# AN INTRODUCTION TO THE PHENMENON OF LUMINESCENCE

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## ABSTRACT

The phenomenon of fracture has been associated with man's life for better or worse. since the beginning of human existence in prehistoric days, man utilized brittle fracture in shaping of stone tools and carving of houses out of rocks, although he felt its less fortunate consequences when he got his bones broken. Quarrying, shaping and structural fitting of stones the essential processes of ancient construction, all depends upon controlled manipulation of brittle fracture. Likewise today many industrial manufacturing and constructional processes, machining of materials for example, involve brittle fracture at some point. Fracture of phosphors give rise to luminescence. The present paper reports the elementary idea about luminescence, its type and applications.

**Keywords :** Phosphor, coactivator , centres, deformation.

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## INTRODUCTION

Scientific development has proved to be a boon by providing light sources to human beings. In dark a small piece of burning coal and a flashing firefly look similar, whereas it is difficult to touch a piece of burning coal, we can put a flashing firefly on our palm for any time we wish. This fact clearly indicates that there should be two type of light sources, namely the hot light sources and cold light sources. The sun, hot iron, burning piece of coal, tungsten filament etc. are example of hot light sources, and firefly, oscilloscope screen, television screen, light emitting diodes, fluorescent tubes, self luminous watch dial etc. are examples of cold light sources by touching or recording the spectra we can identify the hot and cold sources of light, whereas the light coming from hot sources has continuous spectra, the light from cold sources has band spectra or line spectra or combination of both. In fact the phenomenon of cold emission of light is known as luminescence. In other words any type of emission except incandescent is called luminescence. Scientifically luminescence is the non- equilibrium phenomenon of excess emission over and above the thermal emission of a body in which emission has a duration considerably exceeding the period of light oscillations. Although excess emission over and above the thermal background takes place in reflected and refracted light, Rayleigh and Raman scattering and in Cerenkov and laser radiation, they are not the phenomenon of luminescence, as the emission duration is these phenomena are of the order of the period of light oscillations, whereas the intensity of incandescent emission increases with temperature, in most cases the intensity of luminescence decreases with increasing temperature of the materials. Luminescence may occur in crystalline and non-crystalline solids as well as in liquids and gases. Luminescent solids are usually referred to as phosphors. Luminescence process involves at least three steps (i) energy absorption causing electronic excitation (ii) storage of absorbed energy, and (iii) emission of photons, Depending on the storage time i.e. the time delay between the excitation and emission, luminescence can be classified into two categories. If the storage time is shorter than $10^{-8}$s, the process is termed as fluorescence otherwise it is phosphorescence. The interval $10^{-8}$s is chosen as it gives the lifetime of an atom in the excited state for which return to the ground state is accompanied by dipole radiation. The present article reports the basics of luminescence in solids.

## MECHANISM OF LUMINESCENCE

The basic mechanism of luminescence is conceptually simple. A lone atom in vacuum absorbs energy to become excited and then disposes of the absorbed energy by emitting light. In some cases, a part of the absorbed energy is dissipated while, in some cases the excitation energy is totally dissipated. An atom is said to be excited when an electron is lifted from a lower to a higher energy level, and if this occurs it may be due to mechanical collision, when an electron hits the atom or when a quantum of radiation of the correct energy is absorbed. The electron in the higher level (for about $10^{-8}$s ) may return to its original states in one or several jumps. There is a very high probability of its emitting radiation. Most of the solid materials are non-luminescent in their purest form as the energy absorbed is non-localised. Luminescence is usually associated with very dilute concentrations of ions (impurities) more or less isolated in a relatively inert matrix. These ions are known as "activators". The energy states of the activators are modified by the crystal field of the matrix (Host). These activator ions known as "Centre" which discrete energy levels in the forbidden gap plays an important role in luminescence. These luminescent centres have a high electrons capture cross-section and greater probability for radiation transition than for non-radiative ones.

There are some metastable states in a crystal which are responsible for luminescent emission known as "traps". When an electron or a hole is captured by a trap, it is no longer free through the crystal unless an optimum quantity of energy is supplied to release it. Conventional luminescence generally comprises transitions of excited electrons to the uppermost normally filled energy levels of a solid and may provide efficient external emission spectrum lies in a region where the solid has low absorption.

### TYPES OF LUMINESCENCE

On the basis of the means of excitation, luminescence may be classified into different types. Luminescence in which the prefix to luminescence indicates the type of energy being converted into light may be called energy conversion type luminescence for example

**ELECTROLUMINESCENCE** - Direct conversion of electric energy into light energy takes place.

**PHOTOLUMINESCENCE** - Light emission due to excitation by relatively low energy photons (visible light, uv light)

**CATHODOLUMINESCENCE** - Direct conversion of cathode ray energy into light energy takes place.

**RADIOLUMINESCENCE** - Direct conversion of radio active particle energy into light energy takes place.

There are many other type of luminescence in which prefix to luminescence does not show the energy which is concerted into light energy but it indicates the energy or process to stimulate or induce the luminescence such type of luminescence a may be called stimulation or induction type luminescence .

For Example

**THERMOLUMINESCENCE** - Luminescence is stimulated in previously irradiated materials by the thermal vibrations.

**MECHANOLUMINESCENCE** - Light is induced during the elastic or plastic deformation or fracture of solids.

**CRYSTALLOLUMINESCENE** - Light is induced during the crystallization of materials.

**LYOLUMINESCENCE** - Light is induced during the dissolution of previously irradiated solute in solution.

In superluminescence (or amplified luminescence) negative luminescence cross-luminescence and anti stokes luminescence the prefix neither shows the energy being converted into light nor stimulation or induction of luminescence. Such type of luminescence may be called conceptual-type luminescence.

