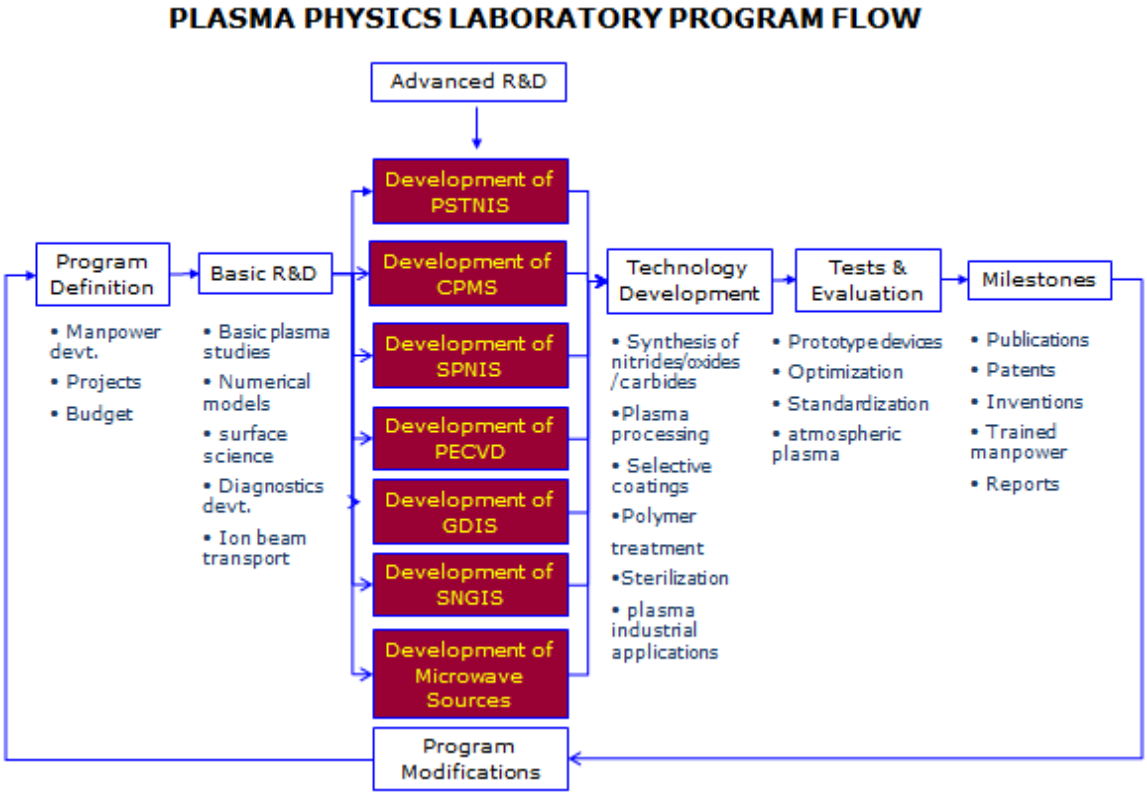
PLASMA PHYSICS LABORATORY

National Institute of Physics
College of Science, University of the Philippines
Diliman, Quezon City

ANNUAL REPORT 2013

A. Introduction

The laboratory continued implementation of its program supported in part by the Department of Science and Technology (DOST) and other agencies in 2013. It has pursued the second year of implementation of projects on MAX phase materials supported by the Philippine Council for Energy and Emerging Technology Research and Development (PCIEERD). It implemented the first of three years of the bilateral research agreement with the Japan Society for the Promotion of Science and the Human Resources Development Office, PCIEERD, DOST. Continuing studies were done on applications of microwave equipment donated by IBF Electronic, GmbH, Germany. It has continued the implementation of a DOST- Technicom grant towards commercialization of TiN coating developed in the laboratory. These programs and other projects are summarized in this report. They constitute the research and development program in plasma science and technology for the period 2011-2013. The program flow for the last three years with the addition of the development of a compact planar magnetron system, is shown in the diagram.



The acronyms stand for Plasma Sputter-type Negative Ion Source (PSTNIS), Compact Planar Magnetron System (CPMS), Sheet Plasma Negative Ion Source (SPNIS), Plasma Enhanced Chemical Vapor Deposition (PECVD), Gas Discharge Ion Source (GDIS), and Streaming Neutral Gas Injection System (SNGIS). A description of the R&D activities

on each device follows.

