# SYLLABUS
# MASTER IN MATERIALS SCIENCE

## A. Compulsory Courses of Master by Research Programs

### 1. Course: General Materials Science

**Code / Credits / Prerequisites: SCMS801101 / 4 Credits / -**

**Objective:**

The aim of this course is to provide a basic understanding and broad scope of materials science. Debriefing general materials science can make it easier for participants to follow other subjects in more detail and depth according to the topic to be taken

**Subjects:.**

This course discusses the nature and structure of atoms and crystals of materials, electronic configurations, chemical bonds, metallic, covalent, crystallographic foundations, impurity of materials, impurability in materials, dislocations and interactions, and defects on the surface. This section also describes the types of failure in materials such as fatigue, brittle creep faults and embrittlement. Surface energy, ceramics vitrification and the sintering process are also discussed. Diffusion theory, magnetic properties in materials, dielectric materials, electronic materials, ceramics, polymers and composites are also discussed.

**Bibliography:**


- William D. Callister, Jr., Materials Science and Engineering: An Introduction, Third Edition, Toronto, John Wiley & Sons, Inc., 1994
- Lawrence H. Van Vlack, Materials Science for Engineers , Sixth Printing 1975, Amsterdam, Addison-Wesley Publ.Co


### 2. Course: Materials Thermodynamics

**Code / Credits / Prerequisites: SCMS801102 / 3 Credits / -**

**Objective:**

The materials thermodynamics course discusses state functions, process variables, intensive and extensive properties of materials. Specifically, the notion of the use of parallel differentials in thermodynamics is discussed, equilibrium criteria and analytic relationships of several variables related to materials thermodynamic processes.

**Subjects:**

Use of the first thermodynamic law, work concept, equation of state, application of the second law of thermodynamics, heat capacity, Joule-Thompson calculation, binary phase diagram with application of Claussius-Clapeyron equation, concept of vapor pressure, enthalpy calculation, entropy, Gibbs free energy , Gibbs-Helmholtz equation, specifically thermodynamics statistics which are related to the randomness of entropy. Binary system and phase diagram calculation, using Elingham diagram, calculation of activity coefficients, fugacity concept, Raoult's law. Henry's law concerning the deviation of the nature of ideality, as well as calculating the equilibrium coefficient for metallurgy process reactions. The third thermodynamic law, empirical rules from Richard and Trouton, multi-component systems, oxidation processes, Gibbs-Duhem equations and ternary phase calculations, the concept of surface energy and the process of crystal defects occurring by thermal processes, and calculation of materials resistivity.

**Bibliography:**


- David V. Ragone: Thermodynamics of Materials, Vol I and Vol II, John Wiley & Sons, 1995
- Gaskel, Introduction to Metallurgical Thermodynamics , 3rd ed., London: Taylor & Francis, 1995
- Swalin, Thermodynamics of Solid , Hoboken, New Jersey: Wiley, 1972
- R. Q. DeHoff, Thermodynamics in Materials Science , McGraw-Hill, 1993


### 3. Courses : Crystallography of Materials and Diffraction Techniques

**Code / Credits / Prerequisites: SCMS801103 / 3 Credits / None**

**Objective:**

Provide the basics of crystallography and diffraction techniques.

**Subjects:**

History and understanding of crystallographic science, aspects of crystal geometry and crystal structure, crystalline symmetry, space group and group groups, x-rays, initial studies of crystal system determination, scattering intensity, determination of lattice parameters for powder methods, x-ray diffraction on polycrystalline and amorphous, modeling on data analysis (example: rietveld smoothing method), other diffraction techniques (neutron diffraction, electron diffraction, SAXS), and similar techniques (SEM / EDAX, XRF, EXAFS)

**Bibliography:**


- BD Cullity and SR Stock, Element of X-ray Diffraction , Prentice Hall, 2001
- FC Phillips, An Introduction to Crystallography , Longman, London, 1970
- C. Suryanarayana and M. Grant Norton, X-ray Diffraction a Practical Approach , Plenum Press, 1998
- Q. Hahn (editor), International Table for Crystallography, Reidel, Dordrecht,
- AR West, Solid State Chemistry and Its Application, John Wiley & Sons, 1995
- C. Giacovazzo et al., Fundamental of Crystallography, IUCr, Oxford Science, 2001
- EF Kaelble (ed.), Handbook of X-rays: for diffraction, emission, absorption and microscopy , McGraw-Hill Book Company, New York, 1967


