INTRODUCTION TO ENGINEERING DISCIPLINES

(With Relevant Information on Engineers in Society)



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MATERIALS AND METALLURGICAL ENGINEERING DISCIPLINE

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CHAPTER 8

COURSE SYNOPSIS

Materials and Metallurgical Engineering
Introduction to material and metallurgical engineering profession: Definiti materials and metallurgical engineering. Specializations/options in material metallurgical engineering. Use of various implements and equipment in ma and metallurgical engineering for different operations/process. Prospects a opportunities in material and metallurgical engineering as a profession. Re regulatory bodies and societies in material and metallurgical engineering. T of material and metallurgical engineers in advancement of humanity.

8.1 INTRODUCTION TO MATERIAL AND METALLURGICAL ENGINEERING DISCIPLINE

8.2 DEFINITION

The breadth of training afforded to engineers specializing in materi metallurgical and materials engineering permits entry into many exciting te fields. All fields of engineering involve the use of metallic, ceramic, polyr composite materials. Virtually every component of any engineered stru limited by the properties of the materials chosen for its fabrication. The s methods of production, heat treatment, finishing and maintenance of the r involved in all aspects of systems of transportation, power ge communication, food preparation, entertainment and housing depend on in trained in materials.

The study of materials and metallurgy as a discipline has undergone tre transformation since the ancient times. There are different areas of spec which are:

1. Chemical metallurgy
2. Extractive or process metallurgy
3. Physical metallurgy
4. Mechanical metallurgy, and of recent
5. Forensic metallurgy.

1. Chemical metallurgy deals with heat treatment of metal in order t or enhance the properties of that material for various applications.
2. Extractive metallurgy deals with the extraction of ferrous and n metal.

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3. Mechanical metallurgy is the area concerned with the study of mechanical properties of all engineering materials e.g. hardness, strength, wear, flexural and their pressure shaping
4. Physical metallurgy is the branch of metallurgical science that uses the principles of the basic science like chemistry, physics and mathematics in the study of structure, properties and development of metals or alloy to suit a typical application
5. The area of forensic metallurgy is not quite distinct from physical metallurgy. It is part of it. However, it mainly deals with the study of failure mechanics in materials.

Today's Engineers have a vast range comprising of several thousand materials available to them. Some of these (Timbers, Stone and Clay products, some Cast Irons and Copper Alloys) have been in use as constructional materials for centuries. At the other end of the scale, many polymers, high temperature super alloys, industrial ceramics and fibre reinforced composite materials have come into use in recent decades, while other materials of great potential interest, including new alloy compositions, new polymers, metallic glasses and metal-matrix composites ar currently in the development stage. Running parallel to the invention of new an improved materials there have been equally important developments in materia processing including vacuum melting and casting, new moulding techniques fo polymers, ceramics and composites and new joining technologies.

The complete range of materials can be classified as METALS, POLYMER CERAMICS and COMPOSITES.

Composite materials have been developed to overcome some of the deficiencies members of a particular class of materials and there are examples of ceramics/met polymer/ceramics and metal/polymer composites in current use. Ceramics thou strong in compression, generally are weak in tension, but metals tend to have eq strengths in both tension and compression.

Reinforced and pre-stressed concretes are composites designed to improve tensile characteristics of concrete structural members. Polymers have low densi but also have low strength and stiffness without adding and excessive weight pen The load bearing characteristics of metals and the low friction characteristics polymer such as Polytetra Fluoroethylene are combined to give good effect in m particle PTFE composites developed as bearing materials.

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8.3 SPECIALIZATIONS/OPTIONS IN MATERIALS AND METALLURGICAL ENGINEERING

These are different modes of materials classification and these determine various specializations/options:

8.3.1 Metallurgical Engineering (Ferrous and Non-Ferrous Metals)

The specialization is basically that of metallic materials, ferrous metals are essentially iron, steel and alloys which the principal element is iron (Fe). Non-ferrous metals and Alloys are those that contain elements other than iron as their main constituents, such as brass, aluminium, copper, tin, zinc, tungsten, molybdenum, among others.

8.3.2 Materials Engineering

Ceramics engineering and polymer engineering these are other materials with the exception of metals and are majorly ceramics and polymeric materials

8.3.3 Wear and Corrosion Engineering

This involves tribology and including degradation of materials due to the effect of the environment and how to mitigate the effect.

8.3.4 Mineral Processing Engineering and Extractive Metallurgical Engineering

This entails beneficiation, sintering, coking and calcinations of different minerals prior to refining which is addressed by extractive metallurgy.