I.Project Title: Market testing and process optimization of industrial prototype plasma enhanced chemical vapor titanium nitride coating technology
Total Funds: P 9,797,092.00
Source: DOST-TECHNICOM
Duration: November 16, 2011 – August 31, 2013

The Sheet Plasma Negative Ion Source (SPNIS) was developed from previous DOST-funded projects purposely for the production, extraction and enhancement of negative hydrogen ions (H^-) using a mixture of hydrogen, argon and magnesium plasma. The H^- ions extracted using a modified Wien filter was used in the synthesis of silicon hydride. Selective solar (IR) coatings of tin-bismuth on various metal substrates were also deposited using the facility. The facility was subsequently configured for TiN coating of metal tools used by various industries (tool and dye, etc.) operating in the Philippines.

An upgraded machine has been developed starting November 16, 2011 under a DOST-TECHNICOM project titled "*Market testing and process optimization of industrial prototype plasma enhanced chemical vapor titanium nitride coating technology*". Costing PhP 9,797,092.00, the one year project includes design, construction, and operational testing of an industrial prototype magnetized sheet plasma source for coating of TiN based on patented technology to service the manufacturing needs of industry. The prototype machine is based at the DOST-Metals Industry Research and Development Center (MIRDC). The design, construction, testing and commissioning of the machine was completed in October 2013. It will be operated under a research and patent licensing memorandum of agreement with the Asian Semiconductor Electronics Technologies (ASET) Corporation and the university starting in March 2014.

II. Project Title.Plasma Etching Using Low Energy Ions from a Gas Discharge Source

Funding Source: NIP MOOE Allotment
Amount of Funding :PhP 100,000.00
Duration: January 2013- December 2013

A Gas Discharge Ion Source (GDIS) was developed as an example of a low energy ion beam source. An ion beam of carbon tetrafluoride (CF_4) plasma is used for surface modification applications such as ion etching on silicon carbide (SiC) samples. The ion treatment that the sample surfaces undergo changes their physicochemical properties. The modification is of great significance in the moisture absorption of the material improving its characteristic features like contact angle and other physical characteristics. This study reports the fabrication of SiCnanopillars through a single etching process. 4H-SiC substrates were etched using reactive CF_4 plasma species produced in a gas discharge ion source. As opposed to other methods, the technique operates at low power and does not require pre- and post-treatment processes. The nanopillars formation arise due to a self-masking mechanism using chromium and iron particles that occurs at the start of the etching process. Measured pillar diameters are in the range 11-56nm. The surfaces exhibit strong photoluminescence in the green region with peak at 526nm. The luminescence might be due to band to band recombination arising from quantum confinement effects caused by the nanopillars.

III. Project Title. Beam Transport in a Sputter-type Ion Source

Funding Source: NIP MOOE Allotment
Amount of Funding :PhP 100,000.00
Duration: January 2013- December 2013

Silver (Ag) is used as metal target to produce negative/positive metal ions. The metal ions are fully characterized in terms of ion beam energies and ion currents using a retarding-type electrostatic energy analyzer. The behavior of ion energies and ion currents towards increasing target voltages and differences in beam characteristics between each metal used are studied. The effect of the chamber pressure to the ion beam characteristics is also studied. Silver and TiO_2 films were deposited on glass substrates via the Plasma Sputter Type Negative Ion Source and a Compact Planar Magnetron, respectively. A silver target was biased and is sputtered by argon plasma for 30 minutes. TiO_2 was deposited by sputtering a titanium disk and introducing oxygen in a 1:13 ratio with argon plasma for 2 hours. The resulting composite films (silver on TiO_2 and TiO_2 on silver) were analyzed by its transmissivity in the UV-VIS region showing increased optical absorbance. The synthesized films were used in the photocatalytic degradation of methylene blue showing an increase in photocatalytic degradation when only TiO_2 is used. The introduction of silver with TiO_2 inhibited the effective photocatalytic degradation of methylene blue.