4. **Course : Materials Phase Transformation**

**Code / Credits / Prerequisites: SCMS801104 / 3 Credit / None**

**Objective:**

Students are expected to be able to know the principle of materials preparation, especially metals and alloys and generally inorganic materials and the process of forming materials phases, especially through thermal processes, understanding the phenomena that occur in materials during thermal applications including diffusion problems and phase transformation kinetics; understand the principles and applications of phase diagrams, TTT diagrams or IT and CCT (Continuous Cooling Transformation) diagrams and techniques for determining transformation phase fractions. This learning is expected to improve students' analytical skills in processing their research results related to the problem of phase transformation in materials.

**Subjects:**

In this course, the first concept of materials preparation includes the principle of conservation of mass in materials composition, composition conversion between percent atom (at.%) And weight percent (wt.%) And vice versa and introduced materials preparation techniques such as arc melting, induction melting , solid state reaction or powder metallurgy etc. An overview of several topics in classical thermodynamics will be carried out to understand the mechanism of formation of materials phases in the solidification process. The thermodynamic concepts will also be used for understanding the phase diagrams as well as the analysis of transformations in one-component and multi-component systems. The students are taught how to read, analyze (take the case of the Fe single-component system and the Fe-C binary system) and construct the phase diagram from thermodynamic data.

The next discussion is a review of the basic concepts of kinetic phenomena in the materials including understanding the diffusion mechanism and diffusion theory (Fick I and II) followed by a physical review of the basic transformation kinetic equation (Avrami) and its application especially in constructing Time Temperature Transformation (TTT) or Isothermal Trans (IT) diagrams. Several methods of determining the phase fraction of transformation are also introduced in detail.

**Bibliography:**


- DA Porter and KE Easterling, Phase Transformations in Metals and Alloys , Van Nostrand Reinhold, New York, 1981
- AK Jena and MC Chaturvedi, Phase Transformations in Materials, Prentice Hall, New Jersey, 1992


5. **Course: Technical Economics**

**Code / Credits / Prerequisites: SCMS801105 / 2 Credit / None**

**Objective:**

Provide insights to students who have a non-financial background to understand the concept of investment, business feasibility, business risk, business value, shareholder value, management of corporate wealth, long-term funding strategies, short-term funding strategies, understanding the market conditions of financial markets capital and financial markets, macroeconomic conditions in Indonesia. This learning is expected to improve the analytical skills and abilities of students' management decision making in the business activities that they will later engage in.

**Subjects:**

Company financial statements, earnings (loss), cash flow reports, project feasibility studies or investment activities, how to determine Free Cash Flows to Free Cash Flows to Equity, calculate the Net Present Value of

free cash flows, determine the value of the company, shareholder value, review the conditions of the capital market and money market in Indonesia.

6. **Course : Advanced Laboratory Work**

**Code / Credits / Prerequisites: SCMS801106 / 3 Credits / SCMS801101**

**Objective:**

Students are expected to be able to understand how to work, use, analyze data on several analytical equipment such as DTA-DSC, XRD, SEM / EDAX, FTIR, XRF. At the beginning of the semester students are given *unknown samples* to be identified qualitatively and quantitatively with appropriate tools.At the end of the semester students are required to make a report and present the results obtained.

**Subjects:**

Introduction (overview, assignment, group division, sample preparation), How to work and XRD and XRF analysis; How it works and analyzes the Optical Microscope, SEM / EDS; Optical Spectroscopy (UV-vis, IR, AAS); Thermal Analysis (DTA-DSC); XRD and XRF Practicum; Structure Analysis with XRD; GSAS; How it works and Analysis with SEM; How to work and analysis with FTIR; SEM Practicum; Practicum FTIR or DTA / DSC; Analysis and Presentation.

