FACILITATION CENTRE FOR INDUSTRIAL PLASMA TECHNOLOGIES
INSTITUTE FOR PLASMA RESEARCH

PLASMA PROCESSING UPDATE

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EDITOR'S NOTE

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Welcome to the 79th issue of Plasma Processing Update, an e - Newsletter. The objective of Plasma Processing Update is to increase the awareness about plasma technologies and its industrial / societal benefits among the Indian industries and society. Articles in this issue describe different and interesting applications of plasma based coatings such as increase in life of coal burners by Plasma Nitriding, how plasma based coating can be useful for artificial bone implants, development of a molecular level sensor, deposition of Tantalum based coatings by plasma etc.

A team of enthusiastic researchers at FCIPT , IPR are continuously involved in development of various applications using plasma based technologies. I wish all readers are enjoying the updates on these technologies , which is released time to time in the form of a News Letter.

CO-EDITORS

Mrs. Purvi Dave

Mrs. Nisha Chandwani

Inside this issue:

Plasma: a tool for wireless energy transfer?

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Hard coatings- an alternative solution to combat erosion of coal nozzle burners

World-wide, the majority of electricity is generated in coal-fired thermal plants. Coal is the prime fuel for power generation in coal fired thermal plants. India has a large fleet of coal-fired power plants.

A typical boiler used for coal burning has four vertically tilting burners, each with four coal tip nozzles and two fuel ignition guns. A picture of a typical coal tip nozzle burner is shown in Fig. 1. Coal burners are made of high alloy steels (AISI 310). The coal used in Indian power stations has large amounts of ash (about 50%), which contain abrasive mineral species such as hard quartz (up to 15%), which increase the erosion propensity of coal. The resulting damage to the tip causes poor fuel distribution, which in turn leads to reduced combustion efficiency, coal wastage and higher heat input costs. Frequent repair and replacement of the coal burner tips extend downtime and leads to higher production losses. The conventional practice is to prepare these nozzle tips using hard facing materials, which offer higher resistance to abrasion and oxidation but these tips are still prone to erosion and impact wear. Coating technology is one of the more rapidly growing technologies in the field of materials. Hard coating like plasma sprayed metallic coating of nickel-aluminide deposited on Fe-based superalloy have shown better erosion resistance as compared to the uncoated samples.Another, alternative solution to combat this wear resistance would be to deposit a duplex coating. The component will be initially be plasma nitrided followed by a Tungsten based hard coating deposited by thermal spray process. The resulting hardness will help in resisting the erosion of coal burners.

Fig.1 : Coal tip nozzle burner

Fig. 2 : Eroded coal tip nozzle burner

- Erosion of coal burners is a serious problem in power generation plants.
- Use of hard coating have found to improve the service life of coal burners.
- These coatings will in turn improve the power efficiency of coal fired power plants.

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Titanium (Ti)/Titanium Nitride(TiN) multi layer coating on stainless steel for Biomedical application

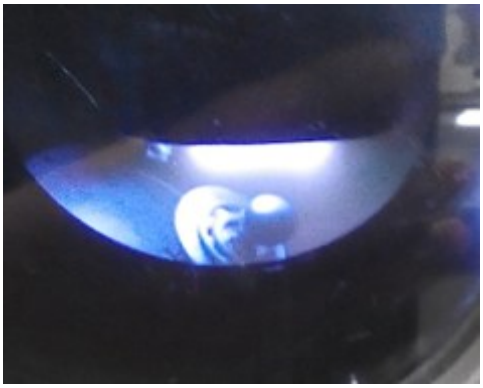
Stainless steel (SS) 316L is an alloy is used as an implant material to make internal fixation devices such as artificial joints, bone plates, stents due to its favorable combination of mechanical properties, corrosion resistance, satisfactory biocompatibility and cost effectiveness compared with other metallic biomaterials .