IV. Project Title: Physical Vapor Deposition of Advance MAX Phase
Funding Source: Philippine Council for Industry, Energy and Emerging Technology Research and Development, Department of Science and Technology
Amount of Funding :PhP 4,051,296.00
Duration: April 1, 20012-March 31, 2014

Physical vapor deposition (PVD) is fundamentally a vaporization coating technique, involving transfer of material on an atomic level. It is an alternative process to electroplating. The process is similar to chemical vapor deposition (CVD) except that the raw materials/precursors, i.e. the material that is going to be deposited starts out in solid form, whereas in CVD, the precursors are introduced to the reaction chamber in the gaseous state**.** The synthesisofnew materials thatpossess a unique combination of metallic and ceramic properties has been of much interest lately. A large solid group of compounds with similar attributes are called “MAX phases”, where M is a transition metal, A is an A-group element, and X is C and/or N

The objective of the project is to establish a reliable and reproducible PVD procedure using a magnetized sheet plasma facility for obtaining advanced MAX thin films with desirable properties for functional and decorative applications. Combinations of remarkable properties of MAX phases open up new applications for heating elements, burner nozzles, reactor heat exchangers, high temperature bearings and components in the chemical and related petrochemical industries.

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V. Project Title: Studies on Microwave Plasma Systems

Total Funds: P6,850,713.50 (cost of equipment donation)
Source: IBF Electronic GmbH & Co. KG, Ober-Ramstadt, Germany

Duration: August 2010 – December 2013

The R&D aims to develop an atmospheric plasma jet from a 2.45 GHz microwave source and use it for adhesion enhancements of epoxy on industrial materials. The R&D preliminary targets are the studies on the stability of the plasma jet in terms of ignition, minimum reflection, and heating using high-ripple 2 kW and low ripple 6 kW magnetrons. An initial experiment on a low pressure microwave plasma source shows that the treatment of stainless steel surfaces have enhanced its adhesion with an epoxy adhesive. Based on tensile test results, the adhesion strength of epoxy-bonded O_2/Ar plasma treated surfaces was increased to 3816.0 N from 3038.3 N for the epoxy-bonded untreated surfaces. These results would be replicated in the atmospheric microwave plasma jet.

The atmospheric microwave plasma jet is developed to enhance the paintability of various industrial materials such as stainless steel, glass, plastics, etc. Plasma treatment can quickly enhance the surface paintability of industrial materials to ordinary paints without the need for primers. From initial results, it has been shown that the plasma jet treatment of stainless steel can achieve superhydrophilic surfaces using argon and argon-nitrogen plasmas.

VI.**Project Title:Dual Planar Magnetron for TiO2-based Photo-catalytic Wastewater Treatment System**
Funding Source: Philippine Council for Industry, Energy and Emerging Technology Research and Development, Department of Science and Technology and the Japan Society for the Promotion of Science
Amount of Funding :PhP 1,639,256.00 (local counterpart) and Yen 2M (JSPS) per year
Duration: February 1, 2013-January 31, 2016

This is a bilateral research agreement with the Japan Society for the Promotion of Science and the Human Resources Development Office, PCIEERD, DOST for a period of three years.The aimsof the collaboration work are: a)build a dual planar magnetron (DPM) system;b)deposit nanostructured coatings of TiO_2 on appropriate material, tailor and optimize the parameters of synthesis for the preparation of a dense, strongly adhered, highly photo-catalytic TiO_2;c)build a prototype of an advanced oxidation process for depollution of water;and d)train graduate students.

Highlights

Publications of the laboratory in SCI-indexed international journals (4), refereed journal articles (2), proceedings of international (19) and local conferences (14) and papers presented in various other conferences are summarized in Section C of this report. The laboratory trained four (4) undergraduate theses, three (3) graduate (masters) theses students and one Ph. D. dissertation student who were awarded their respective degrees in 2013.

One senior faculty (H. Ramos) , three Ph.D. students (Mr. Giovanni Malapit, Mr. Marcedon Fernandez, and Ms. Michelle Villamayor), one M.S. student (Ms. Aubrey Faith Mella), and one B. S. student (M. A. J. Viernes) were sent on research visit and/or attendance in an international conference under the auspices of the DOST-JSPS bilateral agreement to the Department of Applied Physics, Doshisha University, Kyotanabe, Japan for ten days in August, two weeks in May and two weeks in September, respectively.

The laboratory hosted three Japanese professors, one Korean professor, ten Japanese

graduate students, five local graduate students, eight local undergraduate students, three high school students and two DOST immersion program grantees.

The present laboratory coordinator (H. Ramos) was promoted to the rank Scientist III in 2013.

