inserting this conductive graphene spacer between the metal hydroxide-coated MWCNT films not only prevents agglomeration between the MWCNT films but also creates substantially enhanced specific capacitance cycling stability, ultrafast charge discharge rates, and excellent energy and power densities by improving the electrical conductivity and electrochemical stability of the metal hydroxides. Furthermore, electrodes based on the developed LBL assembly allow electrolyte ions to easily access the electrode, and the LBL assembly also provides an excellent mechanical robustness and high-rate ion storage performance, which makes it a promising technique for creating electrodes for high- performance, large-scale energy storage devices. Our approach uses facile LBL assembly to produce an exciting opportunity for enhancing the performance of metal hydroxide-based electrochemical supercapacitors for next-generation flexible energy storage devices. The successful completion of this project will open new vistas in the search for new, practical electrode designs for flexible portable electronic devices.
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Contact	imranskku@gmail.com	