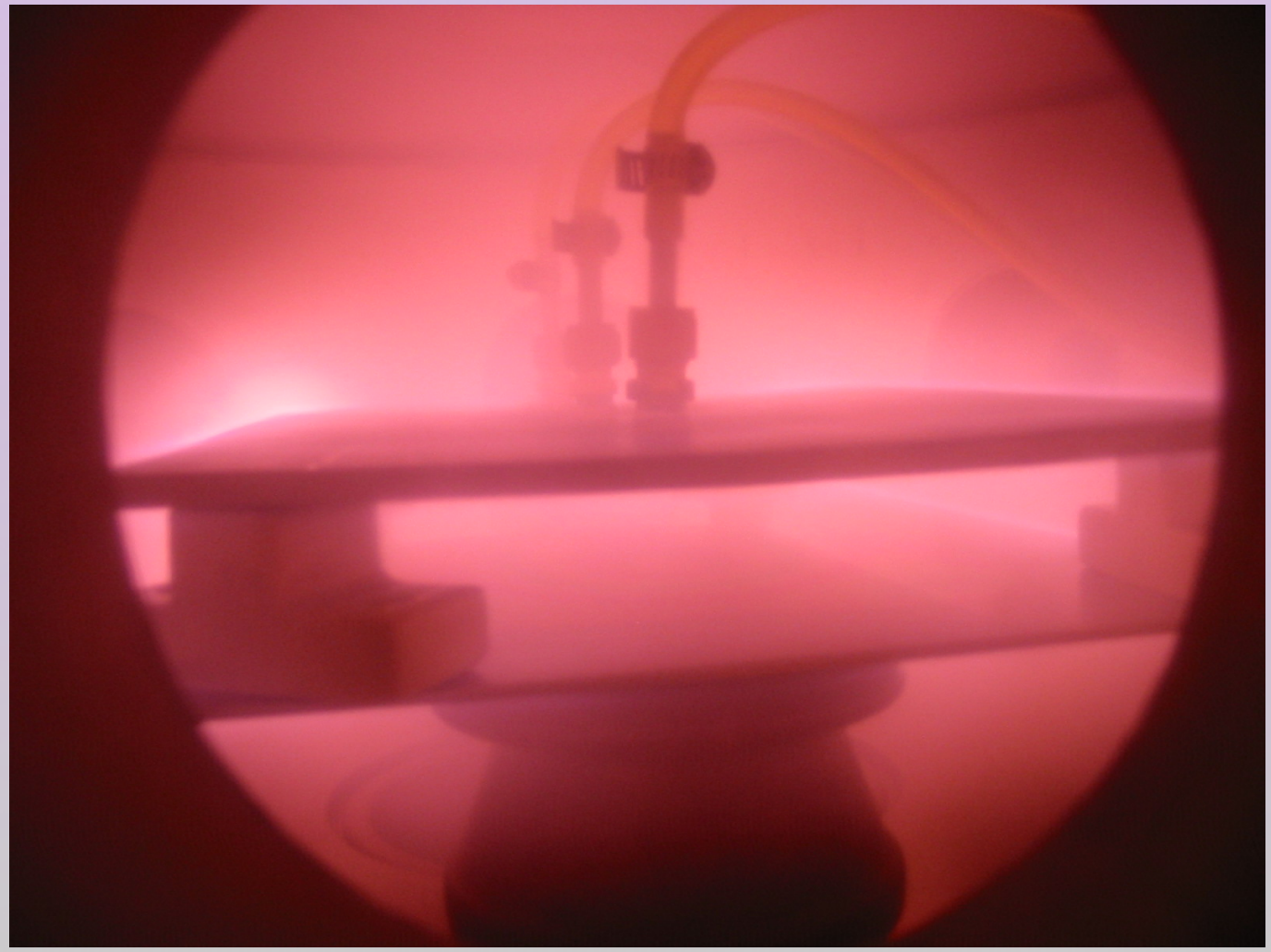
PLASMA PROCESSING UPDATE

A Quarterly Newsletter from Institute for Plasma Research

ISSUE No. 101 *JANUARY 2025*

Editorial Team: Satyaprasad Akkireddy Alphonsa Joseph

HAPPY NEW YEAR 2025



INDEX

RESEARCH ARTICLE

Underwater Plasma Discharge for Sustainable Wool Cleaning and Bleaching

Ms. Nisha Chandwani
Scientific Assistant
nisha@ipr.res.in

Team members

Mr. Atik Kumar Mistry

Mr. Ramesh Bhatia

Mr. Ambati Siva Reddy

Dr. Vishal Jain

Wool has been cherished for centuries as a versatile and durable natural protein fiber. Sourced from animals such as sheep, goats, rabbits, camels, and yaks, this fiber is the backbone of countless textile products. However, the journey from raw wool to finished fabric involves tackling a significant challenge: cleaning the fiber to remove natural contaminants like wax, grease, suint, dust, vegetable matter, and dags. Traditionally, wool cleaning has relied on chemical-heavy methods, including washing, scouring, bleaching, and carbonization. While effective, these processes generate large volumes of wastewater laden with toxic effluents, posing a severe threat to the environment. Addressing this issue has become a pressing need for the textile industry, which seeks eco-friendly alternatives that maintain fiber quality while remaining economically viable.

