Syllabus: Advance Laboratories.

UNIVERSITY OF PUERTO RICO
RÍO PIEDRAS CAMPUS
COLLEGE OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

Title: Advance Laboratory II.
Code: PHYS 6406-OU1
Number of Credits: 6
Prerequisites: Permission of the Graduate Committee

Description
Advance Laboratories. Development of the basic statements including the various representations and 'pictures' of experimental and theoretical research studies. Detailed consideration of modern experimental and theoretical.methods. Study of methods of data analysis, creation of modeling analysis of experimental data etc.

Objectives
Through this course, the students will:

- Acquire a basic understanding of the modern experimental technique, methods of experimental system setup meaning study of basic statements of modern experimental setup designee, analysis of possible artifact creation during of experiment, application of such knowledge to correct data measurement, technical realization of correct data obtaining and analysis.
- Become proficient with the experimental and theoretical tools of the Advance Laboratories.
- Develop problem-solving skills and strategies in basic Advance Laboratories.
- Communicate effectively a topic pertinent to basic of Advance Laboratories.

Course Contents and Time Distribution

Chemical vapor deposition (CVD) and complete characterization of BN nanolayers (white graphen)

I. Introduction (1 wks)
II. Learning and preparation of the CVD system used for BN nanolayer deposition. Preparation of substrates and system calibration (temperature of ammonia boron complex sample area and carrier gas flow). (2 wks)
III. Deposition of BN nanolayers on different substrates. (3 wks)
IV. Characterization of optical properties of BN nanolayers deposited on the fused silica substrates.(2wks)
V. TEM and SEM measurements. (2 wk)
VI. AFM measurements. (1 wk)
VII. XPS measurements (1 wk)
VIII. FTIR spectra measurements (1 wk)
IX. Raman spectra measurements. (1 wk)

Detailed research plan is represented below

Instructional Strategies
Students will learn experimental technique and carry out real research work, results of which is research report. If new and interesting data will be obtained, students will work with manuscript for publication in research journal.

Minimum Required Facilities
Laboratory Dr. Morell (FB146), commercial furnace tube (FT), ammonia boron powder, etc.

Student Evaluation
Final research report and oral presentation.

Grading System
Standard A to F grading system:
100-90% = A, 89-80% = B, 79-70% = C, 69-60% = D, 59-0% = F.

Rights of Students with Disabilities
UPR complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act 1990 (ADA) and the Commonwealth of Puerto Rico Law 51. Students receiving services through R http://www.sciencedirect.com/science/book/9780124177550 Rehabilitación Vocacional must contact the professor at the beginning of the semester in order to plan for a reasonable accommodation and any required support equipment according to the recommendations given by the Oficina de Asuntos para las Personas con Impedimentos (OAPI) of the Dean of Students. Likewise, students with special needs that require some type of accommodation must contact the professor.

Advance laboratory
Work plan

I. BN nanolayers deposition on Cu, Si and fused silica surfaces:

Protocol of substrate cleaning

1. Cu foil piece 2×2 cm^2 or commercial substrate with 12.5 mm diameter put in biker (50 ml) and add 20 ml of isopropanol (or acetic acid);
2. Add to biker 15 mg of diamond powder;
3. Ultrasonificate sample during 20 min;
4. Take out from biker Cu “substrate, and put in biker second one. Repeat ultrasonification for the second substrate, etc. for total set of 6 substrates.
5. Ultrasonificated substrates wash by water and then by isopropanol.
6. Dry substrates at 100^{o}C temperature during 30 min.
7. For Si amd fused silica substrates, the same procedures (1) – (6) should be carried out.

Protocol of BN nanolayer deposition

1. Input 1 substrate in active area of furnace tube (central area of FT);
2. Put inside FT in gas inlet area aluminum foil diaphragm (d = 2 mm). Distance between inlet end of FT to diaphragm is variable parameter with approximated value 10 cm.
3. Insert in the inlet end of FT alumna/fused silica boat with ammonia-boron powder (5 g).
4. Adjust Ar gas flow through FT 100 ccm at pressure 300 Torr.
5. Setup FT for temperature program: from room temperature to 1000^{o}C with temperature growth rate of 50^{o}C/min.
6. Keep 1000^{o}C temperature in active area of FT during 1 hour.
7. During FT heating time (approximately 20 min) heat inlet area of FT, where ammonia boron sample is located, till 90^{o}C.
8. After finishing experiment turn off all equipment keeping gas flow turned on till system will be thermalized.
9. Move out substrate and save it.

10. Repeat such experiments for other substrates at different temperatures of ammonia boron evaporation: 60, 70, 80, 100 and 110^{o}C.

II. Repeat such deposition procedure of BN nanolayer deposition on Si substrates (12.5×12.5 mm^2) and fused silica (d = 2 cm) substrates.

III. Carry out characterization of the BN thin films bymeasurements of:
   a) Raman;
   b) FTIR spectra;
   c) XRD spectra;
   d) XPS;
   e) SEM images;
   f) TEM and HRTEM images.

IV. Measurements of optical absorption spectra of the BN thin films deposited on the fused silica substrates;

V. For measurements of rigid UV emission (quant energy is about 6 eV) of the BN samples deposited on the Cu substrate, we will send such samples to Dr. Wojeciech (Ohio University). he will carry out measurements of BN nanolayer emission induced by electron beam with electron energy of about 10 – 15 eV. Such measurements are addressed to practical application of BN nanolayers in luminescence lamps, where mercury can be substituted by Cu/BN nanolayer electrodes, if rigid UV yield in the case of BN is higher than 0.3.

VI. In UPR, we will carry out measurements of UV emission of BN nanolayers deposited on fused silica substrates. Emission will be induced by pulsed radiation of the fourth harmonic of YAG laser (wavelength 266 nm; quant energy is 4.65 eV). Quant energy in this case is less than energy gap in BN, but expect that at high power density of the used laser radiation, we create two photon emission excitation processes. In this case, we are going to estimate emission quantum yield of UV with energy around 6 eV, and measure time evolution of such emission, if emission lifetime is longer than 20 ns (laser pulse duration is around 10 ns).

VII. Fabricate Cu-BN-Dye interface and check photovoltage activity.

VIII. Fabricate AlN –Graphen –BN –dye interphase and check photovoltage activity.

IX. Fabricate Cu-BN-Graphen-dye and check photovoltage activity.

Protocol of gtaphen deposition

1. Using protocol for BN deposition deposite graohene on the same substrate used for BN deposition, but replace material sourse from ammonia boron complex to naphtalen powder/ Deposition carry out at the same experimental conditions.
2. Deposite graphen on the BN surface of selected samples prepared earlier.
3. Carry out complete characterization of the fabricated samples.
4. Investigate current – Voltage characteristics of the BN-graphen interphases.

Notice: This is very broad plan of work, and it is not possible to make all this work during one semester, but as least, if we can carry out I – V steps, it will be enough for preparation of good research report. The last step, we will carry out later – may be in summer.