8.3.5 Advanced Materials Engineering

This is the study of Nano materials, Smart materials, Composite materials, Semi-conductors and Bio-materials. These are sets of non –traditional materials that are employed because of their unique properties.

8.3.6 Materials Production Engineering

Foundry, welding, forging, rolling, extrusion and other mechanical forming of materials through various processing routes are undertaken.

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8.4 USE OF VARIOUS EQUIPMENT IN MATERIALS AND METALLURGICAL ENGINEERING

The following are some of the implements and equipment used for various operations in
Materials and Metallurgical Engineering (Table 8.1):

Table 8.1: Equipment, Implements and Instruments Used for Various Operations in Materials and Metallurgical Engineering

S/No.	Name of Equipment	Picture	Uses
1	Optical Microscope		Microscope is an optical instrument used for viewing very small objects, such as mineral samples and other materials samples typically magnified several hundred times.
2	Universal Testing Machine		A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials. An earlier name fo a tensile testing machine is a tensometer. The "universal" part of the name reflects that can perform many standard tensile and compression test on materials, components, a structures

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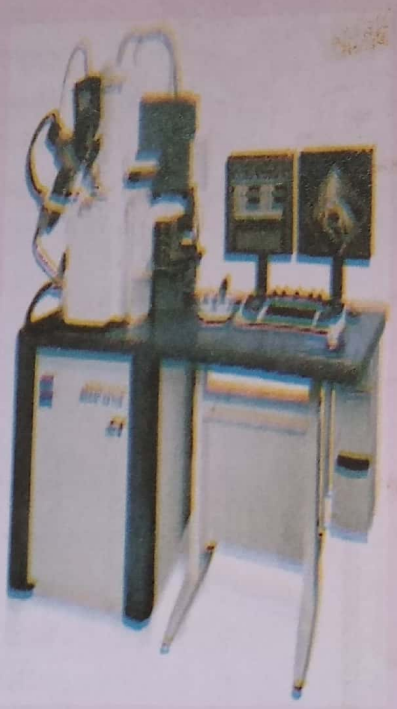
3 Fourier Transferred Infrared Spectroscopy



Fourier-transform infrared spectroscopy (FTIR)is an equipment used to obtain an infraredspectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high-spectral-resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time.

3

Scanning Electron Microscope



A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The electron beam is scanned in a raster scan pattern, and the position of the beam is combined with the detected signal to produce an image.

Vickers Hardness Testing Machine



.It is used to determine hardness in materials in the micro hardness test load range.

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5 Transmission Electron Microscope



Transmission electron microscope (TEM), type of electron microscope that has three essential systems: (1) an electron gun, which produces the electron beam, and the condenser system, which focuses the beam onto the object; (2) the image-producing system, consisting of the objective lens, movable specimen stage, and intermediate and projector lenses, which focus the electrons passing through the specimen to form a real, highly magnified image; and (3) the image-recording system, which converts the electron image into some form perceptible to the human eye. The image-recording system usually consists of a fluorescent screen for viewing and focusing the image and a digital camera for permanent records. In addition, a vacuum system, consisting of pumps and their associated gauges and valves, and power supplies are required.

6 Polishing Machine



These are machines that work with brushes, and are designed to perform operations of brushing, buffing, polishing, and for the finishing of any metal material.

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9 *Weighing Balance*



A weighing scale (or weighing balance) is a device to measure weight or mass. They are also known as mass scales, weight scales, mass balance, weight balance, or simply scale, balance, or balance scale.

8 *Sieve*



A sieve, or sifter, is a device for separating wanted elements from unwanted material or for characterizing the particle size distribution of a sample, typically using a woven screen such as a mesh or net or metal

10 *X-ray Fluorescence Spectrometer*



An X-ray fluorescence (XRF) spectrometer is an x-ray instrument used for routine, relatively non-destructive chemical analyses of rocks, minerals, sediments and fluids. It works on wavelength-dispersive spectroscopic principles that are similar to an electron microprobe (EPMA).

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11 Energy Dispersive Fluorescent X-Ray Spectrometer



The energy dispersive fluorescent X-ray spectrometer is utilized in a very wide range of fields as "instruments that enable anyone to carry out elemental analysis". This wide applicability is due to its versatility; providing analysis of samples in various forms, including solids, powders, liquids, and thin films with easy pre-treatment (sampling), and of executing quantitative analysis without a standard sample.

