ALTERNATE ENERGY LAB (CLUSTER INNOVATION CENTRE)

ALTERNATE ENERGY LABORATORY: WITH EMPHASIS TO SOLAR ENERGY

LABORATORY IN-CHARGE: PROF SWATI ARORA

LABORATORY MOTO: CLEAN ENERGY FOR A CLEAN WORLD

NEED IN TODAYS WORLD: FOCUSS ON ALTERATE ENERGY

Modern civilization has brought a drastic change in the living standards of man. The increased comforts and industrialization has led to arise in the energy demand as well. To meet the growing energy demands, the conventional resources of energy such as fossil fuels are being increasingly consumed. However, these resources are leading to pollution. The concern towards the environment and its conservation has led to an interest in utilization of Alternate energy/Renewable energy resources. Alternate/Renewable energy harnessing technologies, includes photovoltaic system, solar thermal applications, wind mills, hydro-power plants, hydro-power plants, biomass/biomass plants, geothermal, wave and tidal plants and their associated energy storage components, Most of the current resources on Earth are limited, whereas sunlight is practically inexhaustible and hence special emphasis should be made on solar energy. There is a need to educate and encourage our youths towards usage of Alternate energy especially to solar energy and hence a dedicated laboratory was essential in Cluster Innovation Centre. To the best of our knowledge it is the only one such laboratory in the University of Delhi which is promoting education and innovation in Alternate energy.

MISSION:

Awareness and Popularization of Renewal energy usage with special emphasis to solar energy.

OBJECTIVES:

(1) **Understanding the basic characteristics of the alternate energy units like solar cell.**

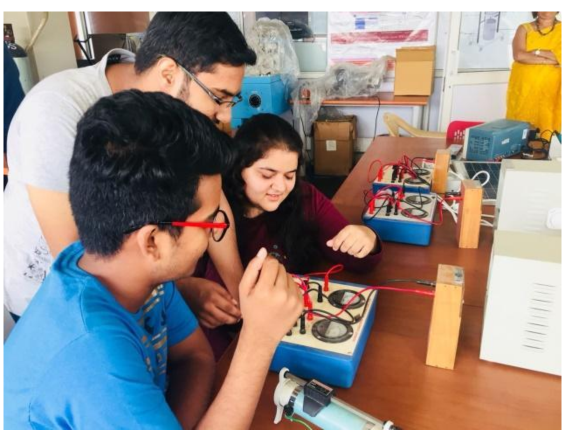
(2) **Learning the applications and the engineering concepts of assembling the units like Solar panels**

(3) **Generation of electricity from solar energy and becoming self reliant for functioning of Alternate energy laboratory**

(4) **Fabrication and innovation of renewable energy devices**

USERS:

(1) **All students of B Tech(IT and Mathematical Innovation) CIC DUcourse . It is part of the assigned curriculum .Basic experiments on alternate energy is done in first year of the course and advance experiments are done in the following years.**



(2) Semester long Projects are performed.

