

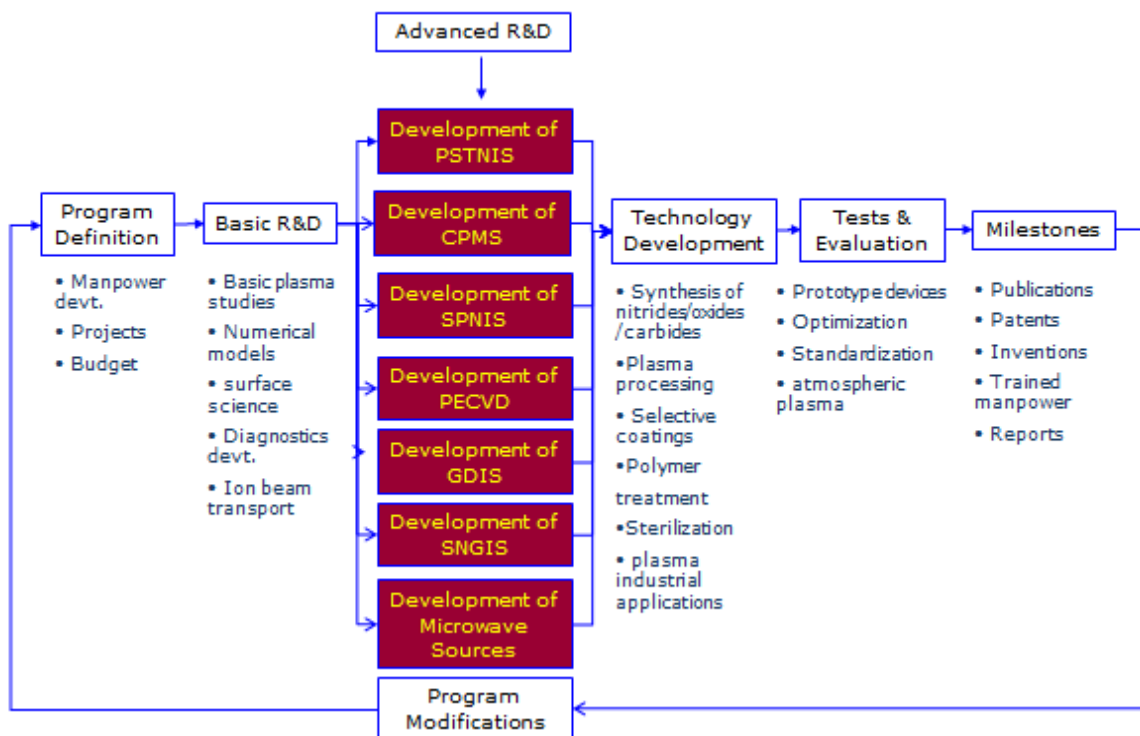
PLASMA PHYSICS LABORATORY
National Institute of Physics
College of Science, University of the Philippines
Diliman, Quezon City

ANNUAL REPORT 2014

A. Introduction

The laboratory continued implementation of its program supported in part by the Department of Science and Technology (DOST) and other agencies in 2014. It has completed the implementation of projects on MAX phase materials supported by the Philippine Council for Energy and Emerging Technology Research and Development (PCIEERD). It continued implementation of the second 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.

PLASMA PHYSICS LABORATORY PROGRAM FLOW



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. The following are the funded projects implemented in 2014.

Project A: Adhesion enhancements of metal and plastic surfaces with adhesives using microwave-induced atmospheric plasma jets

Total Funds: P6,850,713.50 (cost of equipment donation)

Source: IBF Electronic GmbH & Co. KG, Darmstadt, Germany

Duration: August 2010 – August 2014

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. The project will determine if plasma jet treatment of metals and polymers can achieve superhydrophilic surfaces using argon and argon-nitrogen plasmas.

Project B: Development of microwave-induced plasma jets

Total Funds: P1,966,423.00

Source: DOST-PCASTRD

Duration: September 2010 – September 2014

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.

Project C: 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 – April, 2014

The project aims to demonstrate the feasibility of locally developed PECVD for TiN deposition. It will create a metal composition - plasma parameter database specifically catering to the target market for the tool and die industry. Quality assurance testing of coated tools (hardness, thin film adhesion, thickness, surface morphology tests and parallel run testing in the industry) will be done. It will also promote TiN coating to semiconductor and other industries for various added value applications.

