Facilitation Centre for Industrial Plasma Technologies
Institute for Plasma Research

Plasma Processing Update

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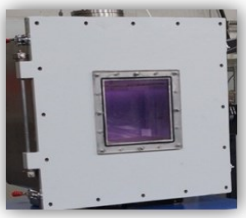

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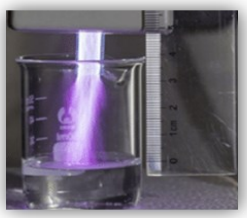

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Research Focus - Plasma assisted duplex surface engineering of SS 316L for Hip Implant application

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Highlights

- Improved wear resistance of SS femoral head
- Improved adhesion of Ti-TiN multilayer coating

Team members

IPR

- Ramkrishna Rane
- Ghanshyam Jhala
- Alphonsa Joseph
- Subroto Mukherjee

External Collaborators

- Biswanath Kundu
- Dipak Kr. Chanda
- Jiten Ghosh
- Sandip Bysakh
- Mitun Das
- Anoop Mukhopadhyay

The austenitic stainless steel SS316L (SS) is widely used in various biomedical applications e.g. orthopedic implants, bone scaffolds, stents etc. [1-3]. However, SS suffers from poor wear resistance and corrosion resistance under the body fluid environment. Further, release of toxic metal ions such as those of Nickel and Vanadium (Ni^+, V^+) etc. into the body can create allergies [1–3]. One of the ways to overcome these difficulties is to use protective coatings such as that of Titanium (Ti), Titanium Nitride (TiN) and Ti/TiN multilayers (MLCs). These coatings have excellent chemical stability, hardness, tribo-corrosion resistance and biocompatibility [1–3]. Ti/TiN MLCs have performed much better than TiN alone, as they accommodate stresses more effectively by sliding one layer over the other. Further, MLCs result in much thicker composites. Such composite coatings provide significant improvements in toughness, adhesion and impact resistance [1-5]. However, there is an issue of elastic modulus mismatch between the Ti/TiN MLCs and SS, which is responsible for pile up and poor adhesion of the coating. Hence, there is a need to develop an alternative technique to solve this problem.

In the present work, we use a novel concept of duplex surface engineering. On one hand the subsurface of stainless steel substrate is modified through plasma nitriding to enhance adhesion and, at the same time, the architecture and microstructure of the Ti/TiN MLCs is optimized to ensure much better tribological performance. A major achievement of the present research lies in the development of thick Ti/TiN MLCs of ~ 6.5µm thickness on plasma nitrided SS substrates. The results of bio-tribological and hip simulation studies clearly indicate that the cyclic fatigue resistance of duplex surface engineered SS femur head is much superior to that of the SS femur head.

The susceptibility of elastic strain to failure of a coating is generally evaluated by the hardness (H) to elastic modulus (E) ratio i.e. H/E quotient. Similarly, the resistance to fracture of a coating due to plastic deformation as well as elasto-plastic deformation is linked to fracture toughness. It is defined by the ratio H^3/E^2.

Therefore, higher the H/E ratio, better the wear resistance of a given coating. Similarly, for a given coating, higher the H^3/E^2 ratio, better the fracture resistance and in turn the fatigue resistance. The difference in H/E ratio between bare SS and Ti/TiN MLCs is very high (about 93%). Thus, the elastic modulus mismatch induced strain is very high, leading to poor adhesion in case of Ti/TiN MLCs on bare SS. Thus, the tribological resistance in this case is the least. The experimentally measured data also supports this picture. On the contrary, the difference between the H/E ratios is the lowest (about 9%) between the plasma nitrided SS sample and Ti/TiN MLCs. Therefore, the elastic modulus mismatch induced strain is the very small, leading to much better adhesion.