## LUMINESCENT MATERIALS

A large number of organic and inorganic crystals and amorphous solids exhibits the phenomenon of luminescence [1-4]. Some compounds are luminescent even in their purest form, as example, manganous halides, salts rare earth, platinocyanides, tungstates, molybdates and uranyl. Mst phosphors, however, consist of host crystals, which is non luminescent t which one or more foreign elements have to be added, as for example, silicates, phosphates, sulphide, etc. thus the host materials to be used in the synthesis of phosphors must possess a chemical purity of 99.9999 (6N) commonly specified as luminescent grade compound, which is better than the spectroscopically pure materials (5N). The small traces of impurities which play an essential part in luminescence of solids, called activators. These activators may be impurity atoms occurring in relatively small concentration in the host materials, or a small stoichiometric excess of one of the constituents of the materials. In the latter case, one speaks of self-activation. The presence of a certain type of impurity may also inhibit the luminescence of other centers, in which case the former are referred to as “killers”.

Pure zink sulphide do not so luminescence[5]. Its ability to become luminescent is induced by adding suitable activators, which form the centres. In order to increase the efficiency of luminescence, it is necessary to ad activators as well as other impurity atom known as coactivators. The most commonly used activators for ZnS are element from group IB of the periodic table, such as copper and silver. As coactivators halogens are used, most frequently chlorine. Trivalent impurities such as aluminium, gallium, indium etc. are also used as coactivators. The presence of coactivator compensates the charge of the activators in the basically divalent lattice of ZnS. This enables to add a greater quantity of an activator into the elementary lattice of the phosphor and so a greater number of luminescence centres are created making the phosphor more efficient.

Important groups of luminescent crystalline solids are as given below :

(i) Compound which luminescence in the pure state. Such compounds should contain one ion group per unit cell with an incompletely filled shell of electrons which is well screened from its surroundings. Examples are magnous halides, samarium sulphate, gadolum sulphate, various platinocyanides, tugstates of magnesium, calcium and zink, various molibidates and uranyl salts.

(ii) The alkali halides activated with thallium or other heavy metals.

(iii) ZnS and CdS activated with Cu, Ag, Au, Mn or with an excess of one of their constituents (self activation).

(iv) Alkaline earth sulphides, particularly those of calcium and strontium activated by bismuth or some other metals and rare earths.

(v) Silicates phosphors, inclusive of zink, beryllium, cadmium, magnesium, strontium, barium and manganese silicates.

**CURRENT TRENDS IN LUMINESCENCE RESEARCH**

Even though the applications of luminescence is so vast in depth, the theory behind it has been complex and incomplete. At present the research in luminescence is rapidly advancing on many fronts. There is such a large number of new trends in the field that it is difficult to single out any one, which stands above all others. Last few decades have witnessed a dramatic change in quality and approach and phenomenal growth of life literature in luminescence. The discovery of materials with interesting luminescence properties continues to increase. The recent addition includes one dimensional crystals, pyroelectrics some unusual glasses and biological materials and even super conductors . The pyroelectroluminescence[6] and vibronicluminescence are the most recent contributions to the phenomena of luminescence . The application of luminescence to characterize super conducting materials is also of recent origin .

## APPLICATION OF LUMINESCENCE

Luminescence finds a lot of application. Some of the important applications of luminescence are as given below :

(i) Phosphor are used in fluorescent tubes, energy saving lamps etc.

(ii) Semiconductor luminescent materials capable of exhibiting recombination luminescence are used to fabricate LEDs and semiconductor laser. Also for designing the light sources, upconversion phosphor are coated on arsenide LEDs which convert IR rays to visible light with significant efficiency.

(iii) Cathodoluminescence phosphors are used in the screen of television, cathode ray oscilloscope, radar, electron microscope, night vision devices etc.

(iv) Luminescent materials are used in fabricating the detectors for ultraviolet rays, x-rays, infrared rays etc.

(v) Luminescent materials are also used in scintillation counters whereby nucleons can be detected.

(vi) Light emitting diodes and thin film electroluminescence are used for numeric and alphanumeric displays. LEDs and thin film EL displays flat panel television have been designed whose shape is similar so that of a picture frame. It can be hung on a wall and it can be taken easily from one place to another[7-8].

(vii) Electroluminescence is used in light amplifier.

(viii) Phosphors are used in the fabrication of x-ray intensifying screens.

(ix) Luminescent materials are used in the fabrication of x-ray imaging plates which has presently replaced x-ray photographic films.

(x) X-ray fluorescence is used in non-destructive testing of rocket and ship materials.

## CONCLUSIONS

Luminescence has many potentially important applications. It provides a self-indicating method of monitoring the microscopic and macroscopic processes occurring during deformation and fracture of solids. Since the plastico-induced ML in crystals has memory effect i.e. the ML appears for the second time only after the previously applied stress or strain, the ML measurements may give an idea of the stress and strain occurred in a material in some accident, which may be useful in criminology and also in dating of the archaeological and geological objects. When some image is projected on a γ–irradiated CsBr crystal using F-light, and the crystal is squeezed some time later, then the part that had been exposed to F-light shows considerably bright ML and thereby reproduces the image. This fact shows that appropriate development of the science and technology of this fact may be useful and interesting in photography as well as in writing secret messages which has fund an important application in defence area. Luminescence has been observed even in nanomaterials and make them very useful for futuristic devices.

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