However, SS 316L and other austenitic stainless steel types (such as 304, 310) are rather soft materials and often suffer from a high amount of wear caused by mechanical loads. Hardness and wear resistance improvement of SS 316L alloy can often be accomplished by an appropriate surface modification technique. Plasma nitriding, TiN coating by PVD technique are most popular methods to enhance the surface mechanical properties of stainless steel e.g. SS 316L.

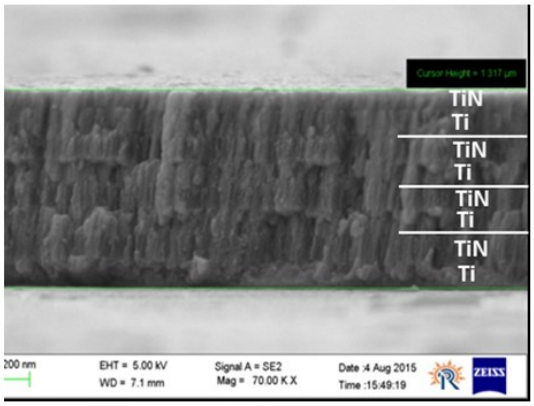
At FCIPT, plasma nitriding and plasma based Ti-TiN coating process for SS 316L have been developed. The plasma nitriding and magnetron sputtering based coating has been performed on the ball of a typical hip joint . The mechanical and biomedical testing of the coating is going on at CGCRI (Central Glass and Ceramic Research Institute) , Kolkata

Advantages:

- Environment friendly surface modification technique.
- The coating properties can be controlled by tuning different process parameters.
- Ti-TiN multilayer coating will enhance the performance as compared to only TiN coating



Magnetron sputtering for coating



SEM images of Ti-TN multilayers

SS Balls

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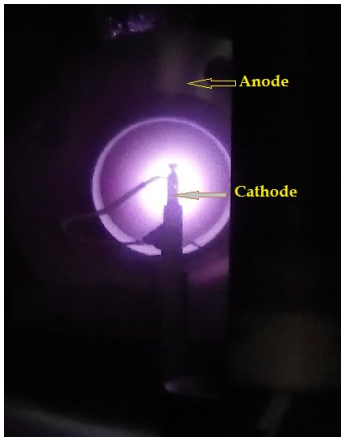
Plasma based Tantalum coating for cylindrical geometry

Plasma based magnetron sputtering technology is used to coat materials of different geometry. This coating can be done on internal as well as external surfaces of corresponding geometry using cathode anode configuration. In these configurations, cathode is the material that has to be sputtered and anode is the material which is supposed to be coated. The Ions inside the Magnetron gain sufficient kinetic energy due to radial Electric Field and axial magnetic fields. These ions then bombard the surface of cathode causing the atoms in cathode to sputter out and get deposited on anode surface. Materials like Copper, Aluminum, Tantalum etc. which are used for coating are determined by the surface properties that we want to modify. Recently, in our lab SS cylindrical geometry was coated with Tantalum (Ta) on the inner side. Of the ring of 77.4 mm ID . Tantalum is known to improve ductility toughness, thermal shock resistance and thus extends the life of surface on which coating is done. The coating was done in Argon environment The coating morphology can be seen in SEM image . Tantalum coating thickness has been found in range of 140-150 nm.

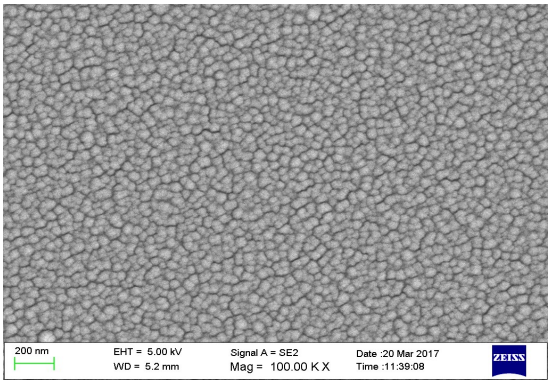
Advantages:

- PVD produces uniform surface coatings with extremely low surface roughness.
- Due to scalability, the technology can be used for multiple coatings.
- Since deposition happens at low temperatures, properties of the

