Thermoluminescence Study of Based Materials of Ceramic Tiles

Mandavia H.C. 1, Murthy K.V.R. 2, Purohit R.U. 3 and Sayani A.N. 4

1Shri M. M. Science College, Morbi-363 642, Gujarat, INDIA
2Display Materials Laboratory, Applied Physics Department, Faculty of Technology, M. S. University, Baroda, GJ, INDIA
3Commissioner of Higher Education, Gujarat State, Gandhinagar, INDIA
4College of Fishery, Veraval, Gujarat, INDIA

Available online at: www.isca.in

Abstract

Many flooring materials most of them are in natural form are used to manufacture floor tiles for household flooring purpose. The peoples demand for variety of flooring materials leads to develop various types of ceramic tiles. In India ceramic industry is fast growing one, more than 500 units of manufacturing ceramic tiles, vitrified tiles and sanitary ware, situated around Morbi, Rajkot, Gujarat, India. Many natural minerals are used as the raw materials required for the manufacturing ceramic ware. The following minerals are used to manufacture the ceramic tiles i.e. Quartz, Feldspar, Zircon, Talc, Grog, Alumina oxide, etc. Most of the minerals are from Indian mines of Gujarat and Rajasthan states, some of are imported from Russian sub continent. The present paper reports the thermoluminescence characteristics of Feldspar, Alumina and Quartz minerals collected from the ceramic tiles manufacturing unit, Morbi. The as received minerals TL was recorded (NTL), and annealed and quenched from 400°C followed by 15Gy beta dose given from Sr-90 beta source TL was recorded and the comparative TL (Thermoluminesnces Study) study of above materials are presented and it represent some special characteristics of the materials.

Keyword: NTL– Natural Thermoluminescence, TL- Thermoluminescence.

Introduction

Many natural mineral are used to manufacture floor tiles for household floorings. The demand of a variety of flooring materials has lead to develop various types of ceramic tiles. In India the ceramic industry is one of the fastest growing industries, more than 200 manufacturing units of ceramic tiles, vitrified tiles and sanitary wares are situated at Morbi (Rajkot District, Gujarat state, India). Many natural minerals are used as the raw materials for the manufacturing ceramic wares. The minerals used in manufacturing the ceramic tiles are Quartz, Feldspar, Zircon, Talc, Frit-O, Frit-T, Aluminium oxide, Sodium trypoly phosphate China clay, Bikaner clay, etc. Most of the minerals are from mines in Gujarat and few are from Rajasthan state and imported from Russia. The phenomenon of TL has been studied by many investigators. The thermoluminescence (TL) study in geology, particularly for natural minerals, is an important research tool. The TL study of minerals commonly used in ceramic tiles industry, such materials gives better understanding about their properties and characteristics. The systematic study of TL of such minerals is helpful to solve the basic raw materials quality problem the ceramic tiles industries.

Experimental method: The natural minerals used in manufacturing ceramic tiles are collected from the ceramic tiles industry. Most of the materials used for the TL analysis were indigenous ones and a few were imported minerals. First make a fine powder of such mineral and then 5mg powder of each materials are taken and placed this powder between circular ring and then put Sr 90 Beta source on it for twenty min. for irradiation. The source capacity is 500rad./min. after irradiation the sample is collected from the circular ring and placed into the TL (Thermoluminescence) reader. TL of these minerals was recorded using TL set-up supplied by Nucleonix Systems, Hyderabad. Irradiation was carried using Sr-90 beta source. Equal quantities of samples (5 mg) were used for the analysis.

Figure-1
High temperature Furnace
Thermal Annealing Treatment: Thermal annealing for the specimen was carried out in the muffle furnace. The laboratory muffle furnace has temperature range up to 1200°C and the size of chamber for sample heating was 22cm × 10cm × 10cm. The temperature was maintained with ±1°C accuracy using a temperature controller, which supplied required current to the furnace. Power supply of 230V was provided to the furnace. A silica crucible containing a powdered form of virgin specimens was kept in the furnace at required annealing temperature for desired time. After completion of annealing duration the specimens were rapidly air-quenched to room temperature by withdrawing the silica crucible onto a ceramic block. Such material or specimens are called “annealed and quenched” or “thermally pre-treated specimen”.

