Instructional Resources for a Technician-Level Plasma Technology Course

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Abstract

Text materials, training systems, and supporting laboratory exercises have been developed by Portland Community College to support a technician-level course in plasma technology. Faculty workshops are planned for 2003 and 2004 to equip community college faculty to teach technician-level courses in plasma technology. The project is funded through an Advanced Technological Education Program grant from the National Science Foundation.

Introduction

Plasma technology, although not as pervasive in the wafer fab as vacuum technology, is essential to the manufacture of integrated circuits. Plasma-based tools are used to clean the surface of wafers, deposit materials on wafer surfaces, etch surface layers, and implant dopant atoms into the wafer itself.

Despite the growing importance of plasma-aided manufacturing in semiconductor and surface coating industries, only a small number of community colleges have developed plasma technology courses or integrated plasma technology topics into other related technology courses. Even those technical programs with stand alone plasma technology courses are struggling to fully implement their courses. Major roadblocks to implementation of technician-level plasma technology courses at the community college level include the lack of suitable textbooks, lack of plasma training systems, and lack of faculty expertise in this emerging technology.

Portland Community College, through an Advanced Technological Education Program grant from the National Science Foundation, DUE 0101533, is addressing this need for instructional resources and faculty enhancement opportunities. The project aims to create technician-level instructional materials, prototype plasma training systems, and host workshops for community college faculty.

Context

Because of the interplay of multiple disciplines in the study of plasma-aided manufacturing, the design and placement of a plasma-aided manufacturing course in an associate degree program is critical.¹ By necessity, a plasma technology or plasma-aided

manufacturing course must be placed near the end of the program of study, allowing students sufficient time to lay a foundation in the disciplines of chemistry, physics, electronics, mathematics, vacuum technology, and semiconductor manufacturing processes. Figure 1 shows the disciplines that are fundamental to the study of plasma-aided manufacturing.

Figure 1. Disciplines that are fundamental to the study of plasma-aided manufacturing.

Course Design

Four learning outcomes drive course design.

At the end of the course, students will be able to:

1. Configure, operate, maintain, and troubleshoot plasma-aided manufacturing systems.
2. Practice safe operating and testing procedures.
3. Work effectively in teams.
4. Communicate technical and non-technical information in oral and written form.

To achieve the four course outcomes listed above, course design must focus on highly integrated lecture and laboratory components of the course and in fact, the lecture lays the foundation for the laboratory exercises. Course formatting varies from college to college and program to program.

PCC's MT 240 RF Plasma Systems course is configured as a 3 quarter credit course. It is required for the associate of applied science degree in Microelectronics Technology. Prerequisite coursework includes MT 223 Vacuum Systems, CH 221/222/223 General Chemistry, and MT 111/112 Electronics Circuits & Devices I and II. A co-requisite course is MT 200 Semiconductor Processing I.

Students meet for two lecture hours per week and three laboratory hours per week over a period of 11 weeks. Time allocation to six topical areas is summarized in Table 1.

Table 1. Time Allocation by Topical Area.

Topical Area	No. of Weeks	Lecture Hours	Lab Hours
Electric Circuits	1	2	3
Plasma Physics	2	4	6
Transmission Lines	2	4	6
RF Power Delivery	2	4	6
Sputtering	2	4	6
Assessment*	2	4	3
TOTAL	11	22	30

* Assessment includes Final Exam

Text-Based Materials

The material covered in this course is scattered throughout the current literature and finding one text that covers the diverse topics for the plasma technology course is impossible.

There are a couple dozen technician-level electric circuits texts on the market. Established authors include Boylestad and Floyd.^{2,3} These textbooks cover the operation of R, L, and C at low frequencies and do not present equivalent circuits of these components that can support a study of power delivery to a process chamber.

Plasma physics is covered in specialized texts on glow discharge processes and industrial plasma engineering.^{4,5} The coverage is much broader and has more depth than would be required in a technician-level plasma course.

Transmission line fundamentals are covered in most technician-level electronic

communication texts.^{6,7} The coverage focuses on radio transmission and includes both RF and microwave systems. Impedance matching networks focus on those used in the communications industry rather than in industries such as semiconductors.