12 Defectoscope



It is an ultrasonic or ultrasound based device which uses a contact transducer (two different poles of 45° and 90° for the purpose of measuring the thickness of materials, and identifying the faults and defects that are present in it such as discontinuity in welds, other non-destructive testing (NDT) and inspection purposes. It has wide applications in metallurgical, oil and gas, quality control, metal working, machining, product design and development, construction, etc.

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13 Grinding Machine



This is a machine that uses an abrasive wheel as the cutting tool, for the purpose of grinding work pieces. The abrasive wheel works by shredding off small portions of the work piece as required through shear deformation.

Materials processing involves refining of raw materials to produce bars and billets in melting furnaces like the blast furnace, basic oxygen furnace and electric arc furnaces for ferrous metals and alloys and eventual casting into some shapes known as billets and blooms in a continuous casting machines. Cast products must further be processed into various structural shapes in the rolling mills, intrinsic shapes can equally be made by direct casting of molten metal or alloys in a ready-made temporary or permanent mould that is replica of the actual shape of the final products. This limit further stages of machining and hence reduces production cost quite significantly. Joining operations like welding, soldering, and riveting may however be inevitable in certain situation but any choice of processing must be weighed based on the cost effectiveness. The final structure of materials and corresponding properties and performances in services may require the products to be subjected to heat treatment by heating in industrial furnace and subsequent cooling appropriately at a pre-determined rate to avoid distortion of shape and corrosion or other degradation. Figure 8.1 is a display of world steel and overview of steel making process. Other finishing operation may include electroplating to prolong the service life and protect the component from environment hazard.



Figure 8.1: World Steel and Overview of Steel Making Process

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8.5 PROSPECTS AND JOB OPPORTUNITIES IN MATERIAS AND METALLURGICAL ENGINEERING.

Process Engineers in Materials and Metallurgical Engineering Companies
Materials and Metallurgical Engineers are involved in the design, execution and monitoring of production process in metallurgical, ceramics and polymer industries.

Corrosion and Integrity Control Engineers
The Engineer works in chemical, petrochemical, power and allied industries. Many of the equipment and production facilities need to undergo regular monitoring and repair by experts in materials and metallurgical areas.

Quality Control Engineers in Manufacturing Industry
The Engineers carry out control of quality of products coming out not only in materials and metallurgical industries but also in rolling mills, foundries and machine building industries.

Procurement Engineers
Materials and metallurgical professional are the most sort-out experts for procurement of materials both in private and public establishment.

Forensic Engineers
When there are sensitive tasks that may or may not have legal implication like collapse of structures, materials engineers are called upon to give their forensic submission.

Research Institution
This helps in the development of new materials and improving the performances of existing ones and finding new areas of application for them. Higher institution of learning offers advancement of knowledge in materials for their application.

Employer of Labour
He could practice as welding Engineer, foundry engineer and consultant in corrosion and renovation for pipeline and Oil and Gas, storage tanks and the lie.

8.6 RELEVANT PROFESSIONAL BODIES IN MATERIALS AND METALLURGICAL ENGINEERING

1. Council for the regulation of engineering in Nigeria (COREN)
2. Nigerian Society of Engineers (NSE)
3. Metallurgical, Mining and Materials Division of the Nigerian society of Engineers
4. Nigerian Metallurgical Society (NMS)
5. Materials Science and Technology Society of Nigeria (MSN)
6. Nigerian Corrosion Association

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7. Nigeria Association of Welding Engineers
8. American Society for Metals (ASM)
9. World Steel Association

8.7 THE ROLE OF MATERIAL ENGINEERS IN ADVANCEMENT OF HUMANITY.

Many modern technologies seem to work in almost magical ways. Yet, all of these technologies are based on real world science. The discoveries by scientists and engineers often allow for the creation and manipulation of new materials. New materials can change how we live. Areas the Materials and Metallurgical Engineers can contribute include:

1. Light-emitting diodes (LEDs) push flowing electrons across a semiconducting material. When electrons fall from a higher to a lower energy state within the semiconductor they emit photons (light) (Figure 8.2). The wavelength (color) of the light is determined by the band gap (the difference between energy states) of the semiconductor. For many years, LEDs could only be manufactured with small band gaps, producing only wavelength light (red, yellow or green).