Project D: Physical vapor deposition of advanced MAX phase materials

Total Funds for 2012 : P 3,887,696.00

Source: DOST-PCASTRD

Duration: April 2012 – March 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 synthesis of new materials that possess 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.

Project E: 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 aims of the collaboration work are: a) build a dual planar magnetron (DPM) system and deposit nanostructured coatings of TiO₂ on appropriate material, b) tailor and optimize the parameters of synthesis for the preparation of a dense, strongly adhered, highly photo-catalytic TiO₂ and c) exchange training of graduate students and visits of faculty.

Project F: Development of plasma technology for the non-thermal sterilization of food products packaging and contact surfaces in food processing

Funding Source: Philippine Council for Industry, Energy and Emerging Technology Research and Development, Department of Science and Technology

Collaboration: PPL, MRSL, DFSN-CHE, PTD-ITD

Amount of Funding : PhP 4,305,958.50

Duration: June 1, 2014-May 31, 2015

This project is a pioneering effort in the local development of atmospheric plasma devices. This is in keeping with other international research laboratories and companies specializing on plasma applications specifically atmospheric plasmas due to their inherent advantages over traditional plasma sources. This study serves as an important and tangible bridge to industry serving as prototype of atmospheric plasmas for non-thermal sterilization of food products packaging Results of the study generated a database of operational conditions of the atmospheric plasmas which can easily be catered to potential contact surfaces in food processing.

Project G: Degradation of Methyl Blue via TiO₂ Physical Vapor Deposition on cloth

Funding Source: OVCRD

Amount of Funding : PhP 300,000.00

Duration: August 1, 2013-July 31, 2014

Nanostructured coatings and films of Titania are prepared on various cheap and easy materials like cloth and glass and modified in order to adapt the photocatalytic properties to the present chemicals. Titania can be tailored and optimized by preparation methods using a dual planar magnetron system in order to tune its band-gap properties to enable the treatment of specific pollution chemicals in the water, e.g. methyl blue. Initial results are featured in Asia Research New 2014: www.asiaresearchnews.com

Highlights

Publications of the laboratory in ISI-indexed international journals (8), non-ISI international refereed journal articles (4), proceedings of international (6) and local conferences (12) and papers presented in various other conferences (10) are summarized in Section C of this report. The laboratory trained two (2) undergraduate theses, three (3) graduate (masters) theses students and three Ph. D. dissertation students who were awarded their respective degrees in 2014.

Three senior staff (M. Vasquez, R. Tumlos and M. Villmayor) , and five (5) M.S. students (J. Daseco, J. K. Soriano, J. A. Nunez, V. Mascarinas, and E. Tinacba), 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.

C. 2014 Publications and Conference Papers Presented (*italicized authors are collaborators, otherwise affiliated with the laboratory*)

a1. ISI-indexed journals

1. H. S. Salapare, III, B. A. T. Suarez, H. S. O. Cosinero, M. Y. Bacaoco, H. J. Ramos, "Irradiation of poly(tetrafluoroethylene) surfaces by CF₄ plasma to achieve robust superhydrophobic and enhanced oleophobic properties of biological applications", *Materials Science and Engineering: C* **46** (2015) 270-275.

2. *Luis De Los Santos Valladares, Adrian Ionescu, Stuart Holmes, Crispin H. W. Barnes, Angel Bustamante Domínguez, Oswaldo Avalos Quispe, Juan C. González, Silvia Milana, Matteo Barbone, Andrea C. Ferrari, Henry Ramos and Yutaka Majima*, "Characterization of Ni thin films following thermal oxidation in air", *J. Vac. Sci. Technol. B* **32** (2014) 051808.

3. J. Albia, *M. Albao*, H. Ramos, "Adsorption and one-dimensional growth of Al and in chains on Si(100):2x1: A kinetic Monte Carlo Approach", *Adsorption Science and Technology* **30** (9) (2014) 749-758.

4. M. M. S. Villamayor, S. Kato, M. N. Soriano, M. Wada and H. J. Ramos, "Color-based tracking of plasma dust particles" *Phys. Plasmas* **21** (2014) 023703

5. J. A. S. Ting, L. M. D. Rosario, H. V. Lee Jr., H. J. Ramos, R. B. Tumlos, R. V. Fischer, "Studies on the use of the coaxial plasma bulb for enhanced wettability of aluminum and polymethylmethacrylate surfaces", *Vacuum* **103** (2014) 9–13.

