Precise and Low Cost Thermoluminescence Instrumentation Using Embedded Techniques

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Abstract –Many branches of scientific and industrial research require precise instrumentation for control and measurement that tend to be prohibitively expensive. In the current globaleconomic climate, the funding to procure such equipment is fast dwindling. Rather than facea gradual downturn in research activity as a result of equipment procurement difficulties, analternative is to design and build low-cost instruments. We present in this work development of Luminescence Instrumentation, this is the very precise and low cost instrumentation develop by using Embedded Technology for the method of thermoluminescent material characterized. This instrumentrequires precise control and measurement of experimental parameters, particularly the sampleexcitation temperature and output intensity.Thermoluminescence (TL) is a misnomer in the conventional sense of the names of Luminescence processes like Cathode-luminescence, Chemo-luminescence, Electro-luminescence andBioluminescence; heat is not an excitation agent in TL but only a stimulant. The excitation is achievedby any conventional agent like ionizing radiations, UV rays, mechanical vibrations, stress, and chemicalreactions and so on. Thus Thermoluminescence is the phenomenon of luminescent emission afterrenewal of the excitation under conditions of increasing temperature. Phosphorescence at any temperature after the cessation of the excitation is nothing but isothermal decay of TL at thattemperature hence TL should be defined as the thermally stimulated release (in the form of opticalradiation) of energy stored in a material by previous excitation.

Keywords: Embedded system, Luminescence, ARM microcontroller, Photodiode, Thermocouple, Solid State Detectors, incandescence, ISA

1. INTRODUCTION

All the branches of science, industry and medicine, where ionization radiation is used, it requires exact luminescence Instrument means Dosimetry equipment for radiation dose monitoring. There are the two different tasks which are personal Dosimetry and Environmental Dosimetry.Light is the source of energy, if we want to generate light another form of energy must be supplied, Luminous simply means giving off light, most things in our world produce light because they have energy that originally came from the Sun, which is the biggest, most luminous thing we can see. Here we develop an instrument which is useful in the area of luminescence generation by applying some external source like thermal energy that is called as Thermoluminescence (TL) [1] or Thermally StimulatedLuminescence(TSL).

Thermoluminescence requires the perturbation of a system from a state of thermodynamic equilibrium, via the absorption of external energy, into a metastable state. This is then followed by a thermally stimulated relaxation of the system back to its equilibrium condition.Embedded Technology was use in the development of that system. This system generates linear temperature count for the Thermoluminescence material which could release Luminescence according absorbed radiation (eradiation) at particular temperature level. Finally all generated current data stores into the RAM or EEPROM (optionally) memory of the ARM microcontroller which is further use for developing graph; by using these graphs user can characterize the used Thermoluminescence material. These current reading of the temperature and luminescence can displayed by using graphical LCD as well as on the computer screen means hyper terminal also we may use some another type of software like visual basic or java for developing front end software for just reading serial terminal from microcontroller to collect data of the system and save it to the computer's memory and further use it for generate graph.

2. THERMO LUMINESCENCE MATERIALS AND TYPES

Commonly encountered ionizing radiation isα-particles, β-particles, γ-rays,X-rays and neutrons. Thermoluminescence is not to be confused with the glowing observed in incandescence and luminescence [2] in response to vigorous heating to high temperatures.The

temperatures involved in TL are far lower, typically less than 400◦C, generally insufficientto heat a material to glow when seen with the naked eye. The response emissions follow adistribution that is characteristic of the sample. In principle, all that a TL instrument needdo is vary the temperature of asample between two thresholds while monitoring the intensityof the light output from the sample. In practice, however, there are many technical challengesthat must be identified and solved. The control of temperature over wide ranges with goodmeasurement resolution and accuracy for the small dimensioned samples can be difficult, moreso if the samples are in powder form. Secondly, the nonlinearity and output drift, spectral
Correlation errors in the optical detector all require careful characterization and compensation.At the very least, the temperature response of the sensor itself over the instrument operating range should be known.Light emitted when a material is subjected to ultraviolet (UV) radiation. This is the luminescence of most interest to mineral collectors as many mineral specimens fluoresce and the colors cover the full spectrum of visible light, from rich red through brilliant yellows and greens to blue and violet. In some materials, electrons excited by the original radiation can take some time to decay back to their ground states. The decays can take as long as few hours to few or days. This type of fluorescence is called phosphorescence and the material continues to emit visible light for a while after the original radiation has been switched off. If the duration is very short, around 10-4s, then the material is a short persistence phosphor. If it lasts for seconds or longer it is a long persistence phosphor. Objects displaying phosphorescence are sometimes said to be luminous. Most luminous toys, stickers and watch dials are coated with long persistence phosphors.

