FACILITATION CENTRE FOR INDUSTRIAL PLASMA TECHNOLOGIES

INSTITUTE FOR PLASMA RESEARCH

PLASMA PROCESSING UPDATE

Issue 77

Oct 2016

MESSAGE FROM DIRECTOR

It gives me immense pleasure to share with you that FCIPT has recently transferred technical know-how for plasma based technologies of Nano-Particle Production to Plasvac (Ahmedabad), Plasma Pyrolysis to Bhakti Energy (Rajkot) and Plasma Nitriding to Therlek Pvt Ltd (Bangalore). The commercial use of these indigenous technologies will enhance our techno-economic independence.

The Department of Atomic Energy (DAE) has recently announced a focus on specific research programmes for societal benefit. Research proposals have been invited in the areas of Healthcare, Food-security, Waste management and so on. FCIPT, which has developed a number of plasma technologies in these areas, plans to emerge as one of the major participants in this DAE vision

Dr. Shashank Chaturvedi,
Director, Institute for Plasma Research

Inside this issue:

EDITOR'S NOTE

Dr. S. Mukherjee
Head, FCIPT Division

Welcome to the 77th issue of **Plasma Processing Update,** an e-Newsletter. You can read it online, download it, can share with your colleagues and friends. The current issue gives information on few interesting applications of plasma based aluminized coatings . This issue also includes updates on the recently developed array of atmospheric plasma jet and feedback compensator for voltage/current regulation by our engineering experts. We are happy to invite you for the upcoming one day workshop on "*Plasmas on Societal Benefits* " to be held at FCIPT on Oct 21st 2016.

For more details, please visit us on

www.plasmaindia.com

Co-Editors

Mrs. Purvi Dave

Mrs. Nisha C.

Warm Welcome To Our New Director !!

Dr. Shashank Chaturvedi , Director ,IPR

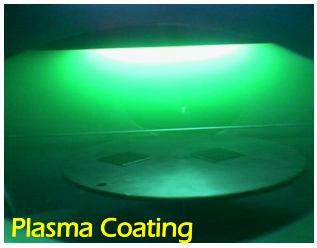
FCIPT Newsletter team would like to extend a very warm welcome to Dr. Shashank Chaturvedi (SO/H+), who took charge as the third Director of IPR on 5th August, 2016. Prior to taking charge as the Director of IPR, Dr. Chaturvedi was heading the Computational Analysis Division (CAD), BARC Facilities at Visakhapatnam . He has obtained his Phd from Princeton Univerisity in 1989. Some of the honours conferred on Dr. Chaturvedi are Institute Silver Medal at IIT Delhi (1985), Homi Bha-bha Science & Technology Award of DAE (2005), Group Achievement award of DAE and Elected as Fellow of Indian Nation-al Academy of Engineering (INAE) in 2013 .

Upcoming one day Workshop on *"Plasmas for Societal Benefit"* 21st Oct 2016

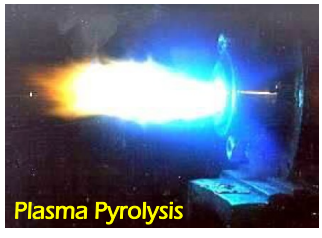
Register Now

Plasma Medicine

Plasma Nitrocarburizing



Plasma Coating



Plasma Pyrolysis

Plasma technologies have been gaining importance recently for its effective eco-friendly processing for a vast spectrum of applications ranging from exotic outer space applications to simple social applications such as water purification, waste disposal etc. As the global scenario and national priority is focused to environment conservation and sustainable living, the role of plasma technologies for societal benefit becomes inevitable. While a strong attempt has been made at FCIPT in developing society specific technologies, specifically those pertaining to environment protection and healthcare, a need of cross-disciplinary efforts to establish a commercially deployable technology is necessary. In this context, one-day workshop on "**Plasmas for Societal Benefit**" has been organized at FCIPT, IPR on 21st Oct, 2016. The objective of the workshop is to showcase and sensitize the audience about the excellent results from the use of plasma technologies in healthcare and environment conservation sectors and foster further collaboration amongst organizations of different disciplines and core-competence. The workshop is aimed to promote and permeate plasma technologies for societal benefit and for a better tomorrow.