6. M. M. S. Villamayor, Y. Hiramatsu, M. Wada and H. J. Ramos, "Transparent ZnO thin film deposition by a compact planar magnetron plasma device", *Jpn. J. Appl. Phys.* **53** (2014) 05FU02.

7. J. A. S. Ting, L. M. D. Rosario, H. V. Lee, Jr., H. J. Ramos, R. B. Tumlos, "Hydrophobic coating on glass surfaces of silicone oil and activated using a microwave atmospheric plasma jet", *Surface and Coatings Technology*, **259** (Part A) (2014) 7-11.

8. M. A. J. Viernes, C. L. S. Mahinay, M. M. S. Villamayor, and H. J. Ramos, "Photo response of silver-TiO₂ film", *Review of Scientific Instruments* **85** (2014), 02C318.

a.2. Non-ISI indexed international journals

1. K. G. Pabeliña, J. P. Hortezueta, R. M. P. Fallesgon, H. J. Ramos, "Wettability of plasma-treated fibers of Anahaw (*Livistona rotundifolia*), Buri (*Corypha elata*) and Pandan (*Pandanus amaryllifolius*)", *Advanced Materials Research* **894**, (2014) 154-157.

2. D. I. Jang, T. H. Ihm, Q. H. Trinh, J. O. Jo, Y. S. Mok, S. B. Lee, H. J. Ramos, "Surface Coating of Phosphor Powder Using Atmospheric Pressure Dielectric Barrier Discharge Plasma", *Appl. Chem. Eng.*, **25** (5) (2014) 455-462

3. J. J. Monserate, F. C. Sumera, J. A. Daseco, K. G. Pabeliña, and H. J. Ramos, "Surface characterization of Argon plasma treated electrospun P(HOLA-e-CL) clay nanocomposite" *International Journal of Agricultural Technology* **10** (1) (2014) 29-37

4. Henry J. Ramos, Michelle Marie S. Villamayor, Aubrey Faith M. Mella, Janella Mae R. Salamina, Matthew Bryan P. Villanueva, Rommel Paulo B. Viloan, "Enhancement mechanism of H₂ production and suitable configurations for materials processing in a magnetized sheet plasma", *Plasma Science and Applications (ICPSA 2013) International Journal of Modern Physics: Conference Series Vol. 32* (2014) 1460339 DOI: 10.1142/S2010194514603391

b. Proceedings of International Conference

1. M. S. Fernandez, K. Doi, G. M. Malapit, M. M. S. Villamayor, M. Wada and H. J. Ramos, "Performance of plasma cathode for a magnetized sheet plasma device", *Proceedings of the 12th Asia Pacific Physics Conference**, *JPS Conf. Proc.* (2014), 015085.

2. H. J. Ramos, *K. Doi*, M. S. Fernandez, G. M. Malapit, *M. Sasao*, M. M. S. Villamayor and *M. Wada*, "Sheet Plasma Configurations Suitable for Materials Processing", *, JPS Conf. Proc. 1 (2014), 015060.
3. M. M. S. Villamayor, *M. Wada*, H. J. Ramos, "Substrate Temperature Dependence of Photoresponse and Crystal Phases of TiO₂ Deposited via Dual Plane Magnetron", *, JPS Conf. Proc. 1 (2014), 015066
4. H. J. Ramos, *K. Doi*, M. S. Fernandez, G. M. Malapit, *M. Sasao*, M. M. S. Villamayor and *M. Wada*, "Sheet Plasma Configurations Suitable for Materials Processing", *, JPS Conf. Proc. 1 (2014), 015060.
5. G. M. Malapit, *J. I. L. Bugante*, C. L. S. Mahinay, *M. Wada*, and H. J. Ramos, "Effects of negative Ag ions on the surface of (200) single-crystalline MgO substrates", *, JPS Conf. Proc. 1 (2014) 015062.
6. J.-A. B. Aleño, H. J. Ramos, and *W. I. Jose*, "Determination of properties of yarns made from water hyacinth and pineapple indigenous fibers treated using plasma enhanced chemical vapor deposition (PECVD)", Proc. 5th International Conference on Chemical, Ecology and Environmental Sciences (ICCEES'2014) Jan. 13-14, 2014 Penang (Malaysia), pp 14-16.