3. THERMO LUMINESCENCE INSTRUMENTATION DESIGNS

Several designs of TL instruments have been proffered over the lasttwo decades at varying levels of complexity and proclaimed ease of usage - leading to solutionsranging from relatively low-tech to high-tech. Neelamegam et al [3] developed a system thatpermits recording TL data based on a legacy microprocessor, the 6502 from Motorola [4]. Theversion created by Molina et al [5] allows arbitrary heating profiles that include logarithmicheating. Bhatnagar et al [6] catered for automatic control of heating with the added use of lightemittingdiodes for additional sample excitation. Lyamayev [7] created a heating and coolingsystem with wide range of control, finer temperature regulation, simplicity and low cost. Morerecent contributions have attempted to employ advancements in embedded controllers [8]. Thedesigns above have mostly relied on the classical, hard to find thermionic emission PM tube thatis notoriously sensitive to temperature variations, exhibiting a noise figure that can only be keptlow by careful cooling, usually at cryogenic temperatures [9]. Quilty et al [10], however, usedplatinum thermopile (PT100) resistors as both heating and sensing. Solid-state PM devices,though expensive, are now on the market shows in figure 1, but TL instrument designs using them are yet tobe seen. In addition, almost all the foregoing designs used third-party hardware proportional integralor proportional-integral-derivative (PID) control of the heating element, detractionfrom true low-cost. Others used "bang-bang" servos - our own experiments with the "openloop"have shown that for the heater small "plant", the techniques of temperature regulationused often could not reproduce the reported accuracy, for example [11]. An additional difficultyin duplicating the work is that the code, hardware specifics and other beneficent aspects aredescribed heuristically or are protected outright. A TL instrument is clearly a versatile tool withpotential in the applied sciences and feasible [12], custom built alternatives have been sufficientlydemonstrated.

Figure 1: Type TL 1009I Thermo luminescence Dosimetry

4. PROPOSED WORK

An Embedded System is a special purpose computer system designed to perform one or few dedicated functions or task often with real time computing constraints. Means any electronic system has some sort of intelligence, it is related to particular task and if it is real time then that system is called as Embedded System [13] and using particular Technology in implementation that technology called as Embedded Technology. So chip level design and development are engaged to reduce component count to be in order, to make system compact, to enhance the reliability, to cut down the power consumption considerably and definitely slash down the price. That's why the Embedded Technology is very beneficial for developing the low cost, precise and reliable instrumentation. It also gives the flexibility in instrument.

The ARM is a 32-bit reduced instruction set computer (RISC) instruction set architecture (ISA) developed by ARM Holdings. It was known as the Advanced RISC Machine, and before that as the Acorn RISC Machine. The ARM architecture is the most widely used 32-bit ISA in terms of numbers produced. They were originally conceived as a processor for desktop personal computers by Acorn Computers, a market now dominated by the x86 family used by IBM PC compatible computers. The relative simplicity of ARM processors made them suitable for low power applications. This has made the dominant in the mobile and embedded electronics market as relatively low cost and small microprocessors and microcontrollers [14].

