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The Effect Doped Impurities in Thermoluminescence Phosphor of Natural Salt

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Abstract:

We have measured the thermoluminescence of a number of natural NaCl crystals following irradiation at ambient temperature with the same dose (1 Gy) of beta- source. We compare the TL of pure samples and of samples doped with Mn, Eu and Dy ions. The effects of irradiation are determined using thermoluminescence. Factors investigated include the effects of different dopants on TL glow curves annealing samples at 500ºC. Changes in TL glow curves relating to changes in the state of aggregation of the impurities produced are reported in this study. Perhaps the most significant effect is a temperature shift of the TL main glow peak compared to pure samples in the case of single doped NaCl: Mn; Eu and Dy. The magnitude of the shift depends on the type impurity. Here the main effect of different impurities is to influence the size of the TL intensity emission and not the structure of the glow curve. Discussion of results are in terms of current thermoluminescence theories.

Keywords: Natural and doped salt, TL glow curve, RE-ions, Retrospective dosimetry, Annealing temperature.

تأثير الشوائب المضافة على الوميض الحراري للملح الطبيعي

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الملخص

لقد قمنا بقياس الوميض الحراري (TL) لعدد من بلورات كلوريد الصوديوم الطبيعية بعد التشعيع في درجة حرارة الغرفة بنفس الجرعة (1 جراي) من مصدر بيتا. قارنا TL للعينات النقية والعينات المخدرة بأيونات Mn وEu و Dy. يتم تحديد تأثيرات التشعيع باستخدام الوميض الحراري. تتضمن العوامل التي تم التحقيق فيها تأثيرات المواد المولدة المختلفة على منحنيات توهج TL التي تقوم بتلدين العينات عند 500 درجة مئوية. تم الإبلاغ عن التغييرات في منحنيات توهج TL المتعلقة بالتغيرات في حالة تجميع الشوائب الناتجة في هذه الدراسة. ربما يكون التأثير الأكثر أهمية هو تحول درجة حرارة ذروة التوهج الرئيسية TL مقارنة بالعينات النقية في حالة كلوريد الصوديوم المخدر المفرد: Mn وEu و Dy. يعتمد حجم التحول على نوع الشوائب. هنا يكون التأثير الرئيسي للشوائب المختلفة هو التأثير على حجم انبعاث شدة TL وليس بنية منحنى التوهج. تتم مناقشة النتائج من حيث نظريات التلألؤ الحراري الحالية.

الكلمات المفتاحية: الملح الطبيعي والمُشَبَّب، منحنى الوميضي TL، أيونات RE، قياس الجرعات بأثر رجعي، درجة حرارة التلدين.

Introduction

Thermoluminescence (TL) has been largely recognized to be a defect related phenomena due to the presence of impurities and defects that can markedly influence the TL-response and sensitivity materials and several models have been proposed to explain the observation of GL-curves that may vary in complexity ranging from one to several TL-peaks [1,2]. The method is useful, handy and efficient for obtaining information on the trapping states and defect distribution of insulators. In crystalline materials, however, the energy levels are due to structural defects or the presence of intrinsic and/or extrinsic atoms in the crystal. Electrons and holes created as a result of irradiation of the material can be trapped at defect sites and subsequent heating causes the release of some of the stored energy as photons, depending on certain processing conditions [3,4].

The common natural salt (NaCl), salt is a very wide band gap (~ 8.5 eV), of natural origin, crystallized from Sea Water, lakes, saline ground water and also mined as solid rock [5]. The natural material, has been extensively studied and is known to exhibit luminescence properties depending on the composition and structure that may vary, and has been studied for its thermal, optical and infrared stimulated luminescence [6-10].
The present paper provides information about possible impurity size effects on TL in the salt system. Here defect production proceeds by trapped electrons in the form of F and F aggregate centers and complementary interstitial anions known as H centers. In NaCl, this radiation induced centers is not particularly stable at ambient temperature or when exposed to background illumination. However, after exposure to ultraviolet illumination, doped crystals of NaCl exhibits thermoluminescence, an effect that is not observed in pure crystals [11-14]. This has encouraged us to investigation is to study TL glow curve effects of crystal powder of different types impurities of doped natural NaCl salt with constant annealing temperature and test irradiation dose.