The current work introduces a novel concept of underwater in-situ plasma treatment (UIPT), which can be used for cleaning/scouring coarse wool fibers and removing impurities such as wax, grease, suint, and dust from their surface. A schematic of the experimental setup of UIPT is shown in Figure 1. A DBD (dielectric barrier discharge) based air plasma jet was used for generating underwater plasma discharge for the experiments.

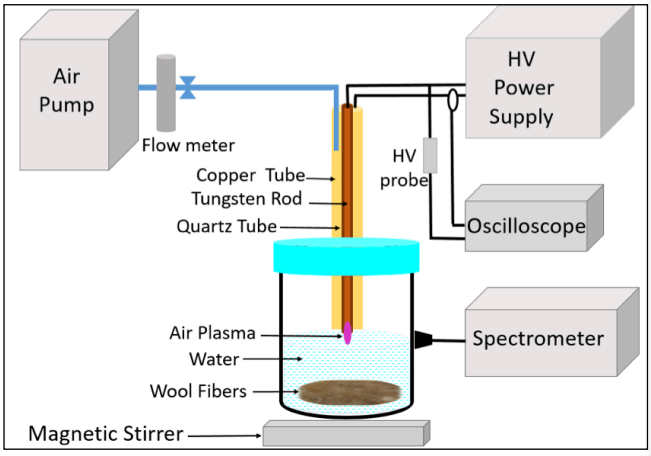


Figure 1: A schematic diagram of the experimental set-up

A visual comparison between untreated greasy/ raw wool fibers and those exposed to UIPT is

shown in Figure 2. The efficacy of UIPT in cleaning/scouring and bleaching the greasy fibres is readily apparent. The scanning electron microscope (SEM) images of the fiber as shown in Figure 3, demonstrate that the raw greasy fiber surface has lots of contaminants while UIPT cleaned fiber surface is clean along with clear visibility of cuticle scales. Further, the residual grease analysis of the fiber demonstrated a substantial reduction in grease content of raw wool from 20% to 2% after plasma treatment. In addition to this, an improvement in the whiteness index of wool fibers from 48% to 70% was also observed, which is comparable to the conventional wet-chemical processes.

Underwater plasma discharges create a highly reactive fluid environment filled with ions, electrons, UV radiation, hydrogen peroxide, ozone, and high-frequency shock waves. This potent combination offers a powerful and efficient cleaning mechanism. UIPT holds the promise of revolutionizing wool cleaning processing by providing an effective, environmentally friendly alternative to conventional techniques.