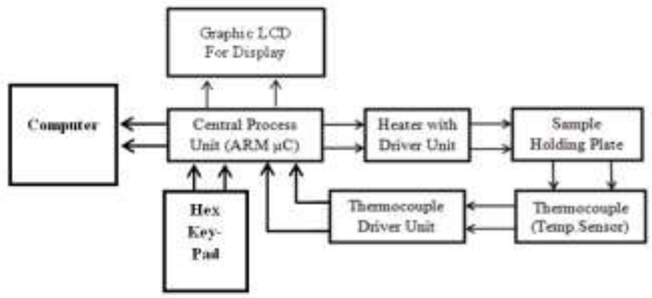

Figure 2: Functional Block Diagram Thermo luminescence

Figure 2 shows the full functional block diagram of Compact and Low Cost Thermo luminescence Instrumentation using Embedded Techniques, in that including ARM microcontroller as a central processing unit which treated as main brain of the system, also with connecting all other blocks peripherally for sample holding plate heater with driver circuit, luminescence sensor with driver circuit, thermocouple as a temperature sensor with driver circuit, graphical LCD for display purpose and this is also readily connected with the personal computer this is optional thing. The hex (16 keys) keypad also connected for controlling as well as data entering for the system but when this system connected with computer system the computer keypad also use for the controlling.

4.1 Thermocouple

Industrially the most important temperature transducer is the thermocouple. Thermocouple works on the principle that the contact potential between two dissimilar metals changes with temperature. Since the thermo-electric electro motive force depends upon the difference in temperature between the hot junction and the reference junction, the temperature of the latter should remain absolute constant in order that the combination holds good and there are no errors on account of change in ambient temperature.
The temperature is controlled for this purpose, the reference junction temperature usually 0 degrees Celsius [15]. Thermocouples are used for measurement of temperature up to 1400 degree C.

4.2 Transformer as a Heater Control Unit

A transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the *primary* winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the *secondary* winding. This varying magnetic flux induces a varying electromotive force (emf) or voltage in the secondary winding. Transformers can be used to vary the relative voltage of circuits or isolate them, or both. Transformers range in size from thumbnail-sized used in microphones to units weighing hundreds of tons interconnecting the power grid. A wide range of transformer designs are used in electronic and electric power applications. Transformers are essential for the transmission, distribution, and utilization of electrical energy. Transformer is used as a Heater is shown in the figure below:

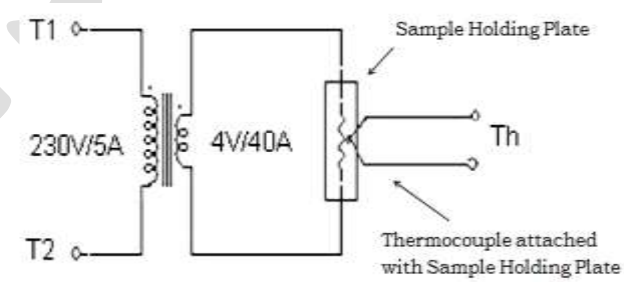

Figure 3: Transformer as a heater

4.3 Photodiode as Luminescence Sensor

There is a class of devices known as solid-state detectors that work on the principle that they collect the charge generated by ionizing radiation in a solid. These detectors are made of semiconducting material and are operated much like a solid-state diode with reverse bias. The applied high voltage generates a thick 'depletion layer' and any charge created by the radiation in this layer is collected by the electrode. The charge collected is proportional to the energy deposited in the detector and therefore these devices can also yield information about the energy of the individual particles or photons of radiation. The detectors are made mostly of silicon or germanium. The two general designs that have received consideration as possible substitutes for photomultiplier tubes are the conventional photodiode also known as a PIN diode, and the avalanche photodiode. Conventional photodiodes have no internal gain and operate by directly converting the optical photons from the scintillation detector to electron-hole pairs that are simply collected.

When light is incident on a semiconductor, electron-hole pairs are generated for incident ionizing radiation. Photons corresponding to scintillation light carry about 3-4 eV of energy, sufficient to create electron-hole pairs in a semiconductor with a band gap of 1-2 eV. The maximum quantum efficiency can be as high as 60-80%, which is several times higher than that of the photomultiplier tube. However there is no amplification of this charge as in the photomultiplier tube, making the output signal smaller [16]. Electrons and holes produced by the light are collected at the boundaries of the central *i* region driven by the electric field resulting from the applied voltage. The corresponding induced charge is processed in an attached preamplifier to produce the output signal pulse.