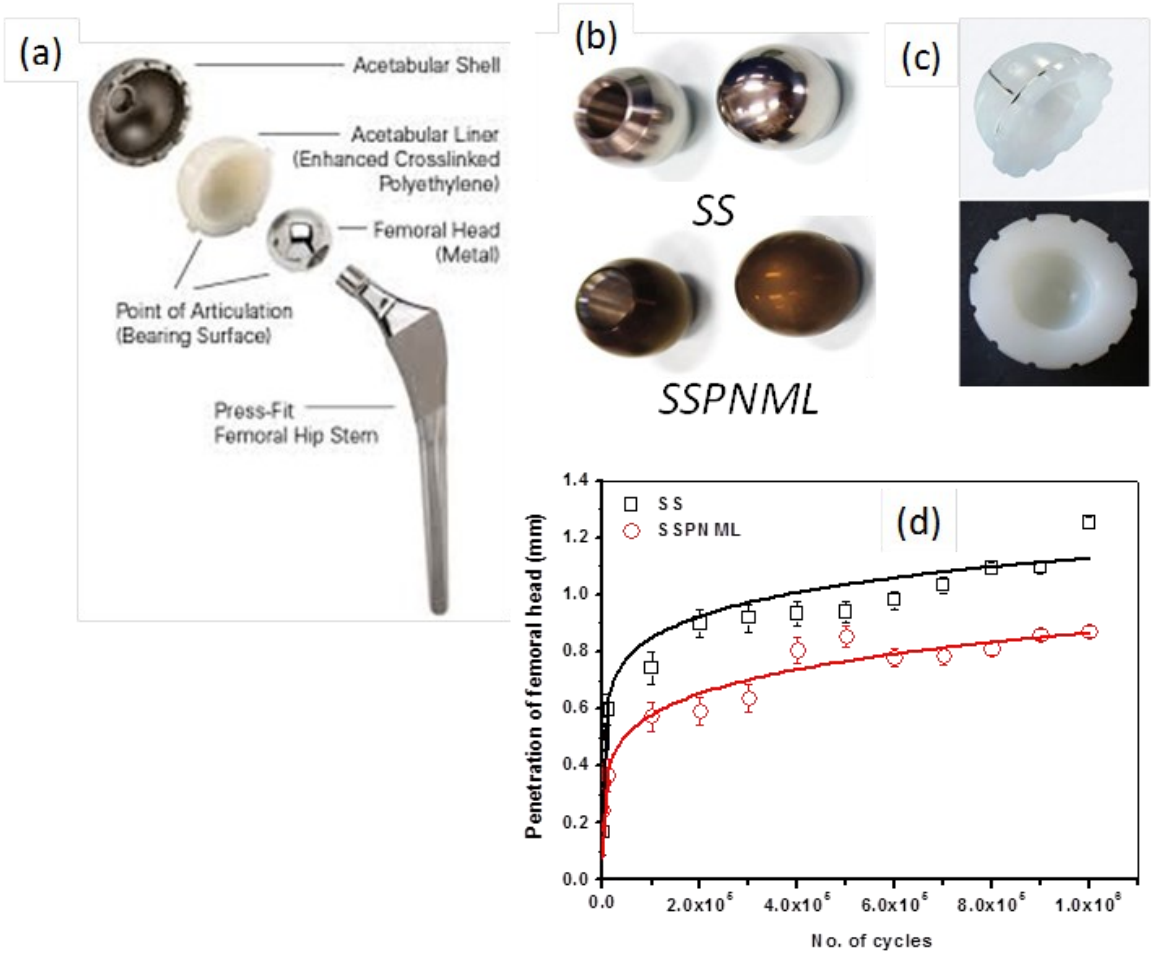

Figure 1: a) Components of total hip implant, (b) Photographs of SS, SSPNML femur head ball (c) UHMWPE acetabular cup used for the HIP simulation study (d) Penetration of the SS and SSPNML Femur heads into the acetabular cup after cyclic fatigue loading up to 1 million cycles in the HIP joint simulator.

Note: SS- Bare Stainless Steel 316L and SSPNML – Stainless Steel with plasma nitriding followed by Ti-TiN coating.

Hence, the experimental results indicate that the duplex surface engineering concept utilized in the present work can successfully enhance the strain bearing ability of the system as well as its tribological resistance. The best tribological resistance leads to the best cyclic fatigue resistance for the duplex surface engineered femur heads. In conclusion, the present research shows that SS femur head with plasma nitriding followed by Ti/TiN MLCs offers a promising technology for futuristic hip implant development.

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Technology Focus - CIPET System: One Atmosphere Uniform Glow Discharge Plasma (OAUGDP) in Air for HDPE Treatment

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Highlights

- OAUGDP Plasma in Air
- 1.5 meter wide film treatment
- Inline treatment

Team members

- Vishal Jain
- Kushagra Nigam
- Nisha Chandwani
- B K Patel
- Adam Sanghariyat
- S.K. Nema

The Atmospheric Plasma Division (APD), Institute for Plasma Research has developed a plasma system for treatment of high density polyethylene (HDPE) that generates One Atmosphere Uniform Glow Discharge Plasma (OAUGDP) in air over 1.5 meter air gap length. This system was developed by IPR under a joint project activity with CIPET (Central Institute of Plastic Engineering and Technology), Ahmedabad for inline processing of HDPE. This project activity was financially supported by Dept. of Science and Technology, New Delhi. The developed system can treat 1.5 meter wide film passing through 6 pairs of non-thermal air plasma discharges. Recently, the system was demonstrated to CIPET officials before dispatch. It will be commissioned at CIPET soon.