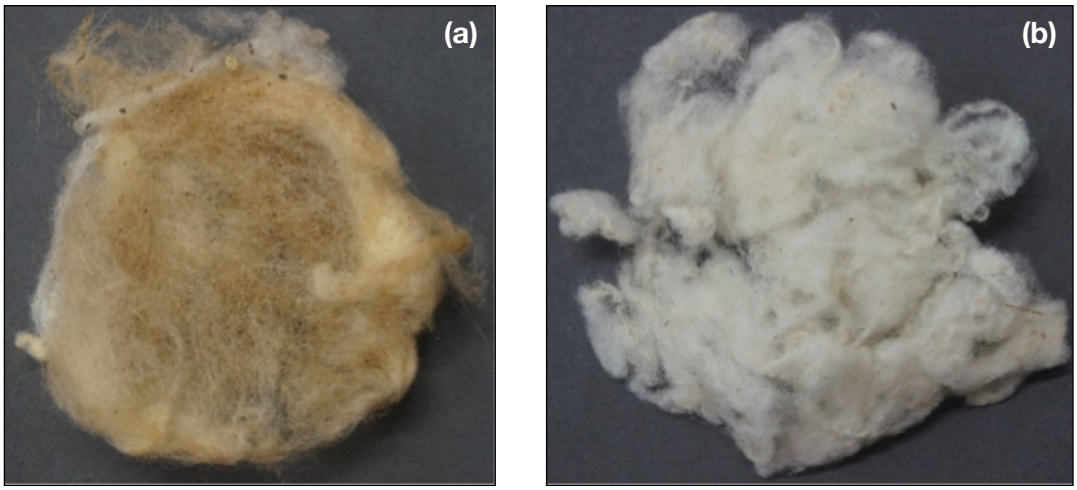


Figure 2: An image of wool fibers (a) Greasy; (b) UIPT

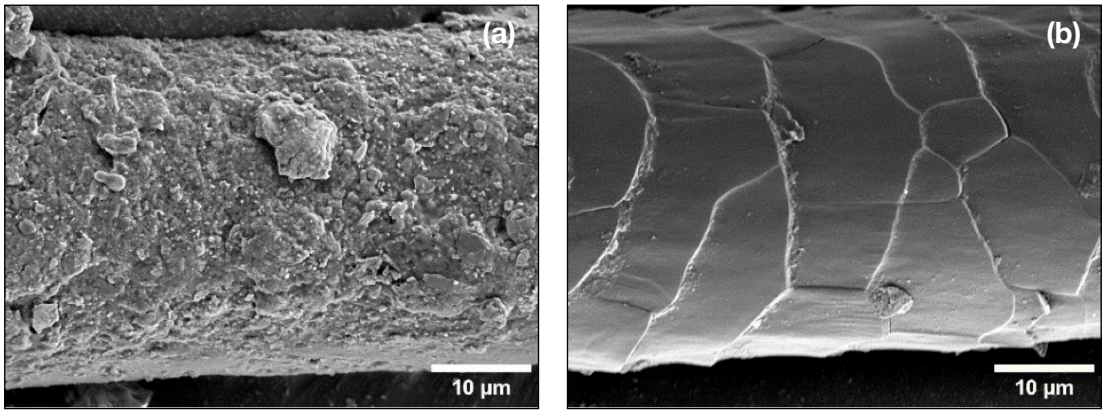


Figure 3: SEM image of wool fibers (a) Greasy; (b) UIPT

Suggested Reading

Chandwani, Nisha, Himanshu Pandey, and Vishal Jain. "Underwater in-situ plasma treatment of coarse wool fibers for scouring and bleaching." *The Journal of The Textile Institute* (2024): 1-8. https://doi.org/10.1080/00405000.2024.2411099

SYSTEM INSTALLATION

Installation of Plasma Nitriding System to be operated in GOCO mode

Many engineering components owing to their critical nature of application, demands very hard surface along with tough core. Hard surfaces tend to break while tough ones don't. Plasma Nitriding is a surface-hardening thermochemical process that introduces nitrogen ions into the surface of steel at a temperature range of 500 - 550°C, while retaining the bulk properties as that of the alloy. The purpose of plasma nitriding is to increase the surface hardness of the steel and improve its wear and corrosion resistance properties thereby increasing the service life of the components. During plasma nitriding, nitrogen diffuses into the steel and forms iron and chromium nitrides, which in turn increases the surface hardness of the material by a factor of three, depending on the substrate material. Conventional nitriding of components carried out in an atmosphere of partially dissociated ammonia (gas nitriding) or cyanide-cyanate salt bath (liquid nitriding) at temperature of 550-600 °C has many disadvantages. Plasma nitriding scores over conventional nitriding methods through lower processing temperature, almost zero contaminations, faster treatment cycles, negligible distortion, reduced treatment duration and eco-friendly process. The process duration can vary from 3 to 24 hours for obtaining a case thickness of ~25 to 500 microns. The treatment time and gas composition is tuned to get the desired surface hardness and thickness of the nitrided layer. Plasma nitriding has been used extensively in automobile, plastic moulding, forging, manufacturing, and textile industries to improve the service life of their components and products.

Recently a plasma nitriding system of 0.8 m diameter and 3 m height has been installed at IPR and is shown in Figure 1. This system will be intended to work in GOCO made for the first

Figure 1: Plasma Nitriding system, recently installed at FCIPT, IPR

time in INDIA. In this model, the Plasma nitriding system and the capital infrastructure owned by IPR will remain a property of IPR. The said capital equipment shall be run, operated and maintained by a company which will utilize the technology & system to its best capacity – thereby facilitating commercialization of home grown technology. The scope of the company will be to market the process so that more jobs are obtained and the plasma nitriding system works with maximum capacity, to arrange for human resources for its operation and maintenance and to ensure safety protocols during their presence in FCIPT, IPR. The company will have to make payments to IPR as per the GOCO agreement.

SYSTEM STATUS UPDATE

Testing of Secondary Chamber and Delivery of Major Sub-systems of Plasma Pyrolysis Plant, RAUDRA, at FCIPT, IPR

Under an activity to establish a Common Biomedical Waste Treatment Facility at Varanasi, installation, commissioning and testing of 200 kg/hr. plasma pyrolysis plant, RAUDRA, at FCIPT, is one of the key milestones of the project. In November 2024 the secondary chamber, a sub-system of RAUDRA got delivered at FCIPT. Installation of the secondary chamber was completed successfully and it was tested by operating continuously for six hours on two continuous days as per set criteria. The required temperature of 1100C was achieved in secondary chamber during the test runs. The emissions from secondary chamber were tested and found well under the norms. The other major sub-systems of RAUDRA, namely primary chamber with feeder assembly, and gas cleaning system for flue gas were delivered at FCIPT in December 2024. At present, assembly of leg support with cylindrical chamber of the primary chamber assembly has been done and it's integration with secondary chamber intermediate duct is in progress. Once, integration with secondary chamber is completed, assembly of other components of waste feeder and primary chamber assembly including surrounding support structures and service platforms will be initiated. Assembling of gas cleaning system with the secondary chamber will be initiated after the integration of primary and secondary chamber. Testing of completely assembled RAUDRA at FCIPT is expected to be completed by February 2025.