C. 2013 Publications and Conference Papers Presented (*italicized authors are collaborators, otherwise affiliated with the laboratory*)

a1. SCI –indexed international journal

1. M. A. C. Camacho and H. J. Ramos, "Comparative analysis of the surface functionalization and texturization of HDPE after H_2 and O_2 ion plasma immersion", *Advanced Materials Research***664** (2013) 768-773.

2. J. A. S. Ting, L. M. D. Rosario, M. C. C. Lacdan, H. V. Lee, Jr., *J. C. de Vero*, H. J. Ramos, R. B. Tumlos, "Enhanced adhesion of epoxy-bonded steel surfaces using O2/Ar microwave plasma treatment", *Int'l. J. of Adhesion and Adhesives***40** (2013) 64-69.

3. H.S. Salapare III**,** *M.G.J.P. Tiquio*, H.J. Ramos, "Superhydrophilic properties of plasma-treated *Posidoniaoceanica*", *Applied Surface Science***273** (2013) 444-447.

4. H.S. Salapare III**,** *F. Guittard, X. Noblin, E. Taffin de Givenchy, F. Celestini*, H.J. Ramos, "Stability of the hydrophilic and superhydrophobic properties of oxygen plasma-treated poly(tetrafluoroethylene) surfaces" *J. Colloid Surface Science* **396** (2013) 287-292.

a.2. Peer-reviewed publications

1. Michelle Marie S. Villamayor, Kenta Doi, Edna Mae D. Cruz, Freya Gay J. Avenir, Motoi Wada, Henry J. Ramos, "A Compact Planar Magnetron Plasma Sputtering Device for TiO_2 Deposition", *Materials Research Society Online Proceedings Library*, Volume **6786**(2013) DOI: http://dx.doi.org/10/1557/opl.2013.1150 (published online)

2. Michelle Marie S. Villamayor, Leo Mendel D. Rosario, Rommel Paul B. Viloan, Ma. Camille C. Lacdan, Julie Anne S. Ting, Beverly Anne T. Suarez, ShuichiKato, Roy B. Tumlos, Maricor N. Soriano, MotoiWada, Henry J. Ramos, "Observation of Plasma-Facing-Wall via High Dynamic Range Imaging",*Plasma and Fusion Research***8** (2013) 2401116.

b. International Conferences

b1. Papers presented at the 12th Asia Pacific Physics Conference and Asia-Europe Physics Summit, International Conference Hall, MakuhariMesse, Chiba, Japan, July 14-19, 2013

1.C.L.S. Mahinay, *M.I.D. Fudolig*, M.S. Fernandez, H.J. Ramos, "Electric field solutions of a 90o electric sector charge analyzer for lowenergy Au- ions"

2. H.J. Ramos, *K. Doi*, M.S. Fernandez, *S. Kato*, G.M. Malapit, *N. Miyamoto, M. Sasao*, M.M.S. Villamayor, *M. Wada*, "Sheet plasma configuration suitable for materials processing"

3. G.M. Malapit, *J.I.L. Bugante*, H.J. Ramos, "Effects of Negative Ag Ions on the Surface of (100) Single-CrystallineMgO Substrates"

4. *M. Wada, Y. Hiramatsu, T. Kasuya, T. Kenmotsu, T. Nakajima,* M.M.S. Villamayor, H.J. Ramos, "Pseudo self-sputtering condition in a compact confronting planarmagnetron device"

5. M. M. S. Villamayor, *Y. Demura, T. Ogawa*, B. A. T. Suarez, *M. Wada*, H. J. Ramos, "Substrate temperature dependence of photoresponse and crystalphases of TiO2 deposited via dual plane magnetron"

6. M.S. Fernandez, *K. Doi*, G.M.Malapit, M.M.S. Villamayor, *M. Wada*, H.J. Ramos, "Performance of plasma cathode for a magnetized sheet plasma device"

b2. Papers presented at the 9th Asian-European International Conference on Plasma Surface Engineering (AEPSE), Jeju, South Korea, Aug. 25-30, 2013

1. Julie Anne S. Ting, Leo Mendel D. Rosario, Henry V. Lee Jr., Henry J. Ramos, and Roy B. Tumlos, "Hydrophobic coating on glass surfaces via application of silicone oil and activated using a microwave-induced atmospheric jet plasma" (Best Poster Award)