Demonstration of Plasma system to CIPET officials by IPR

System Focus - Ion-Acoustic Wave and Langmuir Probe System for UM-DAE CEBS

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Highlights

- User friendly system
- Reduced footprint
- Reconfigurable vacuum chamber

Team members

- G. Ravi
- Adam Sanghariyat
- B. K. Patel
- O. R. Kaila

Atmospheric Plasma Division, IPR has developed Ion-Acoustic and Langmuir Probe system for University o Mumbai - DAE Center for Excellence in Basic Sciences (CEBS). The system has been designed in order to enable M.Sc. Physics students to gain hands-on experience in experimental plasma physics and motivate them to pursue plasma science and technology as a career.

Figure 1: Ion-Acoustic Wave and Langmuir Probe System installed at UM-DAE CEBS

The setup consists of a vacuum chamber, pumping system, power supplies, diagnostic probes, electron emitter filaments and exciter grid. Pressures of the order of 10^{-6} mbar are attained in the chamber using the pumping system. The vacuum chamber is fully reconfigurable and can support both low pressure experiments like Ion-Acoustic Waves and high pressure experiments like Langmuir probe I-V characteristics in DC discharge plasma. The Langmuir probe along with ramp generator power supply equips one to characterize the plasma both at low and high pressures. An optical probe allows one to insert fiber optic cable, camera and laser beam inside the chamber to study the plasma in detail.

The system was successfully installed at the plasma research lab of UM-DAE CEBS, Mumbai in Jan 2020. Demonstrative experiments on Langmuir Probe Characteristics and Ion-Acoustic Waves were conducted and intensive training was imparted to the faculty.

Figure 2: DC Plasma

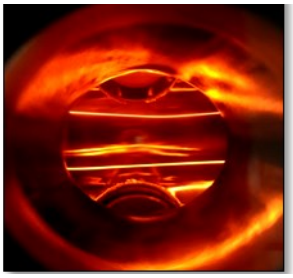


Figure 3: Tungsten Filament Glow

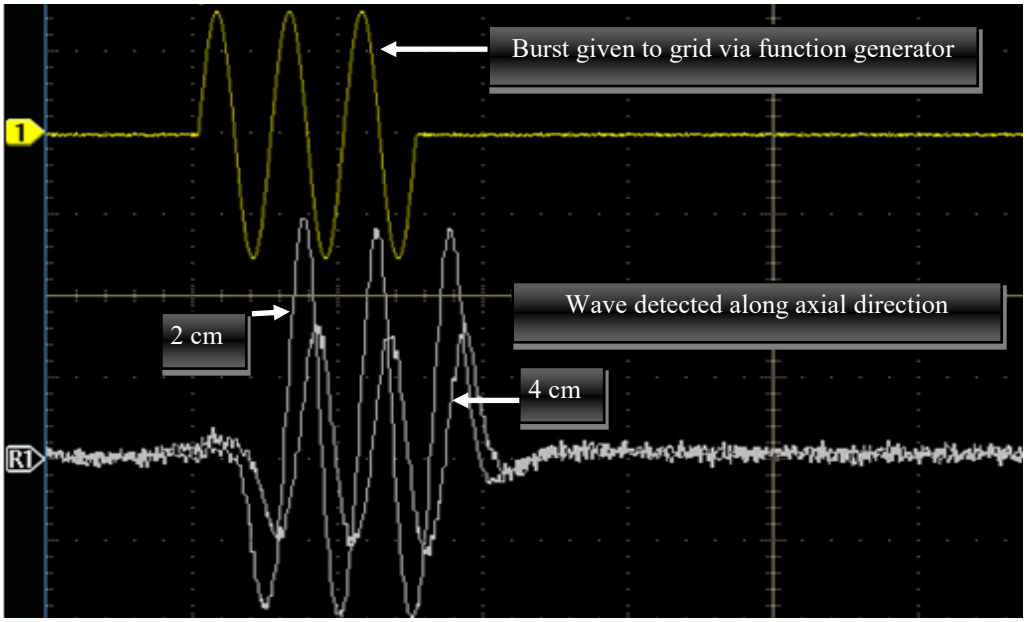


Figure 4: Yellow Channel - 3 cycle burst given to exciter grid, Blue Channel - Ion-Acoustic Wave detected by Langmuir probe at 2 cm and 4 cm along axial direction.

Photograph of the installed system at UM-DAE CEBS, Mumbai
(From Left to Right: Dr. G. Ravi, Dr. V. K. Jain (Director, UM-DAE CEBS), Dr. Brijesh Prithvi (Faculty, UM-DAE CEBS), Mr. Kushagra Nigam)

Past Events

One Day Seminar
Plasma Technologies for Health Sector
(PTHS-2019)