Secondary Chamber of 200 kg/h RAUDRA, installed at FCIPT, IPR

Primary Chamber during installation at FCIPT, IPR

INCUBATION AGREEMENTS & TECHNOLOGY-TRANSFER NEWS

AIC - IPR Plasmatech Innovation Foundation

To accelerate the commercialization of plasma technologies, the Institute for Plasma Research (IPR) has established a Section-8 company, AIC-IPR Plasmatech Innovation Foundation (AIC-Plasmatech). The first Annual General Meeting (AGM) of the Board was held on 25th September 2024. Following the AGM, incubation agreements were signed with two start-ups: Exxcarbon Private Limited and Ecoplaswa Technology Private Limited. Exxcarbon focuses on waste-to-energy applications and is incubated for the commercialization of IPR's RAUDRA Plasma Pyrolysis technology. On November 7th, 2024 an agreement for transfer of knowhow and license for IPR's RAUDRA Plasma Pyrolysis Technology for disposal of organic waste was executed between Exxcarbon and AIC-Plasmatech. Ecoplaswa aims to develop products based on IPR's patented Plasma Activated Water technology for disinfecting and cleaning of containers used in the dairy industry, as well as for agricultural applications such as bio-nutrition and bio-fertilizers for crops. In addition to these, AIC-Plasmatech had earlier signed an incubation agreement with LBIS Research Private Limited for developing glass-like coatings on biodegradable fibres using plasma processing. By doing so, the aim is to have sustainable food packaging solution which will solve the problem of contamination of food due to leaching out of the coating material from packaging containers.

Team from IPR, AIC-Plasmatech Board members with (from top) 1) Dr. Puneet Seth, Founder of Exxcarbon Private Limited; 2) with Ms Sawmya R S, Founder of Ecoplaswa Technology Private Limited; 3) with Mr Rajesh Nair, Founder of LBIS Research Private Limited

On 7th November, 2024, AIC-IPR Plasmateh have executed incubation agreement with PlasmaZen Private Limited for development of cold plasma based device for deodorization & sterilization of textiles and garments.

Incubation agreement executed between AIC-IPR Plasmatech and M/s PlasmaZen Private Limited

On 17th December,2024 IPR's incubation centre, AIC-IPR Plasmatech Invocation Foundation (AIC-Plasmatech), has signed four agreements with 4 nos of industries and start-ups and one MoU with AIC-CCMB (Atal Incubation Centre of CSIR-Centre for Cellular & Molecular Biology) in the presence of Shri K N Vyas, former Chairperson of Atomic Energy Commission and Secretary, Department of Atomic Energy.

To accelerate the commercialization of deep-tech plasma technologies, AIC-Plasmatech has signed two agreements with start-ups: Zenex Lifecare LLP, Hyderabad, and Pharma Envirocare Private Limited on 17th December, 2024. The collaboration with Zenex Lifecare LLP focuses on developing a plasma-based sterilization system for medical applications, while the partnership with Pharma Envirocare Private Limited aims to establish a pilot plant utilizing IPR's proprietary RAUDRA Plasma Pyrolysis technology for the safe disposal of pharmaceutical waste.

In a notable collaboration, AIC-Plasmatech and Veeral Controls Private Limited, Gandhinagar, have entered into an agreement for transfer of knowhow and license for Feedback controlled modular High Voltage DC Power Supply (FCM-HVPS) technology. This indigenously developed technology, created by IPR in partnership with Veeral Controls, is designed for high-voltage applications such as ion sources, RF (radio frequency) systems, HVDC power supply, DC power generation, particle accelerators etc. and this collaboration will enable Veeral Controls to cater the requirements of

Additionally, another patented technology of Wideband Hybrid High Power MW Level CW Radio Frequency (RF) Combiner/Splitter, has been transferred to Raut Unitech Private Limited. With this knowledge transfer, the Indian industry can now serve global needs for specialized RF technology in mega-science projects and other advanced applications.

A total of six start-ups are now incubated at IPR's incubation centre, and three technology transfer agreements have been executed by AIC-Plasmatech, all focused on commercializing plasma-based technologies for various applications. These collaborations mark a significant milestone in advancing the commercialization of plasma technologies, supporting India's self-reliance in high-power systems for applications in fusion, space,

defense, Bio-medical, environment and various industrial sectors.

Technology-Transfer agreement with M/s Raut Unitech Pvt. Ltd.

Technology-Transfer agreement with M/s Veeral Controls Pvt. Ltd.