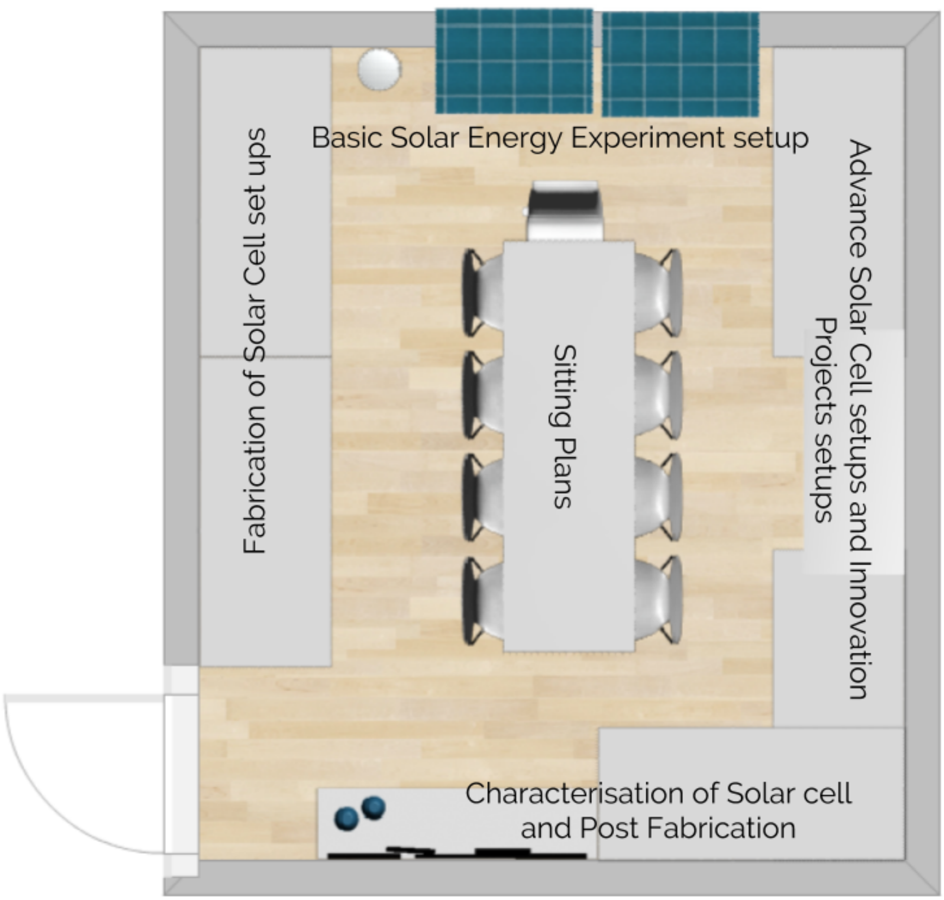
(3) Innovation projects are conducted.

(4) Research and Development projects are undertaken.

(5) Students involved with higher degree courses like Ph.D programmes also contribute to research here.

(6) Educational programmes for school children are run.

LABORATORY /FACILITY LAYOUT:



INSTUMENTS/AVAILABLE FACILITY

(1) Understanding and Characterization of solar cell: I-V characteristics using designed kits with variable intensity light sources.

(2) Learning use of solar panels: Engineering concepts of using these panels in series and parallel combination to generate required electricity for functioning of various utility devices and equipments. Learning concepts of backup electricity plans, day to dawn traffic light concept, solar battery storage, etc using customised kits are available for studies.

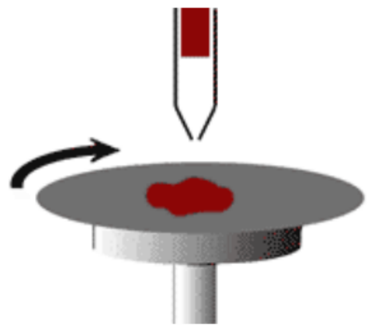
(3) Usage of solar tracker: live experimentation using solar tracker are conducted and innovative ideas like prediction of day temperature, humidity, climatic variation etc are made.

(4) Generation of electricity from solar panels: Electricity is generated for use in the laboratory using solar panel ,solar inverter, solar batteries and charge flow controllers. Various sized solar panels with batteries and charge controllers are available for studies.

(5) Solar cell Fabrication Facilities: The laboratory is well equipped with facitlity to fabricate crystalline, amorphous, polymer and hybrid solar cells .Following techniques are used in the laboratory:

(A) Spin Coating Technique

Spin coating is one of the most common techniques for depositing thin films to various substrates and is used in a wide variety of industries and technology sectors. The advantage of spin coating is its ability to quickly and easily produce uniform films with thickness ranging from few nanometres to a few microns.