**Bibliography:**


- C. Suryanarayana and M. Grant Norton, X-ray Diffraction a Practical Approach , Plenum Press, 1998
- HH Willard, LI Merrett Jr., JA Dean and FA Settle Jr., Instrumental Methods of Analysis , Wadsworth Publishing Company, Belmont, 1988
- Robert D. Braun, Introduction to Instrumental Analysis , McGraw-Hill Editions, 1987
- L. B. McCusker et al., Rietveld Refinement Guidelines , J.Appl. Cryst., 32 , 36-50, 1999
- Allen C. Larson and Robert B. Von Dreele, GSAS: General Structure Analysis System , LAUR 86-748, Los Alamos National Laboratory, 1998
- http://www.ncnr.nist.gov/programs/crystallography/software/downloads.html
- M. Hikam, Training Running GSAS , Lecture Notes for Materials Science Study Program, 2006


7. **Course: Seminar**

**Code / Credits / Prerequisites: SCMS802101 / 4 Credits / SCMS801101**

**Objective:**

Equip students to be able to make good research proposals, thesis writing, written and oral communication, presentation presentation techniques and giving presentation exercises.

**Subjects:**

Writing proposals, writing theses, procedures for oral and written communication, practice presentations.

**Bibliography:**


- Effionora (ed.), Guidelines for Making Theses and Dissertations at FMIPA UI , UI-Press, 2006


8. **Course: Scientific Seminar**

**Code / Credits / Prerequisites: SCMS802001 / 2 Credits /**

**Objective:**

To disseminate the results of their research, students are required to present their work in a reputable international / international scientific seminar.

**Subjects:**

Presentation framework, background, research scope, experimental methods, results and conclusions.

9. **Course: Thesis Defense**

**Code / Credits / Prerequisites: SCMS802002 / 8 Credits / Already ≥ 34 credits**

**Objective:**

A research process so that students can write scientific work at the end of the study period of the master's program in Materials Science and present in front of a board of examiners.

**Subjects:**

Research, writing and final presentation of students under the guidance of one or two counselors.

**Bibliography:**


- Effionora (ed.), Guidelines for Making Theses and Dissertations at FMIPA UI , UI-Press, 2006


## Elective Courses

1. **Courses: Corrosion and Materials Protection**

**Code / Credits / Prerequisites: SCMS801107 / 3 Credits / SCMS801101**

**Objective:**

Students are expected to be able to know the principle of corrosion, corrosion mechanism, type of corrosion, type of corrosion that occurs, corrosion prevention and analysis of the occurrence of corrosion in the materials.

**Subjects:**

Principles of Corrosion, Thermodynamics Electronicsimia Corrosion and Potential Electrodes, Electrochemical Kinetics Corrosion, Passivity, Corrosion Measurement Methods, Galvanic Corrosion, Pitting and Crevice Corrosion, Environmental Effects, Metallurgical Structure Effects, Hydrogen Effect, Erosion and Wear Resistance, Selective Corrosion, Selective Corrosion, Atmospheric Corrosion and Temperature Corrosion Height, Cathodic Corrosion, Coating and Inhibitor and Materials Selection

**Bibliography:**


- Denny A. Jones, Principles and Prevention of Corrosion , Macmallian Publishing Company, New York, 1992.
- Mars G. Fontana, Corrosion Engineering , Eds., Mac Graw Hill, Singapore, 1986.
- Johny S. Newman, Electrochemical System , 2 nd Prentice Hall Int.Eds., Singapore, 1991.


2. **Course : Polymer Materials**

**Code / Credits / Prerequisites: SCMS801108 / 3 Credits / SCMS801101**

**Objective:**

This course aims to give a special understanding of polymers which is a specific choice for participants. This course discusses polymeric materials with several classifications of polymeric materials such as bonds, single molecules and explanations of cohesive energy density.

**Subjects:**

The scope of the discussion includes the physical state of the polymer, amorphous polymer, plasticization and crystallinity of the polymeric materials; processes such as polymer formation are explained starting from polymerization reactions, stepwise polymerization, co-polymerization, polymer modification and polymer biosysnthesis; Characterization of polymers, testing for polymer characterization is given specifically regarding failure tests, fault energy, creep failure and crazing of polymeric materials, polymer fatigue, and the thermal and electrical properties of polymeric materials.