Incubation agreement executed between AIC-IPR Plasmatech and M/s Zenex Lifecare LLP

Incubation agreement executed between AIC-IPR Plasmatech and M/s Pharma Envirocare Private Limited

Collaborations with AIC-CCMB and National Council for Cement and Building Materials:

A Memorandum of Understanding was signed between AIC-Plasmatech and National Council for Cement and Building Materials on 27th November for application of plasma technologies for gasification, application of eco-friendly production of cement, ceramics and construction technology.

AIC-Plasmatech is dedicated to nurturing tech start-ups in plasma science and technology, leveraging the expertise of the Institute for Plasma Research (IPR). Expanding its scope in biotech, medtech, and life sciences, AIC-Plasmatech has partnered with AIC-CCMB (Atal Incubation Centre of CSIR-Centre for Cellular & Molecular Biology) through an MoU. This collaboration aims to provide comprehensive support to start-ups in these sectors. By combining the strengths of CCMB and IPR, the initiative will empower Indian start-ups to excel in medtech, biotech, and life sciences.

Signing of MoU between AIC-Plasmatech & AIC-CCMB

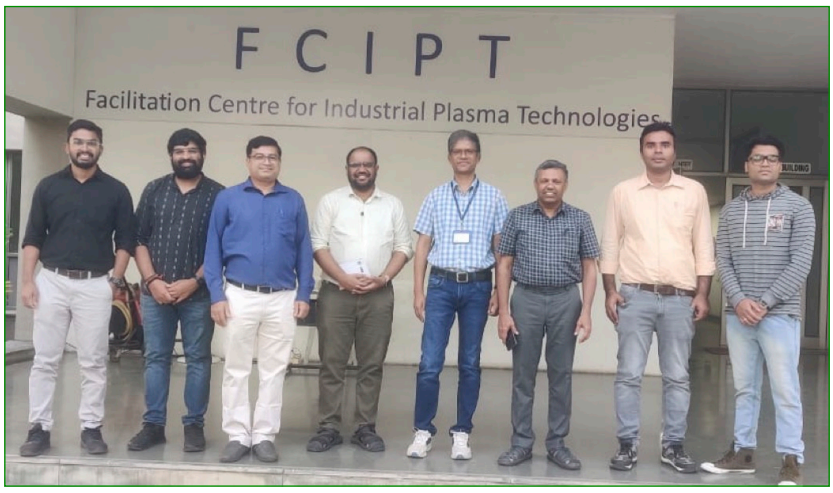
VISITS TO FCIPT

Visitors from Karnavati School of Dentistry, Adalaj, Gujarat

Faculty and under-training doctors from Karnavati School of Dentistry, Adalaj visited the FCIPT, IPR on 03/12/24. Plasma applications in medical sciences in relevance to dentistry were primarily focused during the visit.

Visitors from IITRAM, Ahmedabad, Gujarat

A few faculty and students from IITRAM have visited FCIPT, IPR on 04/12/24.



STUDENTS' NEWS

THESIS DEFENCE

Ms. Purvi Dave gave her Ph.D. thesis defence talk on 5th of December, titled “Surface Modification of Silicone Catheters to Mitigate Bacterial Adhesion and Biofilm Formation”. Congratulations Dr. Purvi.

STUDENTS' NEWS

VISIT TO ITER, FRANCE

Under IPR-ITER Ph.D. student exchange program three Ph.D. students from IPR (Tarundeep Kaur, Trivesh Kant, Sagar Chaudhary) were sent to ITER, France. Currently they are doing research work at ITER in their respective fields.

OTHER NEWS

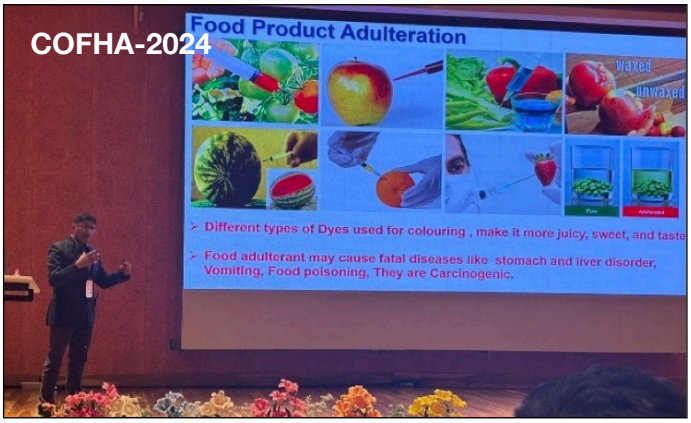
CONSTITUTION DAY

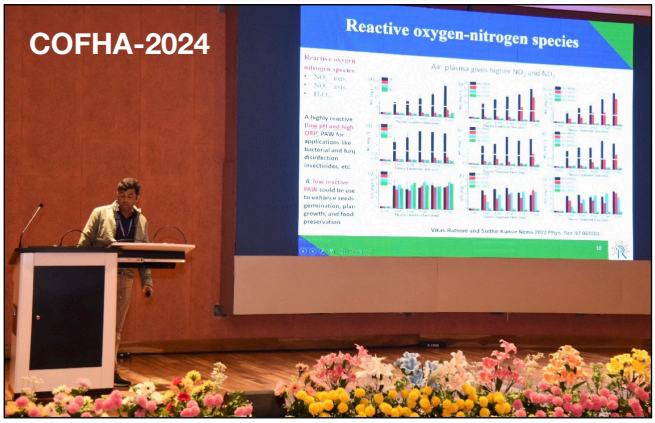
Preamble of Constitution of India was read out both in English and Hindi, as a part of CONSTITUTION DAY (SAMVIDHAN DIWAS), on 25th November (26th being weekend) at FCIPT, IPR.