Spin coating basic process

Figure shows the basic spin coating process and it involves gently dropping a small puddle of a fluid resin onto the centre of a substrate and giving the substrate a desired rotational speed. The basic principle behind spin coating involves the interplay between centrifugal force and viscous force, centrifugal force is controlled by spin speed and viscous force is determined by solution viscosity. Figure below shows the spin coating mechanism which can generally be described by four processes: fluid dispensing, spin up, spin off and evaporation of the solvent.

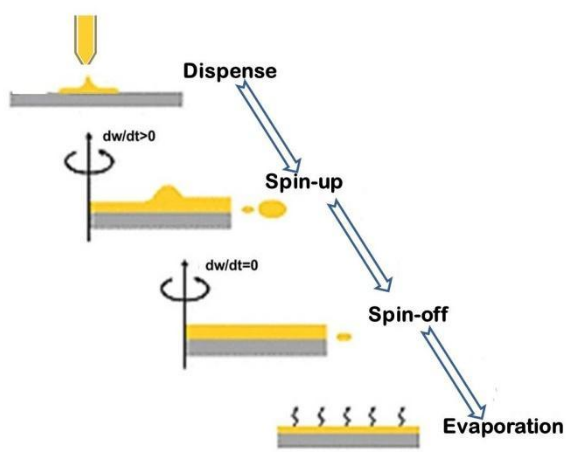


Fig. 2.2: Schematic representation of the spin coating process.

a) **Fluid dispensing:** During this stage, the solution is dropped on the rotating substrate and the substrate is accelerated to the desired speed. Spreading of the solution takes place due to centrifugal force and height is reduced to critical height.

b) **Spin up:** The second stage is when the substrate is accelerated up to the desired rotation speed. In this stage, the excessive fluid is expelled from the wafer by the rotational motion. When the wafer reaches its desired speed, the fluid becomes thin enough that the viscous shear drag exactly balances the rotational accelerations.

c) **Spin off:** In this stage the fluid viscous forces dominate fluid thinning behavior. This stage is characterized by gradual fluid thinning. Fluid thinning is generally quite uniform, though with solutions containing volatile solvents; it is often possible to see interference colors. Edge effects are often seen because the fluid flows uniformly outward, but must form droplets at the edge to be flung off. Thus, depending on the surface tension, viscosity, rotation rate, etc., there may be a small bead of coating thickness difference around the rim of the final wafer.

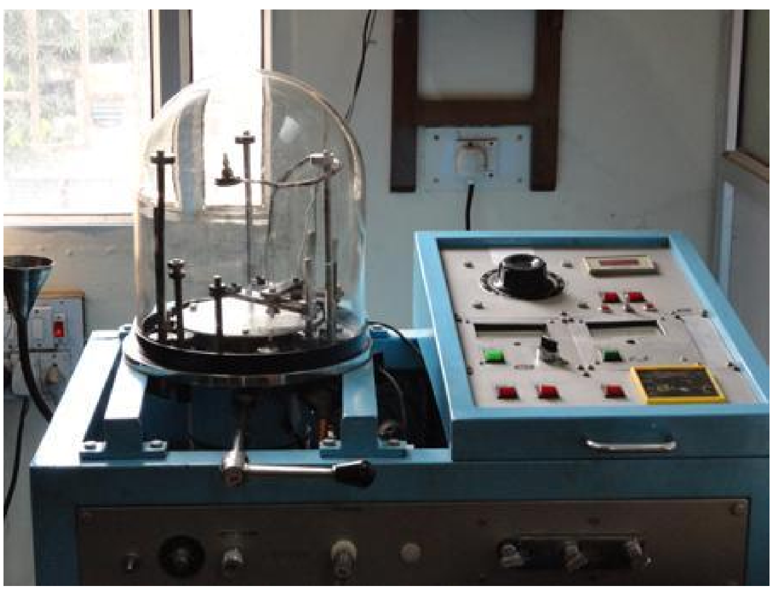
d) **Solvent evaporation:** When spin-off stage ends, the film drying stage begins. During this stage centrifugal outflow stops and further shrinkage is due to solvent loss. This results in the formation of thin film on the substrate. The fourth stage is when the substrate is spinning at a constant rate and solvent evaporation dominates the film thinning behavior.