**Bibliography:**


- F. Rodriguez, Principles of Polymer Systems, Hemisphere Publishing Corporation, Washington, 1982
- FW Billmeyer, Textbook of Polymer Science, John Wiley & Sons, Inc., New York, 1984


3. **Course : Composite Materials**

**Code / Credits / Prerequisites: SCMS801109 / 3 Credits / SCMS801101**

**Objective:**

Providing debriefing to participants regarding the understanding of composite materials.

**Subjects:**

The discussion of composite materials starts from the definition of composite materials, factors that influence the properties of composites, types of composite reinforcing fibers and classifications of composite types. The scope of the discussion includes composite metallic matrices and their process and inter-surface reactions, ceramic-based composites and processing methods, specifically regarding monolithic structure materials, composites with polymer matrix (PMC) types of commercial PMC Characteristics of mechanical properties are also given in particular the method of measuring stress and strain and its relationship, isotropic material, failure criteria, prinicipal stress and strain. The types of laminated composites are also discussed specifically in "off axis loading" in unidirectional composites, constitutive equations for composites. In the discussion of unidirectional and laminated composite strength, laminate and lamina strength was explained because many types of laminated materials were found in Indonesia. The role of composite support fibers is also discussed with the aim of distinguishing stress and strain properties. The size of the fiber is very important for composite reinforcement because it also discusses the critical length of the fiber, the average strength of the fiber, and the orientation of the fiber. The discussion includes fraction mechanisms and strengthening mechanisms, resistance to impact and the effects of the environment and fatigue testing. Non-destructive testing for composite materials is also given such as ultrasonic testing, radiography, and emission testing of acoustic waves.

**Bibliography:**


- Stuart M Lee, J. Ian Gray, Miltz, Lee M Lee, Reference Book for Composites Technology , CRC Press, 1989


4. **Course: Ceramic Materials**

**Code / Credits / Prerequisites: SCMS801110 / 3 Credits / SCMS801101**

**Objective:**

Equip students with ceramics knowledge, how to make and characterize it.

**Subjects:**

Definition of ceramics, bonding to ceramics, ceramic structures, physical properties, defects in ceramics, conductivity and diffusion, formation, ceramics making, thermal properties, dielectrics, electro-ceramics

**Bibliography:**


- M. Barsoum, Fundamentals of Ceramics , McGraw-Hill International, 2000
- S. Somiya, F. Aldinger, N. Claussen, RM Spriggs, K. Uchino, K. Koumoto and M. Kaneno, Handbook of Advanced Ceramics Vol I & II, Elsevier Academic Press, 2003


5. **Course: Electronic Materials**

**Code / Credits / Prerequisites: SCMS801111 / 3 Credits / SCMS801101**

**Objective:**

Study the material, nature and classification of electronic materials

**Subjects:**

Solid band theory, state density, Fermi Dirac and Boltzmann statistics, Fermi Energy and effective electron mass, drift currents, diffusion currents, intrinsic and extrinsic Semiconductors, Heterogenous structures, Minority charge recombinations and injections, Schottky Connections and Ohmic Contact, Light interaction with semiconductor materials. Light interaction with semiconductor materials. The basic concept of PN connection, MOSFET, Solar Cell and Light Emitting Diodes

**Bibliography:**


- Principles of Electronic Materials and Devices, 3rd Edition by SOCoarse
- Electronic Properties of Materials, by Rolf E. Hummel (3ed Edition, Springer, New York, 2000)
- Electronic Materials and Devices , David K.Ferry and Jonathan Bird, Academic Press, San Diego, 2001


6. **Course: Magnetic Materials**

**Code / Credits / Prerequisites: SCMS801112 / 3 Credits / SCMS801101**

**Objective:**

Equip students to gain knowledge in the field of modern magnetic materials.

**Subjects:**

Basic theories of micromagnetics, Para-, Ferro-, Antiferro- and Ferrimagnetics, Magnetic domains and hysteresis curves, Usage.