5. FUTURE SCOPE AND ADVANTAGES

This system is fully digital that gives very precise reading every times and components generated errors are very negligible. Some test results are shown in the figure 4.

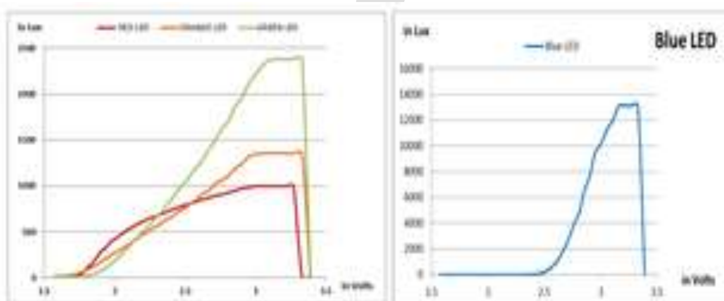

Figure 4: System response for different Luminescence colors

This system is very linear for the temperature in creasing rate for different maximum limit for temperature as well as time in sec. as a sample shown in the figure 5.1 and figure 5.2.

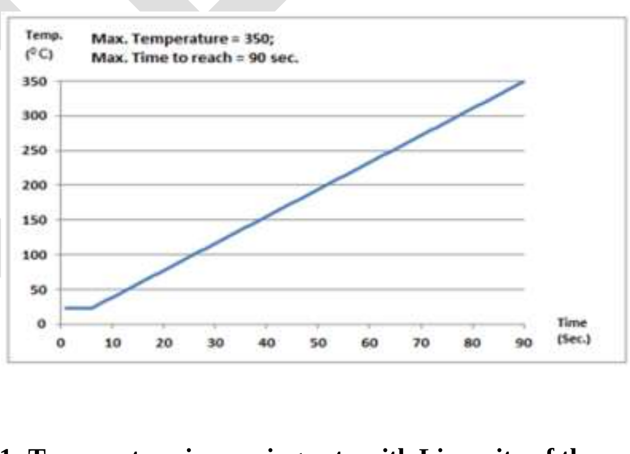

Figure 5.1: Temperature increasing rate with Linearity of the system for 90sec

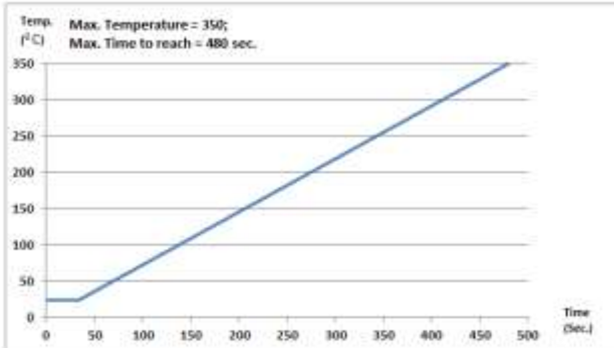

Figure 5.2: Temperature increasing rate with Linearity of the system for 480sec

Some Thermoluminescence material are tested on this system from them one of the result shows in the figure 6 for CaSo4 material.

This system can we develop further like, develop by using touch screen LCD or devices like Tablets in which will have no requirement for keys or external keypads and we can add wavelength finding of the generated luminescence of the system.

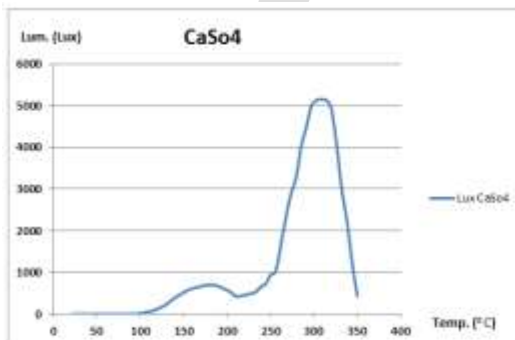

Figure 6: Result of the system testing for CaSo4 TL Material

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