Results and Discussion

TL Study of Quartz: Figure-4 is the TL of 5mg of weighed powder was taken to record TL glow curve of Quartz (NTL) without any pre heat treatment and irradiation. The glow curve exhibit one hump like glow peak at temperature at 332°C. There is no good TL is observed.

Figure-5 shows TL glow curve of Quartz irradiated with beta dose of 15 Gy using Sr-90. Here one peak occurs at temperature 110°C and intensity of 1.83 au here little TL is recorded. It is noted that after irradiation one trap developed and released carrier during the TL measurement.

Figure-6 is the TL glow curve of Quartz annealed and quenched from 400°C and given a beta dose of 15 Gy using Sr-90 beta source. TL glow curve of 400°C AQ sample of Quartz exhibits one well resolved and isolated TL peak with high intensity around 100°C. This peak is interesting TL peak in dosimetric point of view.
Figure-5
TL glow curve of Quartz

Figure-6
TL glow curve of Quartz annealed and quenched from 400°C

Figure-7
TL glow curve of Quartz annealed and quenched from 600°C

Figure-8
TGA of Quartz from the TGA

Figure-9 shows the XRD pattern of Quartz it is clearly matches with the standard peaks observed at 26.66, 20.88, 50.18 and 60° are major peaks of standard quartz sample.

Figure-10 shows the TL glow curve of Feldspar mineral with out any pre heat treatment and irradiation. The glow curve exhibits one well resolved peak at 308°C temperature. Here heating rate is 4°C/sec for TL measurement the intensity of peak is 76au noted this intensity is remarkable this sample gives TL without any pre heat treatment this result is interesting here phase changed thermoluminescence is occurs. Some mineral contain water molecule due to this result the phase change TL
produced. Here till temperature 170°C the intensity remain near to zero but then after intensity continuously increasing with temperature. From this result it is noted that one trap with large numbers of carriers generated with peak 308°C.

141°C with intensity 43au this peak is well resolved and stable so it is considered as dosimetric peak.

Figure-9
X RD pattern of Quartz

Figure-10
TL glow curve of Feldspar mineral

Figure-11
TL glow curve of Feldspar mineral

Figure-12 shows the TL glow curve of Feldspar mineral with pre heated at annealing and quenching temperature at 400°C and irradiated with beta radiation dose of 15Gy by Sr90. Here heating rate is 4°C/s for TL measurement, here one well resolved glow peak occurs at temperature 123°C and peak intensity of 39au is recorded, with comparison of Figure- 2.3 it is clear that peak temperature almost remain same but the peak intensity is decreased about 40%, this interesting this shows the fading effect occurs between temperature range of 200°C TO 400°C into the material also broad hump is produced in the glow curve.

Figure-12
TL glow curve of Feldspar mineral

Figu erw-11 shows the TL glow curve of Feldspar mineral irradiated with beta dose of 15 Gy by Sr90, here no any pre heat treatment is given to the sample, here two well resolved glow peak occurs at temperature 141°C and 312°C it is indicate that two traps with large carriers is related with this temperature range here the intensity of peak is 43au and 39au respectively, here it is noted that the intensity of peak 309°C in in Figure-2.1 is decreased in Figure-2.2 and the peak temperature slightly change from 309°C to 312°C it shows fading effect but one remarkable result is that one new peak occurs at temperature.
Figure-13 shows the TL glow curve of Feldspar mineral with pre heated at annealing and quenching temperature at 600°C and irradiated with beta radiation dose of 15 Gy by Sr$^{90}$. Here heating rate is 4°C/s for TL measurement. Here one well resolved glow peak occurs at temperature 114°C and peak intensity of 51au is recorded, with comparison of Figure- 2.4 it is clear that no major occurs into the result except peak temperature slightly change from 123°C to 114°C and intensity decreased from 34au to 51 au so it is noted that after 400°C temperature treatment more carrier oriented trap is formed that’s why TL intensity is increased but minor variation occurs in peak temperature it shows the stability of peak.

Figure-14 shows the TGA of Feldspar it indicate variation in phase at different temperature. The variation in TL intensity due to phase change in to the material at particular temperature it is co related with TL result.

Figure-15 shows the X RD pattern of Feldspar it is clearly matches with the standard peaks observed at 13, 27.48, and 41.86° are major peaks of standard Feldspar sample.

**TL Study of Alumina:** Figure-16 shows TL glow curve of Alumina with out treatment of heat and irradiation dose. This glow curve exhibits one peak at temperature 159°C and intensity of 0.11au here no significant TL is recorded, the material exhibits low TL sensitivity in natural form.