**Bibliography:**


- E. P. Wohlfarth, Ferro-Magnetic Materials , North-Holland, 1980
- R. C. O'Handley, Modern Magnetic Materials , John-Wiley & Sons, 2000
- BD Culity, Introduction to Magnetic Materials , Addition Wesley, 1986
- McCaig and AG Clegg, Permanent Magnets in Theory and Practice , Pentech Press, London, 1977


7. **Course: Materials Computation Method**

**Code / Credits / Prerequisites: SCMS801113 / 3 Credits / SCMS801101**

**Objective:**

Students are given knowledge about the basics of research methods and procedures for making data analysis. Students are expected to master one programming language that can be used to assist research .Some topics commonly given in numerical analysis (root equations, curve fitting, differentiation, integration, etc.) are discussed with emphasis on the use of materials analysis.

**Subjects:**

Introduction, Basics of Research Methods; Sampling and Measurement; Design and Analysis

Programming One Language Recognition; Roots of Equation; Linear Algebra Equation System; Computing Curve Fitting (Matching); Differentiation and numerical integration; Differential Equation Computing; Partial Differential Equations; Special Topic of Numerical Analysis, Example: application to the determination of materials structure.

**Bibliography:**


- SC Chapra and RP Canale, Numerical Methods for Engineers, McGraw-Hill International Edition, Third Edition, Singapore, 1998
- WH Press, BP Flannery, SA Teukolsky and WT Vetterrling, Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, London, 1997

8. **Courses : Manufacturing Process of Metal and Alloys**

**Code / Credits / Prerequisites: SCMS801114 / 3 Credits / SCMS801101**

**Objective:**

Students of this lecture are expected to be able to understand the relationship between materials behavior and manufacturing processes, especially the influence of process parameters, so that students can improve their analytical skills to support research on materials for manufacturing applications.

**Subjects:**

The initial explanation of this course is about materials mechanics, namely the concepts of stress, strain, materials behavior. Then proceed with the terms and understanding of manufacturing processes related to the behavior of technical materials, product samples, materials selection, manufacturing process parameters. Next is the deepening of manufacturing processes with metal materials, namely rolling, forgery, extrusion, wire drawing, casting / casting. Explanation of each process is related to the formation ability of the materials through the parameters of metal manufacturing processes such as the effects of temperature, process speed, lubrication, mold, deformation quantity and printed materials. For the process of manufacturing non-metallic materials deepening in plastic materials only, such as injection molding, extrusion blow molding. Closing is explained about material materials for manufacturing, quality control and examples of process failures and manufacturing products.

**Bibliography:**


- John Noel Harris, Mechanical Working Of Metal, Theory And Practice , Pergamon International, 1983
- GW Rowe, Element Of Metal Working Theory , Arnold, Paris ,.1979
- Dieter, GE Mechanical Metallurgy , McGraw Hill, 1988
- TS. Alton, H. Gegel, Metal Forming: Fundamentals And Applications , 1995
- GE Dieter, Engineering Design: A Material And Processing Approach , McGraw-Hill, 1991


9. **Course : Thin Layer Materials**

**Code / Credits / Prerequisites: SCMS801115 / 3 Credits / SCMS801101**

**Objective:**

Studying physical and chemical concepts in the formation of thin layers, the parameters of materials in thin layers, identifying, evaluating and classifying modern thin layer deposition techniques that have been applied for various purposes.

**Subjects:**

Thin layer physics techniques and concepts, physics of solids: crystal structures and crystal defects, thermodynamics: free energy, phase diagrams, growth kinetics; Ficks' law, diffusion coefficient, Arrhenius, nucleation and growth, plasma physics, deposition parameters, PVD (Physical Vapor Deposition), Vacuum technique, evaporation and sputtering; n CVD (Chemical Vapor Deposition); Deposition of Plasma / ion beam, Molecular Beam Epitaxi, Pulse Laser Deposition.