And finally, semiconductor manufacturing processes are described in yet another set of texts by authors such as Quirk and Serda, and Wolf.^{8,9} These texts cover the full range of processes used in the manufacture of integrated circuits while a plasma technology course would have time to cover only one of the manufacturing processes.

Hence, the solution to text-based materials for a technician-level plasma technology course is to gather relevant material from these varied sources and adapt them to focus on aspect most appropriate to plasma-aided manufacturing and eventually publish a new textbook that include the requisite topics.

Laboratory Exercises

Much work has been devoted to developing a series of graduated exercises that could support a technician-level, plasma technology course. The following summaries include sample laboratory exercises developed to date:

- **Electric Circuits.** Laboratory experiments on impedance measurement utilize a MFJ-259B SWR Analyzer (distributed by MFJ Enterprises, Inc.). Using the MFJ-259B, students can study the impedance variation of resistors, capacitors, and inductors in the range of 2 MHz to 170 MHz.
- **Plasma Physics.** Laboratory exercises focus on the optical and electrical characteristics of a plasma. Optical studies use an Ocean Optics USB-2000 Fiberoptic Spectrometer to obtain intensity versus wavelength graphs of the light emitted from gas discharge tubes. Langmuir probes are used to obtain current versus voltage graphs for a low-pressure plasma.
- **Transmission Lines.** The MFJ-259B is used to study the impedance transformation properties of coaxial cable. Pulse generators and oscilloscopes provide the instrumentation for velocity of propagation and reflection studies.
- **RF Power Delivery.** The MFJ-259B can be used to show the impedance matching function of a matching unit. Bird wattmeters support measurement of forward and reflected power.
- **Sputtering.** A MKS PPTS-1A Plasma Trainer is used to sputter copper onto glass disks. System maintenance and troubleshooting exercises can be performed on the plasma trainer.

Equipment/Training Systems

The selection and acquisition of equipment to support a plasma technology course is critical to successful implementation. In the case of our plasma technology course, two pieces of equipment have been most useful: (1) the MFJ-259B SWR Analyzer and (2) the MKS PPTS-1A Plasma Training System. The MFJ-259B supports laboratory exercises in electric circuits, transmission lines, and matching units. The MKS PPTS-1A Plasma Training System provides a small, table-top system for sputtering as well as system maintenance and troubleshooting exercises.

The MFJ-259B HF/VHF SWR Analyzer is a compact RF impedance analyzer. The unit combines four basic circuits: a 1.8 – 170 MHz variable frequency oscillator, a frequency counter, a 50-ohm RF bridge, and an eight-bit microcontroller. The unit makes a wide variety of useful impedance measurements from a few ohms to several hundred ohms.¹⁰

The PPTS-1A Plasma Process Training System consists of a 6-inch ID chamber fabricated from a standard 6-inch ISO cross. The forward horizontal port has an access door and view port. The rear horizontal port has the pump connections and tabulation for a 1-Torr full-scale Baratron manometer. The bottom port has mounting hardware for the wafer-substrate platform. The top port has a central Ultratorr-type fitting for the shank of the magnetron sputtering gun and VCR attachments for the Pirani pressure gauge and mass flow controller. The cathode is a four-inch diameter electrode of the magnetron configuration and is powered by a 300-watt, Manitou Systems, 13.56 MHz RF generator and manual match.¹¹

Figure 2. The MKS PPTS-1A Plasma Training System.

Project Status

Thirty second-year, Microelectronics Technology students are enrolled in PCC's MT 240 RF Plasma Systems course Winter Term of 2003. Initial drafts of the text-based materials are being used as the required textbook for the course. The laboratory exercises are being performed in the laboratory.

Equipment is being installed as the course is being taught. To date, seven MFJ-259B SWR Analyzers are available. Two MKS PPTS-1A Plasma Training Systems are being installed and four additional trainers are ordered. Additional equipment includes three

Bird wattmeters and dummy loads for power measurement exercises.

Faculty workshops are being planned for 2003 and 2004. The workshops will be hosted by Portland Community College and held at PCC's Washington County Workforce Training Center. Community college instructors interested in participating in these workshops should contact David Hata at Portland Community College (Phone: 503-533-2929 or e-mail: dhata@pcc.edu).

References:

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