2. Kim T. Soriano, Leo Mendel D. Rosario, Ma. Camille M. Lacdan, Julie Anne S. Ting, Henry V. Lee, Jr., Henry J. Ramos, *Ma.Auxilia T. Siringan*, and Roy B. Tumlos, "Plasma disinfection of stainless steel infected with Candida tropicalis on a liquid medium"

3. Matthew D. Poral, Roy B. Tumlos, Leo Mendel D. Rosario, Henry V. Lee, Jr., Julie Anne S. Ting, Jenica Rosette Y. Uy, Aren Y. Centeno, and Henry J. Ramos, "Surface energy enhancement of high density polyethylene (HDPE) using microwave plasma pencil"

b3. Paper presented at the International Conference on Ion Sources, Chiba, Japan, September 9-13, 2013

1. M. A. J. Viernes, C. L. S. Mahinay, M. M. S. Villamayor, H. J. Ramos, "Photoresponse of silver-TiO_2 film"

b4. Papers presented at theJapan Society of Applied Physics (JSAP) and Materials Research Society (MRS) Joint Symposia, Kyoto, Japan, September 16-20, 2013

1. Aubrey Faith M. Mella, Henry J. Ramos, "Synthesis of Tin Oxide Thin Films on Silicon and Glass Substrates Using the Sheet Plasma Negative Ion Source"

2. Michelle Marie S. Villamayor, *Kenta Doi, Edna Mae D. Cruz, Freya Gay J. Avenir, Motoi Wada*, Henry J. Ramos, "A Compact Planar Magnetron Plasma Sputtering Device for TiO_2 Deposition"

b5. Papers presented at the66th Annual Gaseous Electronics Conference, Westin Hotel, Princeton, New Jersey, USA, September 30 - October 4, 2013

1. Janella Mae R. Salamania and Henry J. Ramos, “Thin Film Deposition of MAX Phase Nb-Al-C Compounds on Stainless Steel Substrates Using a Magnetized Sheet Plasma Source”

2. Matthew Bryan Villanueva and Henry J. Ramos, “Parameter Manipulation in the Synthesis of Ti-Cd-C Films via Reactive Sputtering in a Magnetized Sheet Plasma Facility”

b6. Paper presented at the66th Annual Meeting of the American Physical Society Division of Fluid Dynamics (APSDFD2013), Pittsburgh USA, November 24-26, 2013

1. L. Ma. Bo-ot and *L. Jirkovsky*, “Turbulence in Taylor-Couette Flow and a Molecule dependent Transport Equation”

b7. Papers presented at the 2nd International Conference on Integration of Science and Technology for Sustainable Development (ICIST 2013), Bangkok, Thailand, November 28-29, 2013

1. *J.J. Monserate, F. C. Sumera*, J. A. Daseco, K. G. Pabelina, H. J. Ramos, “ Surface Characterization of Argon Plasma Treated Electrospun P(HOLA-e-CL) Clay Nanofiber Composites”
2. *J.J. Monserate, C.C. Divina, N. M. Panajon, W. M. Concepcion, F. C. Sumera*, J. A. Daseco, K. G. Pabelina, H. J. Ramos, “ Effect of oxygen plasma treatment on the hydrophilicity of electrospunpolylactic acid-cellulose acetate nanofibers”

b8. Paper presented at the International Conference on Plasma Science and Applications, Nanyang Technological University, Singapore, December 4-6, 2013

1. Henry J. Ramos, Marcedon S. Fernandez, *Hamdi S. Barra*, Michelle Marie S. Villamayor, Janella Mae R. Salamania, Matthew Bryan Villnueva, and Rommel Paulo Viloan, “Enhancement Mechanisms of H^- Production and Suitable Configurations for Materials Processing in a Magnetized Sheet Plasma”

b9. Paper presented at the 8th Asia-Pacific International Symposium on t he Basics and Applications of Plasma Technology, Hsinchu, Taiwan, December 20-22, 2013

1. *Edna Mae D. Cruz, Freya Gay A. Jingco*, Michelle Marie S. Villamayor, Henry J. Ramos, “Synthesis and Characterization of Titania-coated Cheesecloth”

c. Local Conferences

c1. Proceedings of NSRI@30, UP Diliman, 25-27 March 2013 and Proceedings 2nd Materials of Value and Essence (MOVE) Symposium, October 18-19, 2013, Center for Innovative Materials in Emerging Applications, Mariano Marcos State University, Batac, Ilocos Norte