TALKS DELIVERED / POSTER PRESENTATIONS

TALKS DELIVERED

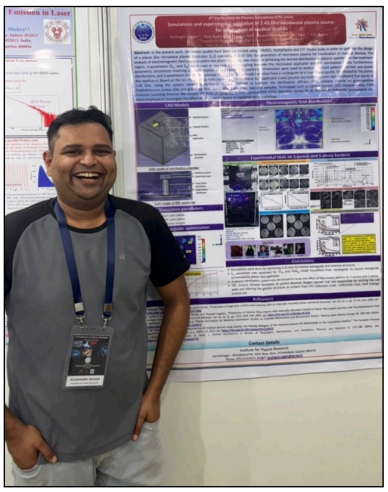
1. **Dr. Mukesh Ranjan** gave an invited talk on ***Sequential growth over patterns a way to minimise optical anisotropy,*** at 3rd International Conference on Functional Materials and Applied Physics (**FMAP-2024**) during 18-19 October 2024; organised by SVNIT, Surat.
2. **Dr. Mukesh Ranjan** gave an invited talk on ***Ion beam-induced nanoripples patterns for SERS based saliva analysis to detect oral cavity cancer*** in a focused Indo-French meeting on "Perspective and challenges of clinical Vibrational spectroscopy in point of care use"; arranged by **ACTREC**, Mumbai; during 28-30 October 2024.
3. **Dr. Mukesh Ranjan** gave an invited talk on ***Sequential growth of metal nanoparticles on low energy ion produced ripple patterns for the isotropic plasmonic response and wettability studies,*** in The National Conference on Frontiers of Ion Beam Science (**FIBS-2024**), during 4-7 November 2024 at IoP, Bhubaneswar.
4. **Dr. Alphonsa Joseph** gave an Invited talk on ***Plasma-based Technologies and Applications*** in AMD-INS international symposium on Challenges and Advancements in Material Characterization (**CAMC-2024**), on 20th November, at AMD, Hyderabad held during 20-22 November 2024.
5. **Dr. Mukesh Ranjan** gave an invited talk on ***Growth dynamics of metal nanoparticles arrays and their optical properties*** at International Union of Materials Research Societies-International Conference in Asia (**IUMRS-ICA-2024)**, held during 3-6 December 2024, in Indore, Madhya Pradesh, India.
6. **Dr. Mukesh Ranjan** gave an invited talk in a **pre-conference workshop** of **PLASMA-2024,** organised by PDEU, Gandhinagar during 16-20 December 2024.
7. **Ms. Purvi Dave** gave an oral presentation on ***Influence of plasma process parameters on bacterial adhesion properties of silicon catheter surfaces*** at **PLASMA-2024,** organised by PDEU, Gandhinagar during 16-20 December 2024.
8. **Dr. Mukesh Ranjan** gave an invited talk at the 1st International Workshop on Cold Plasma and Pulse Power Technologies for Food, Health, and Agriculture (**COFHA-2024**) during 21-22 December 2024; at IIT, Jodhpur.
9. **Dr. Ramkrishna Rane** gave an invited talk on ***Non-thermal plasma for generation of PAW for applications in food, health and agriculture*** at the 1st International Workshop on Cold Plasma and Pulse Power Technologies for Food, Health, and Agriculture (**COFHA-2024**) during 21-22 December 2024; at IIT, Jodhpur.