Spin coating unit used for thin film deposition.

(B) Thermal Evaporation Technique

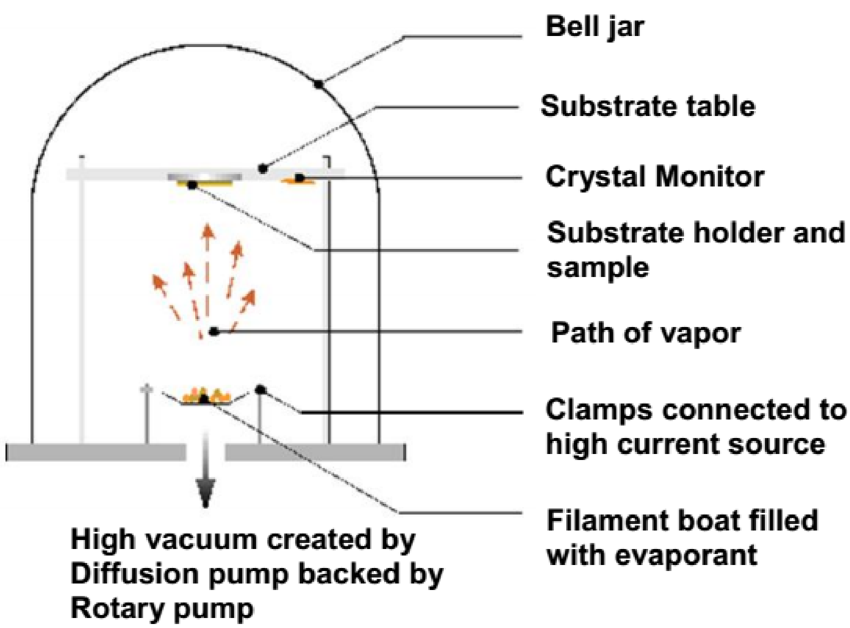
Thermal evaporation is one of the simplest of the Physical Vapor Deposition (PVD) techniques. This is a form of thin film deposition, which is a vacuum technology for applying coatings of pure materials to the surface of various objects in the thickness range of angstroms to microns and can be a single material, or can be multiple materials in a layered structure.

There are three steps in any physical vacuum deposition (PVD) process: creation of an evaporant from the source material, transport of the evaporant from the source to the substrate and condensation of the evaporant onto the substrate to form thin film. The pressure in the chamber must be below the point where the mean free path is longer than the distance between evaporation source and the substrate. The material to be evaporated is kept in a filament or boat, which is connected to two electrodes in the vacuum chamber. The chamber is connected to a diffusion pump backed by a rotary pump. This creates a vacuum of $<10^{-6}$ Torr in the chamber. On the application of the electrical power across the filaments/boats, an electric current pass through and filaments get heated. Because of heating of the filaments, the materials starts



Thermal evaporation unit for depositing thin films.

evaporating. The rate of evaporation and thickness of the film must be controlled and optimized for specific needs. Upon arrival at the substrate, evaporated material condenses on the substrate in a complex sequence of events that determine many of the physical properties of the deposited film.. Figure. shows schematically the thin film fabrication via thermal evaporation of the materials in vacuum.