1. H. Ramos, C.F. Romero, J.K. Soriano, J.A. Daseco, K. Pabelina, L.M. Rosario, R. Tumlos, and *M.A. Siringan*, "Sterilization using atmospheric and dielectric barrier discharge plasmas"

c2.Proceedings of the 31th Physics Congress of the SamahangPisikangPilipinas, University of San Carlos, Cebu City, Philippines, October23- 25, 2013, ISSN 1656-2666, Vol. 10.

1. Aren Y. Centeno, Leo Mendel D. Rosario, Julie Anne S. Ting, Henry V. Lee Jr., Henry J. Ramos, *Daisy E. Taňafranca*, and Roy B. Tumlos, "Ar-N2 plasma treatment of polypropylene sheets via atmospheric microwave plasma pen (AMPP)"

2. L. Ma. Bo-ot and *L. Jirkovsky*, "Multivalued Behavior for the Two-Level System Using Homotopy Analysis"

3. Hannah Shamina O. Cosinero , Janella Mae R. Salamania, Hernando S. Salapare III, Henry J. Ramos, "Fourier transform infrared spectroscopy (FTIR) characterization and contact angle measurement of low energy hydrogen ion shower (LEHIS) treated polyethylene terephthalate (PET) materials"

4. A. R. Y Centeno, H. V. Lee. Jr., L.M.D. Rosario and R.B. Tumlos, "Comparison of the output power of a 2.45 GHz continuous wave magnetron using power meter and calorimetric measurements"

5. Michael Andrei Paguio, Leo Mendel Rosario, Marcedon Fernandez, Henry Ramos and RoyTumlos, "Effectof atmospheric plasma treatment on enhancing solderability in a copper sheet using a (lead-free) Sn-Ag-Cu alloys solder"

6. Matthew Bryan P. Villanueva, Janella Mae R. Salamania, Erin Joy C. Tinacba, Michelle S. Villamayor, *Armando S. Somintac*, Henry J. Ramos, "Optical Properties of Thin a-C films on Si(100) deposited via a Compact Planar Magnetron Plasma Device"

7. Venice Mascariňas, Aubrey Faith Mella, Julius Andrew Nunez, *Armando Somintac*, "Optical Analysisof Tin Oxide Thin Films Synthesized by Reactive Magnetron Sputtering"

8. *Edna Mae D. Cruz, Freya Gay A. Jingco*, Michelle Marie S. Villamayor, Henry J. Ramos, "Synthesis and Characterization of Common Cheesecloth Deposited with TiO_2 via Physical Vapor Deposition"

9. *Arjay C. Sura, HamdiMuhyuddin D. Barra*, Michelle Marie S. Villamayor, Rommel Paolo B. Viloan, and Henry J. Ramos, "Thin Film Sputtering Deposition of MAX Phase Ti_3SiC_2 on Polycarbonate Substrate using Methane as a Carbon Source"

10. *Arjay C. Sura*, *HamdiMuhyuddin D. Barra*, Rommel Paulo B. Viloan, and Henry J. Ramos, "Nonreactive sputtering deposition of Ti3SiC2 thin film on polycarbonate substrate using a magnetized sheet plasma source"

11. *Redentor S. Natividad*, *HamdiMuhyuddin Barra*, Rommel Paulo Viloan, Michelle Marie S. Villamayor, Henry J. Ramos, "Nb-Al-C: A compound belonging to MAX Phase deposited on Titanium Substrate via Magnetron Sputtering"

12. J. A. Daseco, K. G. Pabelina, *J. J. Monserate*, H. J. Ramos, "Effect of oxygen plasma treatment on the UV absorbance of electrospunpolylactic acid-cellulose acetate fiber mats"

D. Manpower trained

D.1 Bachelor of Science (BS) in Applied Physics

1.Venice Mascariñas, “Grain Size Manipulation of Silver Nanoparticles via Plasma Sputter-Type Negative Ion Source”, BS Applied Physics Thesis, University of the Philippines Diliman, April 2013.

