National Cheng Kung University

Department of Materials Science and Engineering

Course Syllabus

Fall Semester, 2025
Instructor: Dr. Kao-Shuo Chang
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Course name: Combinatorial Materials Synthesis and Application
Course classification: Elective
Course number: N554500 (3 credits)
Course hours: 9:10-12:00, every Wed.
Course office hours: By appointment
Course prerequisites: Thin films related background
Classroom: New Dept. Bldg. of Material Eng. 44124
Course web: https://ctrl2010.wixsite.com/44806
https://moodle.ncku.edu.tw/

Course outline

Combinatorial methodology is a new paradigm in the materials technology. The key feature of this technique is high throughput screening of new functional materials, a more efficient strategy than the traditional one-composition-at-a-time approach. Combinatorial manufacturing, characterization, applications, and designs will be addressed in this class. A basic introduction of combinatorial methodology (what, why, where, and how) will be focused in the beginning. Then a variety of applications in the literatures will be highlighted later in the second half of the semester. The student will be highly encouraged to design an experiment for the new materials system using the knowledge they have learned in the class. Depending upon the feedback from the student, the listed contents are subject to change accordingly.

Course objectives

1. Understand the features of combinatorial methodology.

2. Understand how to use combinatorial methodology to explore new materials.
3. Understand how to make and analyze combinatorial samples, and interpret a huge amount of data systemically.
4. Understand the importance of establishing databases of materials under study.
5. Develop the capability to explore new materials using combinatorial methodology.

Course topics

1. A basic introduction of combinatorial methodology
    a. What is it?
    b. Why do we need it?
    c. How do we carry it out?
    d. Where is it applied?

2. How to incorporate combinatorial methodology in the field of thin film deposition?
    a. Chemical vapor deposition (CVD)
    b. Physical vapor deposition (PVD): Combinatorial pulsed laser deposition (PLD), Combinatorial sputtering, Combinatorial e-beam deposition, Combinatorial laser molecular beam epitaxy (MBE)

3. Characterization scanning tools
    a. How to develop a rapid screening tool to meet the criteria for the application of combinatorial methodology?
    b. Scanning x-ray microdiffractometry, electron probe wavelength dispersive spectroscopy (WDS), high resolution transmission electron microscopy (HRTEM), x-ray photoelectron spectroscopy (XPS), scanning ellipsometry, and scanning electrical probe, …

4. Applications: electronic thin films
    Combinatorial methodology applied in a variety of functional materials: ferroelectrics, ferromagnetics, microwave materials, magnetoelectric materials, photoluminescent materials, wide band-gap semiconductors, advanced gate stacks, …

5. Design an experiment for new materials system using combinatorial methodology.

Course textbooks

1. Combinatorial materials synthesis, Xiao-Dong Xiang, and Ichiro Takeuchi.
2. Combinatorial pulsed laser deposition of functional metal oxide thin films, Kao-Shuo Chang, Ph.D. Thesis, 2004.
3. MRS Bulletin, Vol. 27, No. 4, April 2002.

4. Materials Science of Thin Films, Milton Ohring, 2rd edition.

Course evaluation

- Self-introduction: **10 %**
  3 **min/each (including Q&A)**

- 1St oral presentation: **30 %**
  10 min/each (including Q&A)

- Final oral presentation: **50 %**
  (1) Total 33 students
  (2) (25 **+ 10) min/each team (including Q&A)**
  (3) Questions raised during the students' presentations will be awarded as extra points, which will be directly added to their final scores.
  (4) Evaluation from myself: 70% and from students: 30%

- Attendance (first and final presentations): **10%**
  Absence is subjected to score deduction.

Course schedule (tentatively)

Week	Wed. (9:10~12:00)	Content
1.	9/10	
2.	9/17	
3.	9/24	Self-introduction
4.	10/1	Self-introduction
5.	**10/8**	Self-introduction
6.	10/15	
7.	10/22	
8.	**10/29**	1st presentation
9.	11/5	1st presentation
10.	**11/12**	1st presentation
11.	11/19	
12.	11/26	
13.	12/3	
14.	12/10	Final presentation
15.	12/17	Final presentation
16.	12/24	Final presentation
17.	12/31	
18.	1/7/25 (no class)	Final Exam Week (1/5 ~ 1/9/25)