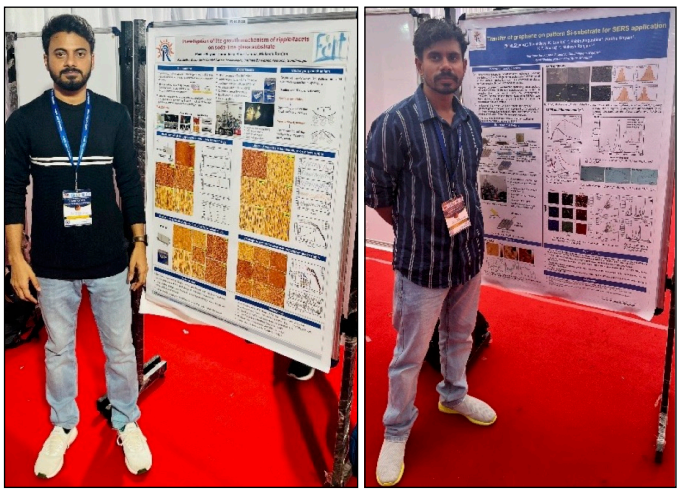


POSTER PRESENTATIONS

1. **Mr. Kushagra Nigam** presented their work on ***Simulation based study and experimental validation of 2.45 GHz microwave plasma source for sterilization of biomedical devices*** at 4th Conference on Plasma Simulations (**CPS-2024**), held during 11-13 November 2024 at IIG, Mumbai.
2. **Dr. Radhe Shyam and Dr. Rohit Sharma** had presented their work at International Union of Materials Research Societies-International Conference in Asia (**IUMRS-ICA-2024)**, held during 3 - 6 December 2024, in Indore, Madhyapradesh.
3. **Mr. Chirayu Patil, Ms. Nisha Chandwani, Mr. K.P.Sooraj, and Ms. Sheetal Singh** had presented their work at **PLASMA-2024** conference held during 16-20 December 2024; organised by PDEU, Gandhinagar, Gujarat.
4. **Ms. Ambesh Kumari** presented a poster on ***A Novel Rogowski coil to detect the pulsed currents associated with high frequency electromagnetic waves in a plasma*** at **PLASMA-2024** conference held during 16-20 December 2024; organised by PDEU, Gandhinagar, Gujarat.
5. **Dr. Ramakrsihna Rane, Mr. Akshay Vaid and Mr. Kushagra Nigam** presented their work at the 1st International Workshop on Cold Plasma and Pulse Power Technologies for Food, Health, and Agriculture (**COFHA-2024**), held during 21-22 December 2024; at IIT, Jodhpur.

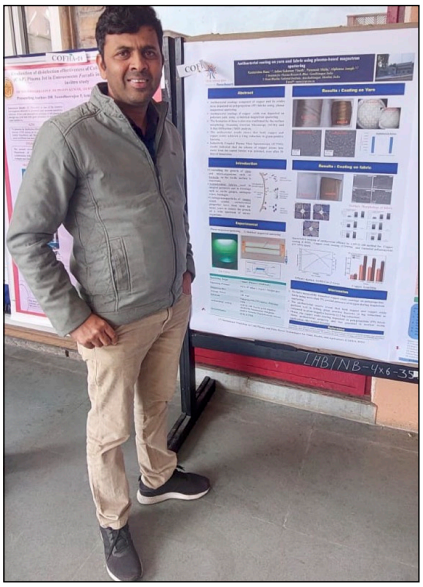
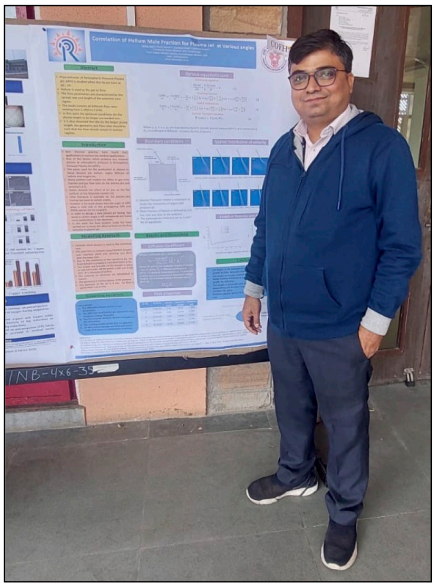


Mr. Kushagra Nigam @ CPS-2024

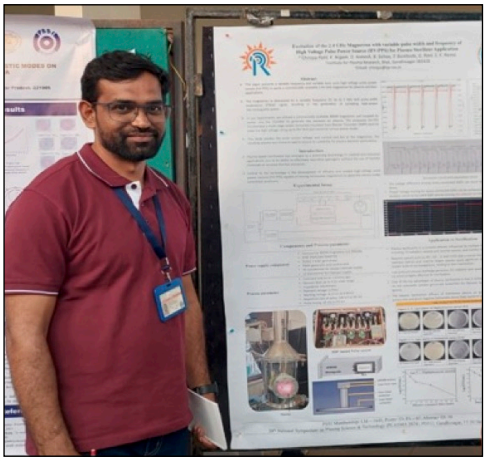
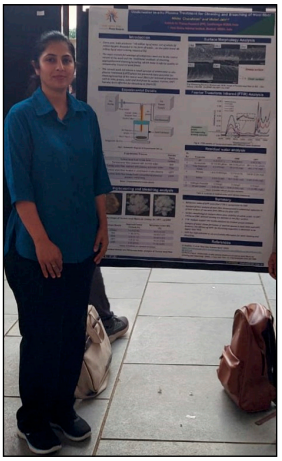
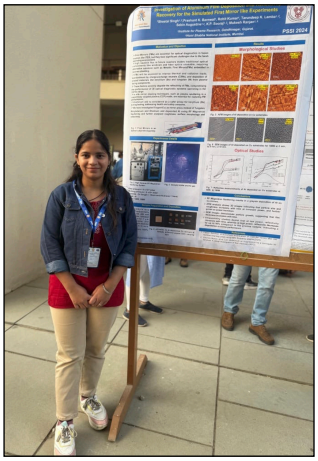
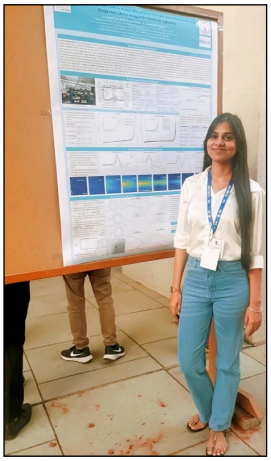