Who Should Attend?

- **Scientists**
- **Engineers**
- **Industrialists**
- **Entrepreneurs**

For Free registration visit :

www.plasmaindia.com

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Industrial Applications of Aluminide Coatings

The next generation machines ranging from aerospace to power plants demand performance at high temperatures. Exposure of structural materials at high temperatures accelerates their degradation due to environmental interaction. High temperature corrosion of materials include oxidation, hot corrosion, metal dusting etc. and are very common in power plants, gas turbines, petrochemical plants etc. Alumina coatings have been considered a reliable option to mitigate high temperature corrosion.

FCIPT has developed a plasma based heat treatment process to generate aluminide coatings with a stable αAl_2O_3 coating and could be extended to a number of applications cited in

Metal Dusting: Metal dust form in Fe/Ni based components functional in H-C environment at 400-800°C. Aluminide coatings resist the diffusion of C in alloys and thus prevent metal dusting as well as carburizing/coking problems.

Sulphidation resistance: At 580-600°C temperature, SS304H steels yield higher degradation rates as compared to aluminide coatings. Aluminide/chromide are also reported to be beneficial in hot-corrosion of boilers.

Molten salt/liquid metal corrosion: Aluminide coatings are preferred choice for liquid metal and molten salt corrosion compared to expensive bulk alloys. Solid reactors etc. are possible application sectors.

Hydrogen embrittlement: Alumina based aluminized coatings have excellent resistance to hydrogen permeation. Pressure sensors in hydrogen based plants can be benefited.

- Fe/Ni aluminides are highly stable at high temperature and resist high temperature corrosion.
- Aluminide coatings can be economically viable against expensive bulk alloys for high temperature applications

Industry	Components	Application use
Cement	Clinker / cooler plates, thermowells	Oxidation, hot corrosion
Sulphuric acid plant	Heat & SO_2/SO_3 exchangers	Sulphidation, hot corrosion
Petrochemical plants (Hydrocarbon cracking)	waste heat boilers, heaters, cokers, catalyst beds, ethylene steam cracker tubes etc.	Metal dusting, carburization/coking
Nuclear fission	Magnox & AGR reactors Coatings in SG modules of FBR	Fretting wear resistance in liquid Na
Nuclear fusion	Components of Fusion blanket modules	Liquid metal corrosion resistance and as tritium permeation barrier.
Solar thermal power plants	Absorber tubes using molten salt corrosion	Corrosion protection against molten salts / liquid metals at elevated temperatures
Gas turbine power plants	Turbine blades	Hot corrosion, oxidation resistance, supports thermal barrier coatings

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Development of an array of Atmospheric pressure Plasma jet for the treatment of large surface area

Non-thermal Plasmas has found its applications in various field such as medicine, agriculture etc. FCIPT has already developed and demonstrated single jet and honeycomb arrangement of jets for the bio-medical and agricultural applications.

In order to treatment larger areas such as vegetables to remove pesticides, polyester films to increase surface energies array of jets are required. In this regard, We have developed an array of 100 jets which can treat large area at a given time.

The plasma forming gas is of argon and the plume length is about 10 mm.

