Syllabus for Comprehensive Examination for PhD Scholars
(2022 Admission Onwards)
SCHOOL OF MATERIALS SCIENCE AND ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

The comprehensive examination consists of two parts. Part 1 is a written examination (100 marks), and Part 2 is an oral examination (100 marks).

Part1: The Written Examination: (2 hours, 100 marks)

The written examination consists of two sections which are core areas and specializations. The core area section is mandatory for all, and the specialization can differ depending on the candidate's research area. A minimum of 50 marks are needed to complete the written part of the comprehensive examination and to qualify for the oral examination. Results will be published within five days after the completion of the written examination.

Section 1: Core Area (mandatory for all the scholars): 40 marks

Module (a)-Synthesis and fabrication of materials:
Structure of materials, crystal structures (crystal systems, miller indices), Thin film fabrication methods (PVD: thermal and e-beam evaporation, Sputtering, PLD, ALD, CVD), Surface energy and Stabilization methods, Nanomaterials synthesis (reduction methods, sol-gel synthesis, microemulsion methods, hydrothermal methods, VLS growth), Fabrication Methods such as Lithography and 3D-printing.

Module (b)-Properties of materials:
Energy bands and band theory, Electrical and electronic properties, Optical properties, Mechanical properties, Magnetic properties, Thermal properties, and material properties at the nanoscale.

Module (c)-Characterization of Materials:
XRD, OM, SEM, TEM, AFM, BET surface area, DLS, Spectroscopic methods (UV-VIS, Raman, FTIR and XPS), Errors and Uncertainty analysis.
.
Module (d)- Scientific Communication, Professional Ethics and Laboratory Safety
Authorship, Plagiarism, IPR, Scientific writing, Scientific integrity, ethics and accountability, protection of research subjects, conflict of interest, protection of animal used in research, the obligation of research to society, referencing and bibliography, copyright awareness, chemical safety, toxicology, risk and precautionary principles.

Section 2: Specialization Area: (scholars can choose one module):60 marks

Module -1

Electrochemical methods, Types of electrodes.

Hydrogen evolution reaction, oxygen evolution reaction, OER mechanisms, adsorbate evolution mechanism, and lattice-oxygen-mediated mechanism

Electrocatalytic, photocatalytic, and electro-photocatalytic water splitting. Properties of electro/photocatalytic materials. Role of co-catalyst in hydrogen evolution reaction, 2D transition metal chalcogenides, properties and structural tuning, Mott-Schottky analysis, Effects of doping, vacancies and strain in HER and OER, Volcano plots, strain-engineered electrocatalysts single-atom electrocatalysts.

Module-2

Heat transfer

Introduction to heat transfer- modes of heat transfer- Conduction- Convection- Radiation- Governing laws- Thermal conductivity - measurements of thermal conductivity- factors affecting thermal conductivity- Heat conduction through single slab- Electrical Analogy- Heat conduction through parallel slabs- Overall heat transfer coefficient- Stefan Boltzmann law- Absorptivity- Reflectivity- Transmittivity

Micro/Nanoscale heat transfer

Introduction to micro scale heat transfer- Observations on deviations from conventional theory – Limitations of Fourier's law- Size effects- Experimental and theoretical findings – Microscale conduction- SOI devices- Thermal issues of SOI- Microscale thermometry- Properties of amorphous dielectric films – Thermal characterization and heat transport in dielectric films – Heat conduction in crystalline silicon films- Fundamentals of heat transport at the nanoscale – characteristic lengths and heat transfer regimes – Nanoscale heat transfer phenomena

Phase change materials

Introduction to Phase change materials- Classifications- Applications- Selection criteria

Module -3

Introduction - Definition of Biomaterials - Properties of biomaterials: bioactive, bioinert, bioresorbable - Biocompatibility - Applications of biomaterials for Healthcare and Medicine - Materials for implant applications: Polymers, Ceramics, Metals, Composites –

Types of implants: Temporary implants, Permanent implants - Orthopaedic implants - Biodegradable implants, Scaffold materials - Electrospinning for scaffold synthesis - green electrospinning - Factors affecting fiber morphology - Bone tissue engineering - Effect of Growth factors in bone engineering.

Biological testing of biomaterials – *In vitro* degradation studies of implants: SBF - Cytotoxicity – Basics of Cell culture - Legal and ethical aspects of biomaterial research