2. Janella May Salamania, “Thin Film Deposition of MAX Phase Nb-Al-C Compounds on Stainless Steel Substrates Using a Magnetized Sheet Plasma Source”, BS Applied Physics Thesis, University of the Philippines Diliman, April 2013.

3. Matthew BryanVillanueva, “Synthesis of Ti-Cd-C Films via Magnetically-Enhanced Sputtering in the Sheet Plasma Negative Ion Source (SPNIS)”, BS Applied Physics Thesis, University of the Philippines Diliman, April 2013.

4. Erin Joy Tinacba,“Atmospheric Plasma Jet Applications on Enhancing Paint Adhesion of Stainless Steel and Cleaning of Oil-Contaminated Aluminum Surface”, BS Applied Physics Thesis, University of the Philippines Diliman, June 2013.

D.2 Master of Science (MS) in Physics/Materials Science and Engineering

1. Arnold Rey Gines , “Formation of Silicon Carbide Nanostructures via Maskless CF_4 Etching in a Gas Discharge Ion Source”, MS Physics Thesis, University of the Philippines Diliman, May 2013.

2. Rommel Paulo Viloan, “Carbide and DLC Synthesis Within the Ti-Al-C System via Sputter Deposition”, MS Materials Science and Engineering Thesis, University of the Philippines Diliman, August 2013.

3. Jason R. Albia, “Influence of C-defects on Enhanced Nucleation of Al and In on Si(100):2x1: A Kinetic Monte Carlo Study”,MS Materials Science and Engineering Thesis, University of the Philippines Diliman, October 2013.

D.3 Doctor of Philosophy (Ph. D.) in Physics

1. Hernando Salapare III, “Stability of Super-Surface Properties of Plasma-Treated Poly(tetrafluoroethylene) (PTFE) and *Posidoniaoceanica*materials”, Ph. D. Physics Dissertation, University of the Philippines Diliman, April 2013.

D.4 The laboratory hosted students and visiting researchers from various institutions throughout the year. The list is a summary of visitors.

1. Dr. Luis De Los Santos Valladares**,** Cavendish Laboratory, University of Cambridge, J.J. Thomson Av., Cambridge CB3 0HE, UK, June 2013

2. Visitors under the bilateral research agreement with the Japan Society for the Promotion of Science and the Human Resources Development Office, PCIEERD, DOST

March 6-9, 2013: Prof. Motoi Wada (Doshisha University, Kyotanabe, Kyoto, Japan*), Prof. Masaki Nishiura (National Institute for Fusion Science, Toki, Gifu, Japan)

March 1-12, 2013: Tomoya Ichikawa, AyuMizoguchi, HiromasaOhara, Naoki Yamada, Kenta Doi (all from *)

October 22-25, 2013: Prof.MamikoSasao (Doshisha University, Kyotanabe, Kyoto, Japan)

October 15-28, 2013: Tomoya Ichikawa, AyuMizoguchi, Kenta Doi, TanemuraYuusaku, Okano Yuuki, KouichiroTaniwaki, IwamuraReiya, Maeji Hiroaki (all from *)

3. Dr. Jang Do Il, May-July, 2013, Visiting Scientist, Jeju National University, Jeju, South Korea

4. On-the-job training of Polytechnic University students leading towards their baccalaureate thesis, June-October 2013

a) Arjay Sura
b) Redentor Natividad

5. Philippine Science High School Summer Internship Program, May 2013

a) Merimae Villamayor
b) Augustine Kane Guerra
c) Ymmanuel Gaffud

6. UP Open University Summer Course on Experimental Methods in Plasma Physics, May 2013

a) Edna May Cruz
b) Freya Gay Jingco
c) Joseph Hortezuela
d) Ruth Mary Fallesgun

7. UP College of Engineering research using plasmas

a) Ph. D. Chemical Engineering dissertation – Jay-Anne Aleno
b) B. S. Chemical Engineering thesis – Alexander John Cruz, Florence Jane Zurbano, Reynaldo Marquez, Jr., Larraine Doon, Paolo Nicolo Perez, Eric del Rosario

8. DOST- PCIEERD Faculty Immersion Program

a) HamdiMyuhuddin Barra, Professor, Mindanao State University, Marawi City, December 2012-May 2013
b) Giovanni Malapit, Professor, College of Science, UP Baguio, September 2013-March 2014

PREPARED BY:

Henry J. Ramos, Ph.D.
Coordinator

January 25, 2014