Dr. Radheshyam and Dr. Rohit @ IUMRS-ICA-2024

TALKS DELIVERED / POSTER PRESENTATIONS

Dr. Ramkrishna Rane, Mr. Akshay Vaid @ COFHA-2024

Mr. Chirayu Patil, Ms. Nisha Chandwani, Ms. Sheetal Singh, and Ms. Ambesh Kumari @ PSSI-2024

UPCOMING EVENTS / ONE DAY SEMINAR

ONE DAY SEMINAR ON

SURFACE MODIFICATION USING PLASMA TECHNOLOGIES (SMPT-2025)

February 04, 2025

FCIPT-IPR, Gandhinagar

MED TECH | SPACE TECH | TEXTILE TECH | AGRI TECH | HEAVY ENGG

Organized by

INSTITUTE FOR PLASMA RESEARCH (IPR)

&

AIC-IPR PLASMATECH INNOVATION FOUNDATION

FOR REGISTRATION

Click Here

In association with

Venue

Facilitation Centre for Industrial Plasma Technologies (FCIPT)
A-10/B, GIDC, Electronic Estate, Sector-25,
Gandhinagar-382016,
Gujarat, India

Advisory Committee

Dr. Shashank Chaturvedi
Dr. Paritosh Chaudhuri
Dr. Subroto Mukherjee
Dr. Sudhir Nema
Dr. Alphonsa Joseph
Dr. Suryakant Gupta
Ms. Falguni Shah
Ms. Supriya Nair

Organizing Committee

Dr. Nirav Jamanpara (Chairman)
Dr. Ramkrishna Rane (Convenor)
Mr. Ghanshyam Jhala (Co-convenor)
Dr. Mukesh Ranjan
Dr. G. Ravi
Dr. Vishal Jain
Dr. Balasubramanian.C
Mr. Satyaprasad Akkireddy
Mr. Tejas Parekh
Mr. Akshay Vaid
Mr. Anand Visani
Mr. Sooraj K P
Mr. Sagar Agrawal
Ms. Keena Kalaria
Mr. Deepak Assudani

About the Seminar

The purpose of organizing SMPT-2025 is to acquaint the industrial sectors like automobile, textile, plastic, dies, and biomedical with the current developments and challenges of surface modification using plasma technologies developed by IPR. This event is also aimed to assist the start-up using plasma technologies. AIC-IPR is an Atal Incubation Centre established by IPR under the Atal Innovation Mission programme of NITI Aayog, Govt. of India which actively supports start-up and industries to develop advanced technological solutions.

Relevant Industries:
TEXTILE | AGRITECH | SPACE TECH | MEDTECH

Topics Covered

- **Plasma nitriding to combat wear and corrosion**
- **Plasma carburizing for the automobile sector**
- **Plasma-assisted PVD coating process**
- **Nano-textured surfaces for water repellency**
- **Plasma activation for increasing adhesion properties**
- **Plasma surface modification for the textile sector**
- **Plasma surface modification of polymers**
- **Plasma-enhanced CVD coating process**
- **Plasma surface modification for the agriculture sector**

Who should attend?

Representatives from industries, MSMEs, Startups Investors/VCs, Engineers, Researchers

Registration Fees

₹ 590/- per participant (Including GST)

SCAN & PAY

UPI ID: aiciprif@sbi

QR Code for UPI Payment

To Register & Pay
Click Here

Accommodation

Participants have to make their own arrangements for accommodation

Contact details

Dr. Ramkrishna Rane (Convenor)
Phone: 079-23269015, +919879475123

Mr. Ghanshyam Jhala (Co- convenor)
Phone: 079-23269050, +919723023198

Mr. Tejas Parekh (PTTS/AIC-IPR)
Phone: 079-23964038, +919925409564
E-mail: smpt@ipr.res.in

FACILITATION CENTRE FOR INDUSTRIAL PLASMA TECHNOLOGIES (FCIPT)

Institute for Plasma Research

A-10/B
Industrial Estate
GIDC, Sector 25
Gandhinagar
Gujarat. 382016

079-23269003/11/29
079-23964039/38

ptts@ipr.res.in
ppu@ipr.res.in

www.plasmaindia.com
www.ipr.res.in