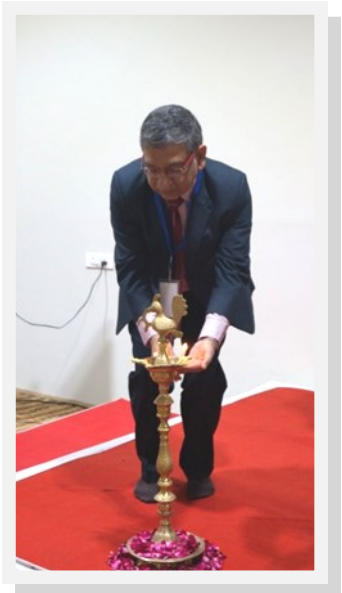
One day seminar about Plasma Technologies for Health Sectors (**PTHS-2019**) was arranged on 29th Nov 2019. Around 120 delegates from various health sectors (hospitals, R&D centres, academic institutions, private industries and medical practitioners) participated in the event. Dr. Sudeep Gupta (Director ACTREC, Tata Memorial Centre, Mumbai), Dr. Srikanth Prasad Tripathy (Director, National Institute for Research in Tuberculosis, Chennai), Dr. Sarat Chandra (AIIMS, New Delhi) were the guests of honour at the event. The purpose of organising PTHS-2019 was to introduce the Indian community of medical practitioners, biotechnologists, bio-researchers, and bio-industrialists to current developments in the field of plasma medicine, with emphasis on the efforts of Institute for Plasma Research (IPR) in this direction. The seminar covered a wide range of important health topics and application of plasma to diagnosis and treatment. Invited talks revolved around various types of cancers occurring in India, diseases like tuberculosis and epilepsy, an overview of world scenario in plasma medicine. Talks also covered plasma based sterilization, pencil plasma for fungal infection treatment, dermatology, dental problems, plasma for waste disposal, plasma activated water, deep learning software and pencil plasma torch for tumour treatment. After the seminar live demonstration of several plasma systems was arranged. Several industries and R&D institutes showed keen interest in further collaboration with IPR.

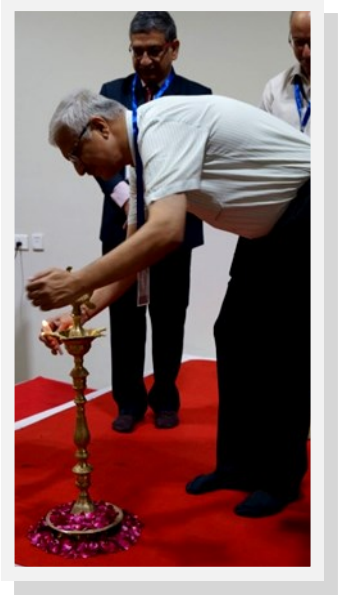
Dr. Mukesh Ranjan (Convener, PTHS-2019) delivering the welcome speech

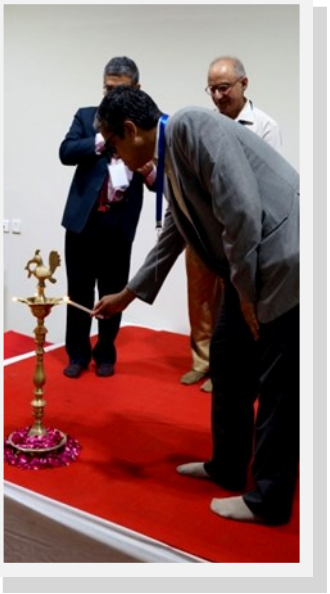
Distinguished guests: Dr. S. Chaturvedi (Director, IPR), Dr. Sudeep Gupta (Director, ACTREC, TMC Mumbai), Dr. Srikanth Prasad Tripathy (Director NIRT) and Dr. Sarat Chandra (AIIMS, Delhi) on the dias

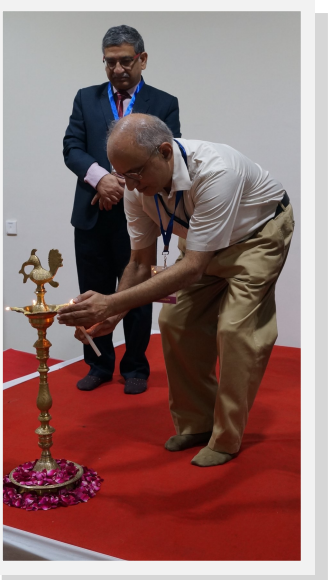
PTHS 2019 - Welcome Ceremony

Lamp Lightning









Overview Talks

Dr. S. Chaturvedi

Dr. Sudeep Gupta

Dr. Srikanth Tripathy

Dr. Sarat Chandra

Invited Talks

Dr. Alphonsa Joseph

Dr. Kshama Pansara

Mr. Akshay Vaid

Dr. Anshu Srivastava

Dr. Murali Krishna

Dr. R. Rane

Dr. Jyotirmoy Banerjee

Dr. Anu Gosh

Dr. S.K. Nema

Mr. Vikas Rathod

Mr. Agraj Abhishek

Dr. Shital Bhutani

FCIPT

VISIT

PTHS-2019 Delegates

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