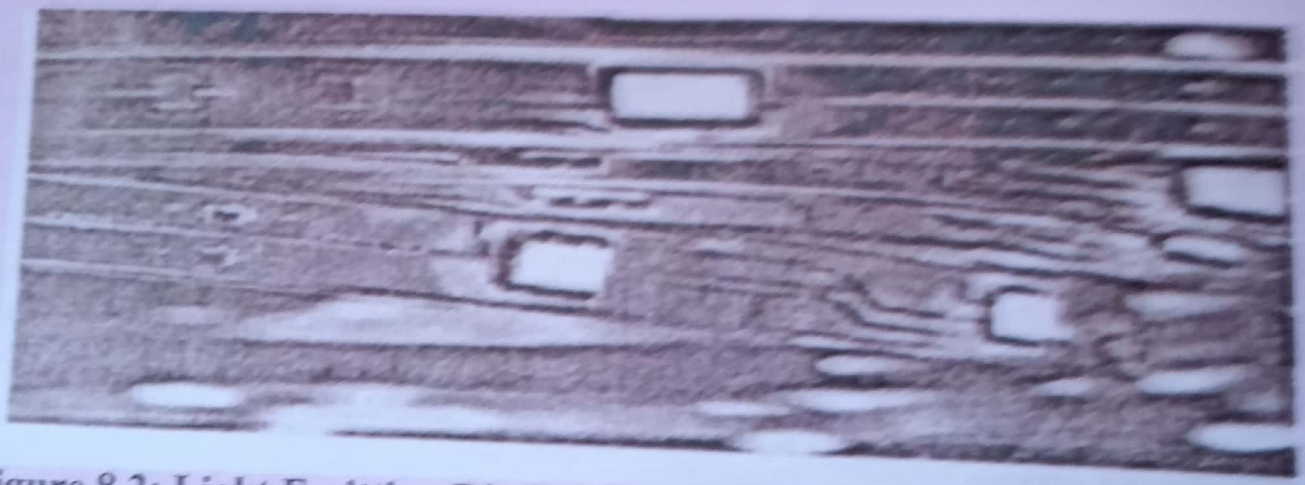


Figure 8.2: Light Emitting Diodes (Leds): A Long-Live Lightening Device

What material discovery changed this?

In 1993, the development of gallium nitride materials enabled blue and white LEDs, finally completing the LED colour spectrum. Today, LED lights are longer-lived and more energy efficiency than most other types of lightning. LEDs are found in traffic lights, video screens, and everything in between.

2. Many blood tests require a vial of blood and several hours of laboratory work. Soon, doctors will be able to perform the same tests in 10 minutes using a single drop and a 'lab-on-a-chip'. These devices are no longer than a credit card, but can be designed to perform a wide range of simple, fast, and cheap medical and genetic tests (Figure 8.3).

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Figure 8.3: Medical Lab-On-A-Chip: Effective Blood Sample Testing Device

What materials discovery enables such a small device?

Microfluids: Lab-on-a-chip technology harnesses the properties of microfluidics to manipulate and identify small molecules, like hemoglobin and DNA. Cheap medical tests could improve healthcare, especially in the world's poorest regions.

3. All batteries store energy in chemical bonds and release energy by allowing ions from those bonds to flow from a high energy state to a low energy state. Cellphones, laptops, and electric cars all require light-weight and powerful batteries that can recharge many times (Figure 8.4).

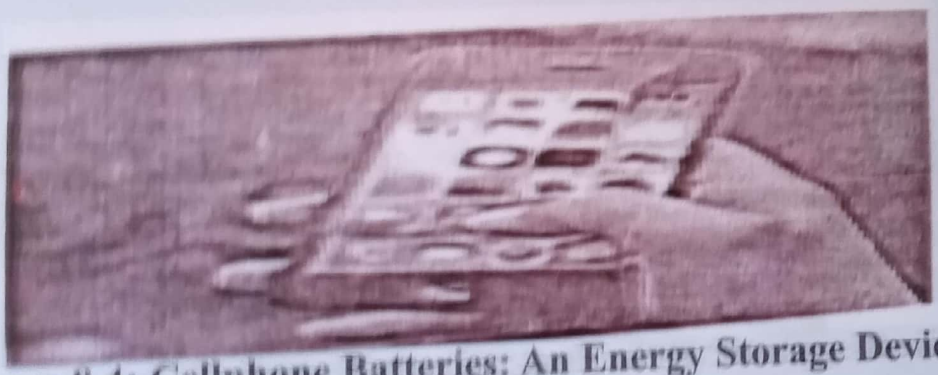


Figure 8.4: Cellphone Batteries: An Energy Storage Device

What materials discovery enabled such a rechargeable battery?