SS surface on which Tantalum coating is deposited



Magnetron Sputtering



SEM image of Tantalum coating on silicon wafer

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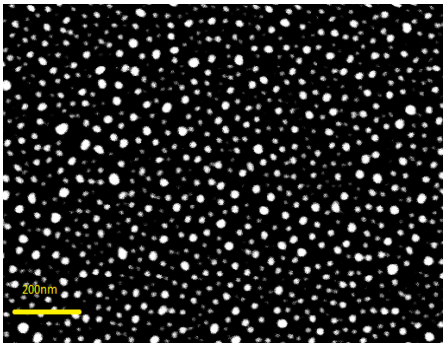
Molecular sensing by Surface Enhanced Raman Scattering

In medical science, scientists are trying to find out novel techniques to identify the early stage detection of various deadly diseases like cancer, tumor etc. Noble metal (Silver, Gold) nanoparticles have shown the possibility to detect the traces of such diseases just at the very beginning using a concept of Surface Enhanced Raman Scattering (SERS)/Surface Enhanced Infrared Absorption (SEIRA). In this method molecule under investigation brought in contact to metal nanoparticles of typically 10-50 nm in size and standard Raman spectra is observed. Characteristic vibrational modes of the molecule are probed. Normally such modes are undetectable by Raman spectra but in presence of metal nanoparticles they are more intensely excited and clearly resolved or observed in the Raman spectra. This is because of the enhancement of electromagnetic field near metal nanoparticles due to Localized Surface Plasmon Resonance (LSPR). In this way, using these techniques, data base of various diseases can be generated .

Recently at FCIPT, we have used magnetron sputtering method for deposition of silver nano-particles on glass substrate . We have observed silver particles size of 30-50 nms using SEM. The ellipsometric analysis has confirmed the presence of plasmon resonance.

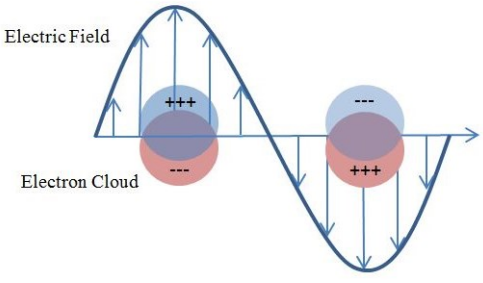
Possible Applications

- Detection of Glucose in highly diluted solution .
- Early stage detection of tumors etc.
- Trace element analysis in Forensic samples.



Left image is HRSEM image of Silver nanoparticles deposited on glass substrate.

Right image showing Conceptual image of electron cloud oscillations with incident light electric field leading to LSPR phenomenon .



FCIPT-IPR Visit by NDTV Team

Mr. Pallava Bagla, the scientific correspondent of NDTV visited FCIPT– IPR in the middle of January 2017. He visited the various laboratories in the three campuses of IPR. He interacted with the FCIPT staff to understand the various technologies developed here. He was amazed to see Plasma Jet, Plasma Pyrolysis, Nitriding and Nano-Particle Production experimental set-ups. Based on his visit to IPR, he has published an article entitled "***Indian Scientists exploiting healing powers of Plasma***" in economic times dated 22nd Jan 2017. Here , he shared his experience about Plasma jet at FCIPT in these words *"Being able to touch and feel this elusive fourth state of matter is a unique experience, reluctantly I put my finger on the plasma jet not knowing what would be the outcome, a mild tingling is what one feels as one pushes the finger into the intense light of the plasma jet. Having experienced solids, liquids and gases this was the first time I actually touched and felt the fourth state of matter! "* This full article can be **read from here...**

Mr. Pallava Bagla , NDTV scientific correspondent with Dr. Shashank Chaturvedi, Director – IPR and FCIPT-IPR staff members at FCIPT Porch.

Dr. S.K.Nema , Scientist-SG, FCIPT explaining about Plasma Pyrolysis Technology to Mr. Pallava Bagla.

Dr. Balasubramanian , Scientist-SE, FCIPT demonstrating Nano-Particle Production .

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