b2. Papers presented at the 8th International Conference on Reactive Plasmas/ 31st Symposium on Plasma Processing, Fukuoka Convention Center, Fukuoka, Japan, February 3-7, 2014

1. Michelle Marie S. Villamayor, Julius Nuñez, *Motoi Wada*, & Henry J. Ramos, "TiO₂ macrocrystal deposition via Compact Planar Magnetron Sputtering Device"
2. Magdaleno R. Vasquez Jr., Henry J. Ramos, Motoi Wada, "Carbon fiber as hot cathode filament for carbon-based material synthesis".

b3. Papers presented at the 5th International Conference on Plasma Medicine, Nara Prefectural New Public Hall, Nara, Japan, May 18-23, 2014

1. Joanna Abigail Daseco, Karel G. Pabeliña, *Ma. Auxilia T. Siringan*, Henry J. Ramos, "Comparative study on the use of different metal electrodes in low pressure glow discharge plasma sterilization"
2. Joey Kim Soriano, Leo Mendel Rosario, *Ma. Auxilia T. Siringan*, Henry J. Ramos, Roy B. Tumlos, "Mold sterilization of contaminated oil-on-canvas paintings via microwave atmospheric plasma pencil (MAPP)"
3. Michelle Marie S. Villamayor, Julius Andrew P. Nunez, Jeremy G. Vicencio, Lani M. Suyom & Henry J. Ramos, "Antibacterial performance of magnetron sputtered TiO₂ thin films deposited at varying discharge current and deposition time"

b4. Paper presented at the 9th International Symposium on Contact Angle, Wettability and Adhesion, Lehigh University, Bethlehem, Pennsylvania, USA, June 16-18, 2014

1. Hernando S. Salapare III, *Ma. Gregoria Joanne P. Tiquio*, and Henry J. Ramos, "Plasma-treatment of neptune grass (*Posidonia oceanica*) to achieve superhydrophilic properties" (Invited Talk)

b5. Papers presented at the 36th International Symposium on Dry Process, Pacifico Convention Center, Yokohama, Japan, November 27-28, 2014

1. Erin Joy Tinacba, Julie Anne Ting, Leo Mendel Rosario, Henry Lee Jr., Henry Ramos and Roy Tumlos, "A study on the correlation of paint adhesion to surface wetting and roughness of stainless steel 304 modified using microwave atmospheric plasma jet"

2. Venice Mascariñas & Henry J. Ramos, "Deposition of silver nanoparticles via Plasma Sputter-Type Negative Ion Source"

3. Roy B. Tumlos, Michael Andrei Paguio, Aren Renz Centeno, Leo Mendel Rosario, Henry Lee Jr., Julie Anne Ting, Michelle Villamayor, Henry Ramos, and Luis Ma. Boot, "Microwave atmospheric plasma devices for enhancing hydrophilicity of surfaces"

c. Local Conferences

c1. Proceedings 3rd Materials of Value and Essence (MOVE) Symposium, October 22-24, 2014, University of the Philippines Baguio, Baguio City

1. H. Ramos, "From lab to market: the CoaTiNTM technology experience"

c2. Proceedings of the 32nd Physics Congress of the Samahang Pisika ng Pilipinas, National Institute of Physics, University of the Philippines Diliman, Quezon City, Philippines, October 17- 20, 2014, 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. Tañafra*, 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. Salamina, 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 Roy Tumlos, "Effect of 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. Salamina, 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 Mascariñas, Aubrey Faith Mella, Julius Andrew Nunez, *Armando Somintac*, "Optical analysis of 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 TiO₂ via physical vapor deposition"
9. *Arjay C. Sura, Hamdi Muhyuddin D. Barra*, Michelle Marie S. Villamayor, Rommel Paolo B. Viloan, and Henry J. Ramos, "Thin film sputtering deposition of MAX phase Ti₃SiC₂ on polycarbonate substrate using methane as a carbon source"
10. *Arjay C. Sura, Hamdi Muhyuddin 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, Hamdi Muhyuddin 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 electrospun polylactic acid-cellulose acetate fiber mats"

D. Manpower trained

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

1. Aren Renz Y. Centeno, "Enhanced Hydrophilicity of Polypropylene Sheets Treated with Ar and Ar-N₂ Plasma Using the Microwave Atmospheric Plasma Pen", BS Applied Physics Thesis, University of the Philippines Diliman, May 2014.
2. Jenica Rosette Y. Uy, "Disinfection of *Staphylococcus aureus* Biofilms Using Microwave Atmospheric Plasma Pen (MAPP)", BS Applied Physics Thesis, University of the Philippines Diliman, May 2014.