The lithium-ion boasts a high energy-to-weight ratio and can hold a charge for a long time. The superior performance of these batteries is due to the crystalline structure of the materials that they are made of, which allow lithium ions to bind loosely between layers of oxygen and other elements. When the battery is charged, the lithium ions can move easily out of the crystalline structure to other higher energy bonds.

1. The information in computer hard drives is stored in memory bits, like tiny compass needles hat can be switched between pointing north and pointing south. To increase the speed and data capacity of computer memory, computer engineers seek to make the bits smaller and more tightly packed (Figure 8.5).

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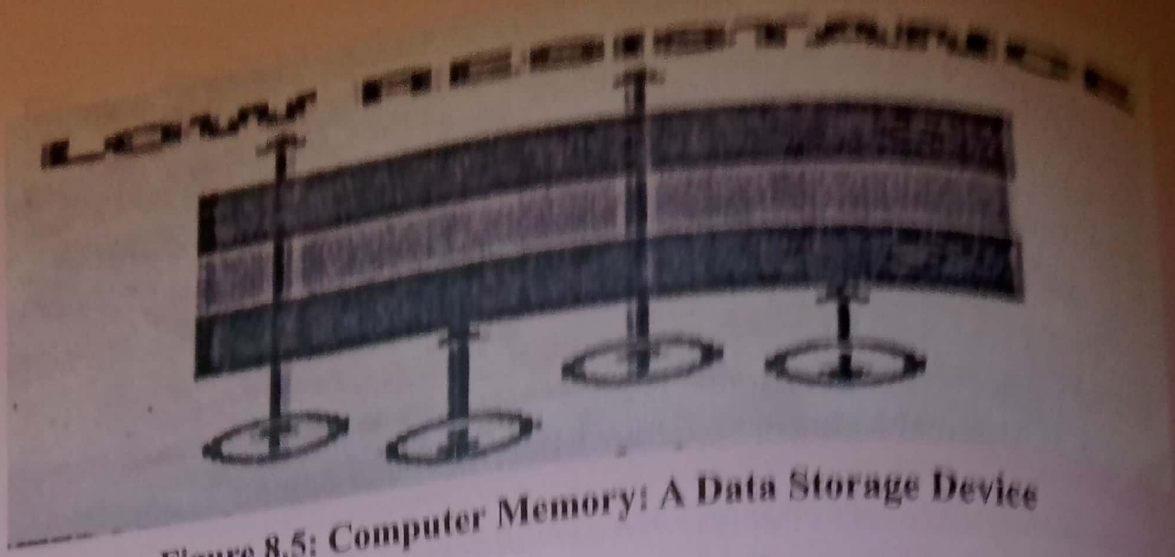


Figure 8.5: Computer Memory: A Data Storage Device

What materials discovery made memory bits smaller?

In special materials, the spin states of electrons can be set within a tiny area. As the image shows, by altering the spin of electrons in the top layer of a computer hard drive, the material will either conduct or block electrical current, recording binary information. The field of spinotrics uses electron spin to improve electronics.

5. Production of clean water. 11% of the world population lacks clean drinking water (Figure 8.6).



Figure 8.6: Clean Water: A Polymeric Filter

What materials discovery will easily remove salt, bacteria, and dangerous chemicals from drinking water?

Membranes are used to separate water from its contaminants in many methods of water filtration. However, most membranes are easily clogged and must be frequently cleaned or replaced. Researchers are designing new polymer membranes that allow water through while repelling contaminants. The diagram shows how this works at a molecular level (10^{9} meters). The dark purple polymers attract water (blue) while repelling contaminant molecules (orange). The light purple polymers provide a backbone of support.

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These are just few of the many materials discoveries that affect our lives. Future discoveries made by curious women and men, maybe by you will undoubtedly enable new technologies and further improve our world.

BIBLIOGRAPHY

1. William D. Callister, Jr (2007) Material Science and Engineering, an Introduction, seventh edition, John Wiley & Sons, inc.
2. Donald R.A., Pradep P.F., Wendelin J.W., (2011), The Science and Engineering Materials, sixth edition, Cengage learning
3. Ad hoc Committee on Social Benefit from Condensed Matter and Material Research, National Academy of Science (2014), Harvesting the Fruits of Inquiry; How Materials Discoveries Improves Our Lives. National Academic Publisher (NAP), 28 pages.
4. Steel Times International January/February, 2015
5. Overview of the Steel Making Process. Retrieved on the 12th January, 2019 from: https://www.worldsteel.org/publications/bookshop.html?page=4Worldsteel .org

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