Figure-17 shows TL glow curve of Alumina with irradiated with beta dose of 15 Gy by Sr$^{90}$. The glow curve exhibits one peak at temperature 257°C and with intensity of 34au, here it is noted that after irradiation the intensity of TL is increased it is means that that large carriers oriented trap is generated.

Figure-18 shows the glow curve of Alumina treated with annealing and quenching temperature of 400°C and irradiated with beta source of 15 Gy. Here glow curve exhibits one well resolved peak at temperature 275°C and intensity of 48au also one broad hump is developed. It compare with Figure- 4.3 the intensity is increased from 19au to 48au it is noted that after the treatment of AQ400°C more carriers oriented trap is formed and it released it when it heated for TL measurement. The heating rate for TL is 4°C/s. The peak 275°C is conceded as stable peak it indicate stability of material also this peak is interesting for dosimetry point of view.
Figure-16
TL glow curve of Alumina without treatment of heat and irradiation

Figure-18
Glow curve of Alumina

Figure-17
TL glow curve of Alumina with irradiated with beta dose of 15 Gy. The heating rate for TL is 4°C/s. Here glow curve exhibits one well resolved peak at temperature 275°C and intensity of 66 au also one broad hump is developed. It compare with Figure-4.4 the intensity is increased from 48 au to 66 au but the peak temperature remain constant increasing intensity exhibits that more carriers involve with trap after this heat treatment.

Figure-19 shows the glow curve of Alumina treated with annealing and quenching temperature of 600°C and irradiated with beta source of 15 Gy. The heating rate for TL is 4°C/s. Here glow curve exhibits one well resolved peak at temperature 275°C and intensity of 66 au also one broad hump is developed. It compare with Figure-4.4 the intensity is increased from 48 au to 66 au but the peak temperature remain constant increasing intensity exhibits that more carriers involve with trap after this heat treatment.

Figure-20 shows the TGA of Alumina it indicate small variation in phase at different two temperatures at 171°C and 518°C. Also it shows the stability of the material against temperature.

Figure-21 shows the XRD pattern of Alumina it is clearly matches with the standard peaks observed at 25.72, 35.28, and 57.62° are major peaks of standard Alumina sample.
Conclusion

The natural TL [NTL] observed in Above minerals under study as well as NTL+ATL followed by the TL observed from annealed and quenched form 400°C and 600°C followed by beta irradiation leads to the conclusions the results are due to the traps formed by irradiation as well as heat treatment to the subjected mineral.

The systemic study may be more useful in checking the purity of the raw materials which in turn leads to improving the quality of ceramic tiles in ceramic industries. Further studies are in progress.

Acknowledgment

The author (H.C. Mandavia) is thankful to U.G.C., New Delhi, for the awarded of Teacher Fellowship and thankful to Shri C.M.Shanghavi (Hons.secretary Sarvodaya Education Society), Shri S.M.Vadia ( Executive Secretary Sarvodaya Education Society) and Dr. P. K. Patel (Principal Shri M. M. Science College, Morbi) to promote this research.

References

1. K.V.R. Murthy and J.N. Reddy Thermoluminescence basic theory application and experiment, Feb.2008, Pub. Nucleonix, Hyderabad (2008)
2. K V R Murthy, Y S Patel, A S Sai Prasad, V Natarajan, A G Page, Radiation Measurements (36 483)
3. K V R Murthy, S P Pallavi, R Ghildiyal, M C Parmar, Y S Patel, V Ravi Kuma, A S Sai Prasad V Natarajan, A G Page, Radiation Prot. Dosim. 120-238 (2006)
4. K V R Murthy , S P Pallavi , R Ghildiyal , Y S Patel , A S Sai Prasad , D Elangovan, Radiation Prot. Dosim. 119-350 (2006)
5. S.W.S McKeever, Thermoluminescence of Solids, Cambridge University Press, Cambridge, (205) (1985)
6. Blasse, Luminescent Materials, Springer, Berlin, 93 (1994)
7. M.J. Aitken, Physics and Archaeology Oxford, U.K.: Oxford Univ. Press (1974)
8. S.W.S McKeever, M.S. Akselrod and B.G. Markey, Radiation. Prot. Dosim, 65-267 (1996)
9. S. Kumar, Source Book of Ceramic, (1998)