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

1. Joey Kim T. Soriano , “Restoration of fungi contaminated oil-on-canvas paintings via microwave atmospheric plasma pencil (MAPP) ”, MS Physics Thesis, University of the Philippines Diliman, April 2014.
2. Michael Andrei C Paguio, “Effect of atmospheric plasma treatment on enhancing solderability in a copper sheet using a (lead-free) Sn-Ag-Cu alloys solder”, MS Physics Thesis, University of the Philippines Diliman, March 2014.
3. Matthew D. Poral, “Ar/N2 Plasma Treatment of High Density Polyethylene via Atmospheric Microwave Plasma Pencil”, MS Physics Thesis, University of the Philippines Diliman, December 2014.

D.3 Doctor of Philosophy (Ph. D.) in Physics/Materials Science and Engineering

1. Michelle Marie S. Villamayor, “Planar magnetron plasma devices and applications”, Ph. D. Physics Dissertation, University of the Philippines Diliman, April 2014.
2. Karel G. Pabeliña, “Improving properties of cellulose-containing materials using low temperature plasma ”, Ph. D. Physics Dissertation, University of the Philippines Diliman, April 2014.
3. Julie Anne S. Ting, “Studies on the modification of the wetting characteristics of surfaces through low pressure and atmospheric microwave plasma activation processes”, Ph. D. Materials Science and Engineering Dissertation, University of the Philippines Diliman, April 2014.

D.4 The laboratory hosted 5 high school, 22 college students from local high schools and colleges on OJT, 10 foreign visiting researchers from Doshisha University and 8 foreign professors throughout the year. The list is a summary of visitors.

Name	Date
Shouma Kanda (Doshisha University)* Michihira Kitagawa * Ryou Tamura *	February 27 – March 10, 2014
Yuuki Okajima * Yasumasa Hashiguchi * Yuuki Haneji * Kota Ogino * Shohei Wada * Yuuta Watanabe * Tomoya Takahashi *	October 16 – October 28, 2014
Prof. Motoi Wada *	February 27 – March 1, 2014; April 1 – April 3, 2014
Prof. Mamiko Sasao * and Tohoku Univ.	October 16 – October 21,

Prof. Junji Fujita	Stray Cats+ and Nagoya Univ.	2014
N. Sugimoto	+	
H. Hayashi	+	
K. Ishikawa	+	
H. Yamamoto	+	
S. Yamaoka	+	
Andres Philip Mayol (DLSU ME Department)		May 2014 – September 2014
Louie Moran (DLSU ME Department)		
David Lingan (DLSU ME Department)		
Joric Alimon (DLSU Manila ME Department)		
Yustin Torreno (PSHS Central Mindanao Campus)		April 21 – May 16, 2014
Fadel Barombongan (PSHS Central Mindanao Campus)		
Dominique Gocal (PSHS Main Campus)		
Nanette Doroja (PSHS Main Campus)		
Ar Jay C. Sura (PUP Sta. Mesa)		April 10, 2013 – March 8, 2014
Redentor S. Natividad (PUP Sta. Mesa)		
Juvy Monserate (CLSU)		2013 – Present
Rogel Jan Butalid (UPD DMME)		October 2014 – Present
Azelea Coleen Salcedo (UPD DMME)		November 2014 – Present
Ian Daniell Santos (UPD DMME)		November 2014 – Present
Ann Elizabeth Rollon (UPD DChE)		November 2014 – Present
Estelle Diane Jose (UPD DChE)		
Ernest Nathan Nogales (UPD DChE)		
Alex Kevin Marc Alonzo (UP Baguio)		February – October 2014
Sushmita De Guzman (UP Baguio)		
Nescy Leann Galban (UP Baguio)		
Meica Ombao (UP Baguio)		
Paolo Martin Litonjua (British School Manila)		July 2014 – Present
Jeremiah Chan (UPD DMMME)		October – November 2014

PREPARED BY:



Henry J. Ramos, Ph.D.
Coordinator
January 25, 2014