Applications:

- *Removal of pesticides from vegetables surface.*
- *Increase the surface energy of polyester films.*
- *Can be used for the treatment of skin diseases.*
- *Can be used for increasing the rate of germination of seeds.*

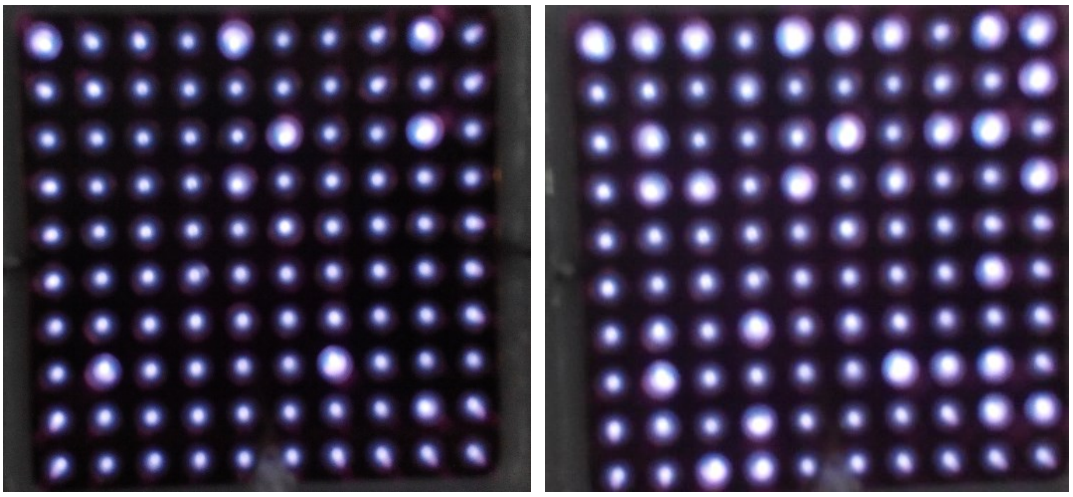

Fig:1 front view of 100 jets

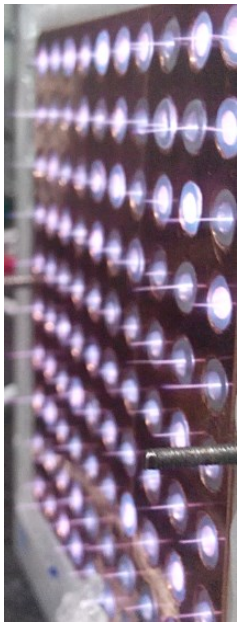

Fig 2: Side view of 100 Jets

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Feedback compensator design for voltage/current regulation in plasma application

Feedback compensator is a part of close loop control system which is essential to generate a regulated output by sensing the output parameter that can be either voltage or current.

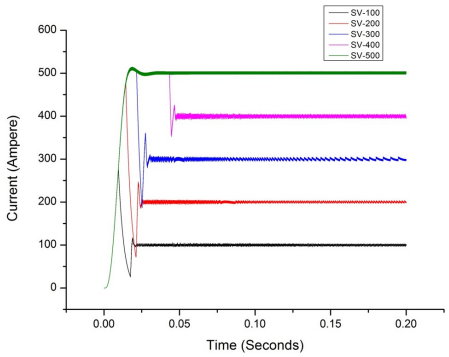
This feedback system design is based on the transfer function of the open loop system. The open loop system defines the gain compensation and phase boost requirement. That is essential input to the design of feedback system.

In case of plasma arc generation, a compensator with two zeros and two poles was designed for current regulation and the simulated was done in MATlab Simulink with using the operating conditions of plasma arc to get 100V and 500A output. The open loop system parameters are taken from the circuit that has already been incorporated in the system for testing purposes. The feedback system thus obtained provides a highly regulated current output at all load conditions from zero to full load impedance.

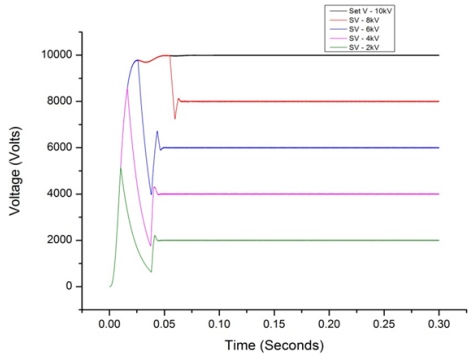
In another case of microwave generation using magnetron, the high voltage regulated power supply is being tested for which another compensator with two zeros and two poles to generate regulated voltage up to 10kV at 1A is designed and simulated in MATlab Simulink. The simulation results are shown in the Fig. 1 for regulated current at output at various set values and in the Fig. 2 for regulated voltage output at various set values.