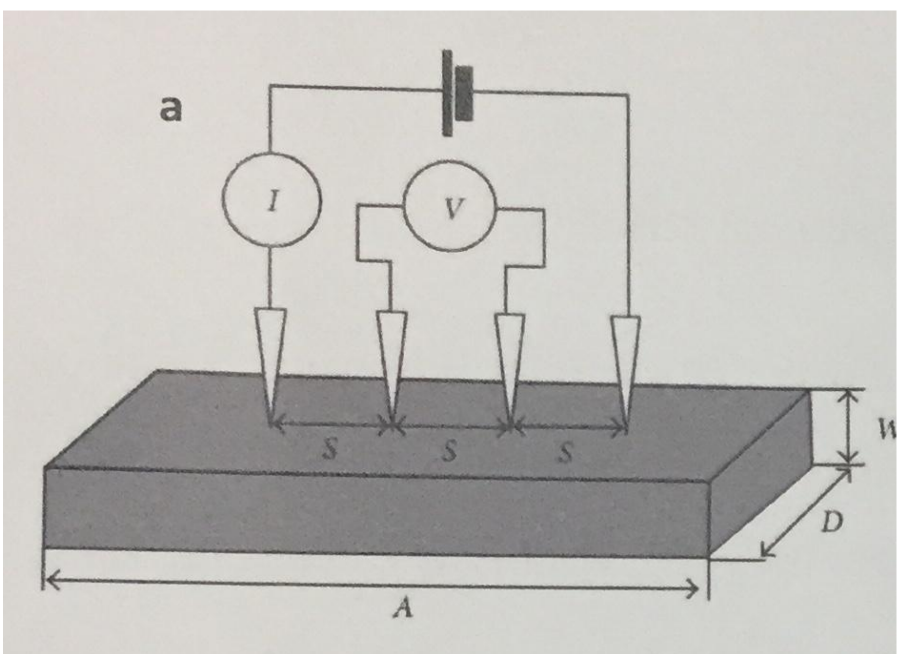
Schematic representation of thin film fabrication via thermal evaporation of the material in vacuum chamber.

(C)Film Thickness Measurements

Film thickness and rate of deposition are important parameters which affect the power conversion efficiency of a solar cell. Thickness as well as deposition rate of the films could be controlled by Digital Thickness Monitor during evaporation. A quartz crystal oscillator monitor senses the amount of material accumulated on it. The monitor uses a quartz crystal as the basic transducing element. The quartz crystal is incorporated into an oscillator circuit, which produces oscillations by piezoelectric effect. The crystal has a resonant frequency of 6 MHz and static thickness resolution of 1Å

Device for insitu film thickness measurement.

(D) Four Probe Conductivity Measurements: The electrical conductivity studies of semiconductor devices by this technique. It permits measurements of resistivity in samples having a wide variety of shapes, including the resistivity of small volumes within bigger pieces of semiconductor devices.