**Bibliography:**


- Milton Ohring, The Materials Science of Thin Films , Academic Press, 1992
- Donald L. Smith, Thin-Film Deposition: Principles and Practice , McGraw-Hill, Inc. , 1995
- John A. Venables, Surface Film and Thin Film Processes , Cambridge University Press, 2003
- Aicha AR Elshabini-Riad and Fred D. Barlow III, Thin Film Technology Handbook , McGraw-Hill, 1998


10. **Course : Nano Materials**

**Code / Credits / Prerequisites: SCMS801168 / 3 Credits / SCMS801101**

**Objective:**

Providing extensive and multipisciplinary introduction to physical phenomena, theoretical concepts and materials fabrication techniques on a nanometer scale, studying the application of nanomaterials in various applications.

**Subjects:**

Introduction of nanomaterials, Nanostructures: structures 0, 1, 2 and 3 dimensions, optical, electronic and magnetic properties of nano publication. Nanomaterials ceramics, metal nanomaterials; plasmon resonance localized surface, semiconductor nanomaterials; quantum dot, quantum well, quantum wire, nanopolymer, nanocomposite, synthesis and characterization of nanomaterials.

**Bibliography:**


- A Edelstein, RC Cammarat (Ed.), Nano materials: Synthesis, Properties and Applications, Institute of Physics Publishing, 2002

- Poole, Charles P., Introduction to Nanotechnology, John Wiley & Sons, Inc. All right reserved 2003
- Hari Singh Nalwa (Ed)., Nano Structured Materials and Nanotechnology, Academic Press 2002

## B. Compulsory Courses of Master by Research Programs

1. **Course : Periodic Seminar**

**Code / Credits / Prerequisites: SCMS801120 / 8 Credits / -**

**Objective:**

It is a literature review and presentation activity to look for and explore one of the research topics in preparation for making a research proposal. Students are required to search, read and analyze reputable journal scientific publications, then present the results of the literature review and periodically discuss scientific issues.

**Subjects:**

Extent and depth of research topics, mastery of materials, scientific systematic, scientific attitude

2. **Course : Research Proposal Defense**

**Code / Credits / Prerequisites: SCMS801121 / 4 Credits / -**

**Objective:**

Based on the results of the literature review in Periodic Seminars, students can analyze one of the problems to be solved, formulate formulas and limitations of problems, collect hypotheses, analyze facilities and infrastructure to conduct research which is then written in research proposals and present them to the examiners.

**Subjects:**

Contents of the Proposal: Background, problem formulation, hypothesis, purpose, update, experimental method. Mastery of proposals: Scientific attitude and dexterity of discussion. Research readiness. Publication potential

3. **Course : Research Result Defense**

**Code / Credits / Prerequisites: SCMS801122 / 8 Credits / SCMS801121**

**Objective:**

As a control of the research process carried out, students will present the results of their research, draw conclusions and plan further research.

**Subjects:**

Framework for thinking, methodology and literature review. Results, sharpness of data analysis, stability draw conclusions. Presentation and mastery of materials. Potential for continuation of research

4. **Course : Scientific Seminar 2**

**Code / Credits / Prerequisites: SCMS902201 / 4 Credits / -**

**Objective:**

To disseminate the results of their research, students are required to present their work in an international scientific seminar and to make scientific articles that will be published in indexed national / international proceedings.

**Subjects:**

Abstract, background problems, research methods, results and discussion, conclusions and suggestions, bibliography.

5. **Course : Scientific Publication**

**Code / Credits / Prerequisites: SCMS802120 / 10 Credits / -**

**Objective:**

Based on the results of his research, with the direction of the supervisor, students are required to make scientific publications starting with literature search activities, collecting materials to be conveyed, sketching papers, abstracts, processing and analyzing data by referring to literature, searching for appropriate scientific journals, following the writing format and procedures for submitting to indexed national or international scientific journals.

**Subjects:**

Abstract, Publication framework, research methods, results and discussion, conclusions and suggestions, bibliography.

6. **Course : Thesis Defense**

**Code / Credits / Prerequisites: SCMS802002 / 8 Credits / Already ≥ 34 credits**

**Objective:**

A research process so that students can write scientific work at the end of the study period of the master's program in Materials Science and present in front of a board of examiners.

**Subjects:**

Research, writing and final presentation of students under the guidance of one or two counselors.

**Bibliography:**


- Effionora (ed.), Guidelines for Making Theses and Dissertations at FMIPA UI , UI-Press, 2006