The Main features of Feedback system are:

- Both the feedback system fulfil the Nyquist stability criteria.
- It can be applied for any physical parameter control if the open loop system is modeled properly and the transfer function of sensor is accurately designed or given by manufacturer.



Current Regulation for Plasma Arc



Voltage Regulation for Magnetron-Microwave Plasma

Technology Transfer : Nano Powder

Metal oxide nano powders have immense applications in varied fields like pharmaceutics, paint, automobile industry, textile etc. These are high value powders and are in great demand for specific applications. There aren't any known Indian industries producing these Nano powders; they are mostly imported or produced with imported machines.

The tech-transfer documents being exchanged between Dr.S.Mukherjee, and Dr.Venkat Ramani

FCIPT has developed a plasma based instrument that can produce metal oxide Nano powders in bulk quantities. The entire system is automated and easy to handle. This was demonstrated during the Workshop on Thermal Plasma Technology conducted at FCIPT in April 2016. Based on this , FCIPT had received technology transfer requests for metal oxide nano powder production by plasma processing. Eventually, IPR has transferred the nano-powder production technology on a non-exclusive basis to an Ahmedabad based company, M/s Plasma & Vacuum Technologies (PlasVac). The agreement was signed on 8thJuly 2016 between IPR and PlasVac at Director's office, IPR, Bhat, Gandhinagar. PlasVac has started activity towards commercialization of this product in order to make this technology penetrate into the market within the next couple of years.

MoU signing : IPR-AAU

Institute for Plasma Research (IPR), Gandhinagar and Centre for Food Processing Technology & Bioenergy (FPTBE) , Anand Agricultural University (AAU), Anand entered into a scientific collaboration agreement on 26th July, 2016 at IPR, Bhat campus. The agreement scope covers joint collaboration and research on development of plasma based technologies for surface decontamination of fruits and vegetables .

MoU signing ...Continued

Cross disciplinary expertise of both the organizations will be helpful to reduce the pesticide contamination on fruits and Vegetables, which is a growing health concern across the nation. The outcome of the agreement will benefit the agro sector of the country as well as to the health of the public. FCIPT has started the experimental trials for removal of dicholorovos in cabbage.

Dr. D. C. Joshi ,Dean, FPTBE, AAU ,Prof. Dhiraj Bora ex- Director,IPR and Prof. Amita Das Dean,IPR , (Left to Right)

Technology Transfer : Plasma Pyrolysis

Dr. A. Vardhrajulu ,Chairman TT,IPR ,Dr. Shashank Chaturvedi, Director IPR and Mr. Ashok Vora ,Bhakti Energy (Left to Right) exchanging tech-transfer documents

FCIPT,IPR as a part of its contribution to Swatch Bharat Mission is expanding the use of Plasma Pyrolysis technology for the waste disposal . In lieu of this, FCIPT transferred technical –know how for Plasma Pyrolysis technology for non-biomedical waste to M/s Bhakti Energy, Rajkot on 29th August 2016 . Bhakti Energy, which is presently engaged in the business of biomass gasification, is planning to use the plasma technology for municipal solid waste as well other types of paper and plastic waste.

Technology Transfer : Plasma Nitriding

M/s. Therelek Engineers Private Limited, Bengaluru which is engaged in the business of furnace manufacturing and heat treatment service had expressed interest in acquiring and obtaining non-exclusive rights over plasma Nitriding technology developed by FCIPT during a tech-transfer meet organized at IPR in December 2015 . The tech-transfer agreement has been recently signed between FCIPT-THERELEK for commercial use of Plasma Nitriding for hardening of metal surfaces, wherein FCIPT shall give all scientific and technical assistance which will enable Therelek to effectively manufacture , market and supply Plasma Nitriding systems.