E) Fabrication Equipments; Aids and Facilities available

(1)Muffle furnace with Digital Profiler

(2)Digital Balance

(3)Conducting Centrifuge System

(4)Heating Mantles

(5)Chiller and Refrigirator

(6)Nitrogen gas cylinder with regulator

(7)Source Meter

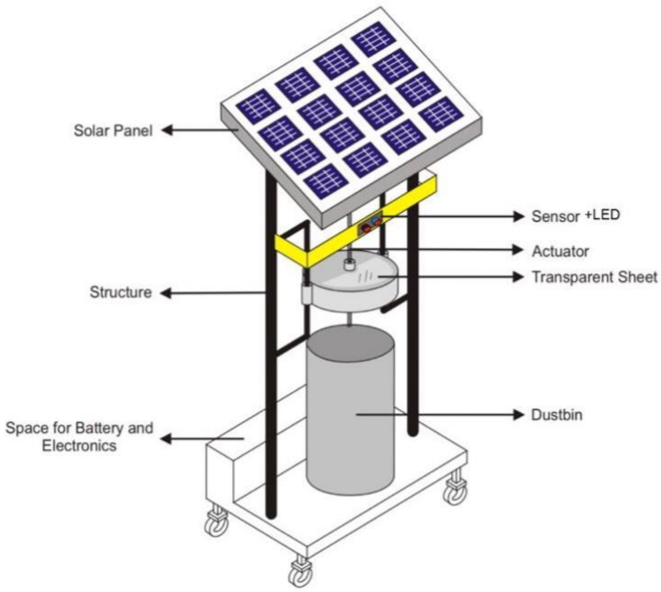
(8)Water Analysis System

(9)Thermo-Couple Data logger

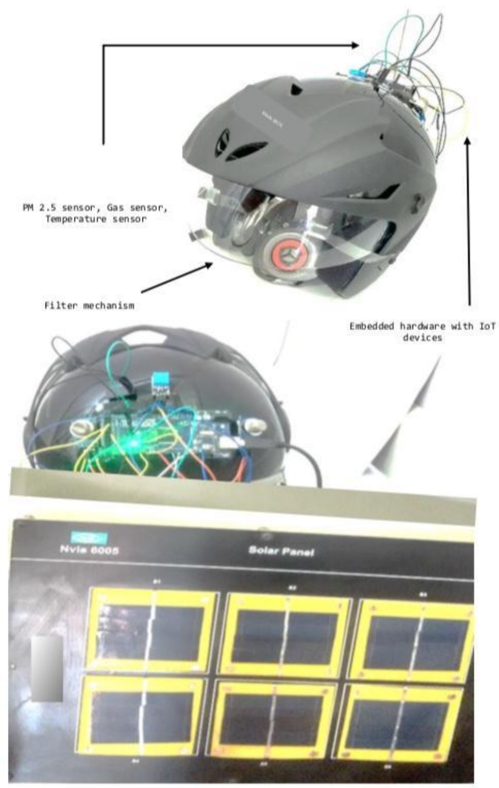
PROJECTS:

COMPLETED ;

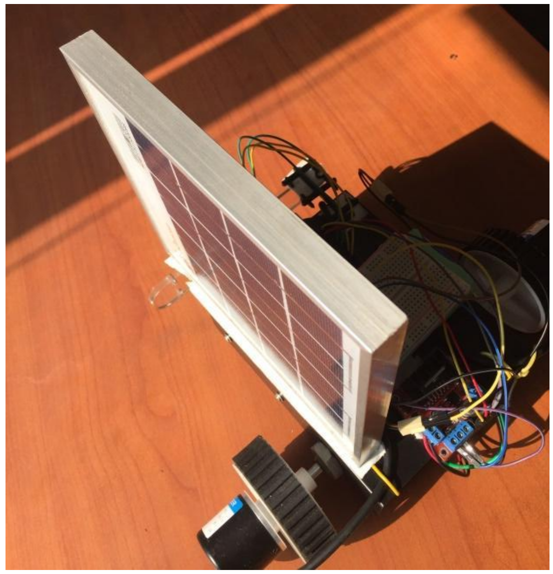
(A)SOLAR HYGIEN TRASH CAN



(B)PROTOTYPING SOLAR POWERED HELMET

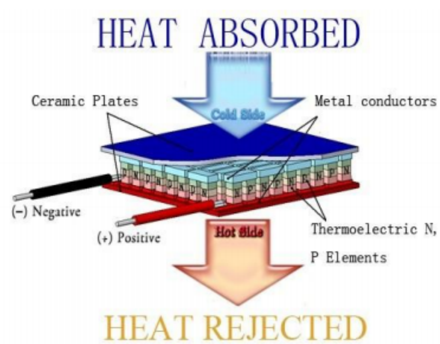


(C)SOLAR POWERED WATER LEVEL DETECTOR

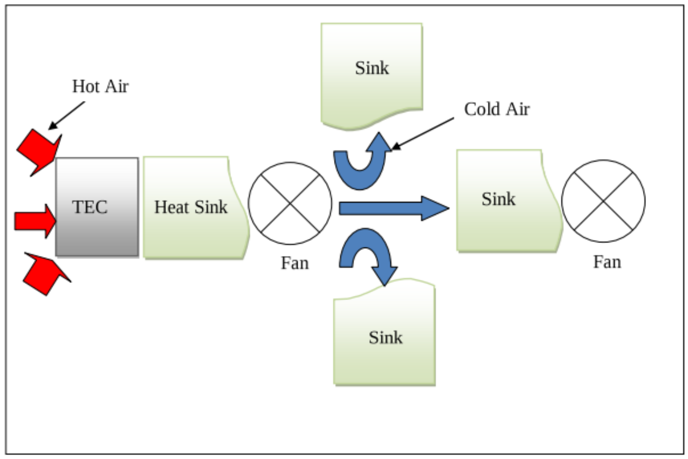


(D)SOLAR POWERED LAMP AND FAN STAND FOR HAWKERS

(E)SOLAR POWERED WATER COOLER USING PELTIER



(F)SOLAR POWERED AIR CONDITIONER



ON GOING PROJECTS

(A)SOLAR POWERED AUTOMATED IRRIGATION AND NUTRIENT DETECTOR AND DISPENSOR KIT

(B)ADVANCED SOLAR POWERED PELTIER COOLING AND MODELLING

(C)EFFECT OF ABSORBER PLATE ON PVT MODULE

(D)FABRICATION OF PVT SYSTEM FOR DATA COLLECTION

(E)FABRICATION OF SOLAR SIMULATOR

(F)STUDY OF DUST MITIGATION PROBLEM ON PV PANELS

(G)STUDY OF EFFECTIVE FILTERS FOR MASKS

(H)FABRICATION AND CHARACTERIZATION OF THIN FILMS FOR SOLAR CELLS

PUBLICATIONS:

Journal Papers:

1. Singh, H. P., Arora, S., Sahota, L., Arora, M. K., Jain, A., Singh, A. 2022. Evaluation of the performance parameters of a PVT system: Case study of composite environmental conditions for different Indian cities. Materials Today: Proceedings, 57: 1975-1984, Elsevier. (Scopus)

2. Singh, H.P., Arora, S., Jain, A., Arora, N., Singh, A., Pal, R. 2022. Systematic study of Indian railways subnetwork: Zone specific analysis. Palestine Journal of Mathematics, 11:151-161. [Scopus]

3. Arora, S., Singh, H. P., Sahota, L., Arora, M. K., Arya, R., Singh, S., Jain, A., Singh, A. 2020. Performance and cost analysis of photovoltaic thermal (PVT) compound parabolic concentrator (CPC) collector integrated solar still using CNT-water based nanofluids. Desalination, 495: 114595, Elsevier. [IF- 11.211]

4. Singh, H. P., Jain, A., Singh, A., Arora, S. 2019. Influence of absorber plate shape factor and mass flow rate on the performance of the PVT system. Applied Thermal Engineering, 156: 692-701, Elsevier. [IF- 6.465]

5. Arora, S., Aggarwal, Y. 2018. Prototyping Solar Powered Helmet, DU Journal of Undergraduate Research and Innovation, 3: 117-124, University of Delhi.

6. Arora, S., Dhingra, K., Babbar, A., Mishra U. 2018. Solar Trash Can: Hygienic and Inexpensive Solution to Open Bigger Trash Cans. DU Journal of Undergraduate Research and Innovation, 3: 110-117, University of Delhi.

Conference Presentation:

1. Arora, S., Singh, H. P., Jain, A., Singh, A. 2019. Impact of heat transfer coefficient on hybrid PVT system. International Conference on Emerging Advancement in Science & Technology (ICEAST), 10th India-Japan Science & Conclave, September 5-6, DRDO, New Delhi, India.

PATENT AWARDED

(1)SOLAR WATER DISTILLER

ON 4TH DECEMBER 2021

PATENT NUMBER: 383711

COMPLETED IOE PROJECT 2020-2021

COMPLETED IOE PROJECT 2021-2022

EXTERNAL INTERNS: 2

FUTURE WORK:

(1) Set up of standard current –voltage,C-V measurement using Solar –Simulator and Source Mete rand Impedence Analizer with Interface facility.

(2) Set up of fundamental educational experiments for students.

(3) Fabrication of Innovative Utility devices.

(4) Collaborations and interaction with other organizers and Universities.

(5) Fabrication of PVT systems and usage to the masses in India