Experimental

Doped natural occurring salt (NaCl) samples were prepared collected from Mediterranean Sea brine in the Libya. The purposely added doped impurities chloride manganese (Mn) and Rare Earth (RE-) Europium (Eu) and Dysprosium (Dy) samples were prepared from RE-chloride and oxide form by adding a same concentration of 0.002 mol% of all impurities to NaCl natural solution. The solution was stirred well for about one hour at room temperature (RT), using a magnetic stirrer, until it became homogenous and transparent. Then the solution was evaporated at 100°C on a hotplate for about a few days. The re-crystallized residue was normally crushed to powder and grinded using a mortar and sieved using a mesh of particle size less than ≤ 75µm. Samples used in the measurements were shaped out in the form of circular discs, each of mass 15mg, and pressed under a half ton pressure with dimensions 5mm diameter and thickness about 1mm. All samples were then annealed temperature at 773Kh-1 in porcelain crucible using a microprocessor-controlled furnace and then cooled slowly to RT prior to irradiation.
The samples are irradiated at RT with an inbuilt beta irradiation β- source with a dose rate of 2870nGy/s. Test dose in all samples doped impurities is 1Gy of β-irradiation. All the samples were read immediately after exposure to radiation. The read-out stage was made using Harshaw Model 3500 TLD-Reader. The reader is connected to a PC, where the TL signals were recorded and analyzed by the usage of the WinREMS software. All phosphors were read using the linear constant heating rate of 2Ks-1, from RT up to 400°C.

Results and Discussion

Effect Doped single impurity on TL- Glow Curve of Natural Salt Comparing with TL Phosphor Pure. Figure 1(a-d) shows typical TL glow curves for pure natural salt and doped with concentration (0.002 mol%) of different impurities, as obtained them from the WinREMS software through reader samples. We compare results for samples single doped with different impurities, (NaCl:Mn, NaCl:Eu and NaCl:Dy(0.002mol%)). All samples annealed with annealing temperature 773Kh-1. The GL-curves inspection of a closer reveal that significant changes are taking position not only to the trap positions but also distinct variations of the intensities of the TL-traps are occurring. The changes occurring to consequently changes in the composition and the average electron number population and the impurity structure are also expected as clearly seen in Figure 1(b, c and d). The GL-curves of natural salt following the doped Mn, Eu and Dy, respectively, correspond to impurity type in F-center concentration.

1. TL Glow Curve of Mn Doped Natural Salt Samples

Figure 2(b) shows the glow curve for the crystals of NaCl:Mn annealed at 500oC and irradiated with dose 1Gy. two prominent peaks are present, near 153, 226oC and a broad shoulder trap can be distinguished, with their maxima occurring at 320oC. In the NaCl:Mn samples the TL intensity of the first peak increases compared with the glow curve of the pure sample.

2. TL Glow Curve of Eu Doped Natural Salt Samples

TL- Glow curve for crystals containing concentration of Eu: 0.002mol%, as an impurity is given in Figure 2. In the case of NaCl:Eu see, Figure 2, a prominent glow peak occurs near 233oC, which shifts to higher temperature comparing with pure sample as shown in Figure 2, with available one peak at intermediate energy level (maximum temperature) near 167oC and high temperature broad shoulder trap occurs at 335oC. Doping with europium has enhanced the TL emission of natural salt.

3. TL Glow Curve of Dy Doped Natural Salt Samples

In Figure 2 shows typical TL- glow curves of NaCl: pure and doped Dy. An isolated the two main TL- traps and one broad peak at high temperature are observed due to luminescence center is formed during irradiation by 1Gy in each sample. Two TL peaks detected near 165 and 231°C and shoulder peak at 350oC are recorded with enhancement of the first main peak in relation to the other TL peak. In addition, an increase in intensity of the prominent main TL traps is more than twofold compared to the naturally as-prepared samples, cf. Figure 2.

Indeed, the TL which is a defect related phenomena and is largely affected by the presence of extrinsic impurity defects, and their interactions can markedly influence the TL response and sensitivity of the material. Our observation which indicates a marked increase in the phosphor's response is explained based on the collective effects resulting from the purposely added heavy ion impurities (extrinsic) and the presence of dissolved minerals in the Mediterranean Sea water. In fact, heavy ion impurities have largely been recognized to reside within the alkali-halides at substitutional places and they may occupy interstitial lattice positions for large impurities ions, see, e.g., [12,13,15,16].

Finally, this study, most previous studies and future studies which that in process indicate that a natural salt (NaCl) pure and doped impurities [Ref. all our works] these samples are of great importance and can be used as a dosimetry irradiation to be a new TLD-NaCl. All tables should be inserted in the main text article at its appropriate place.

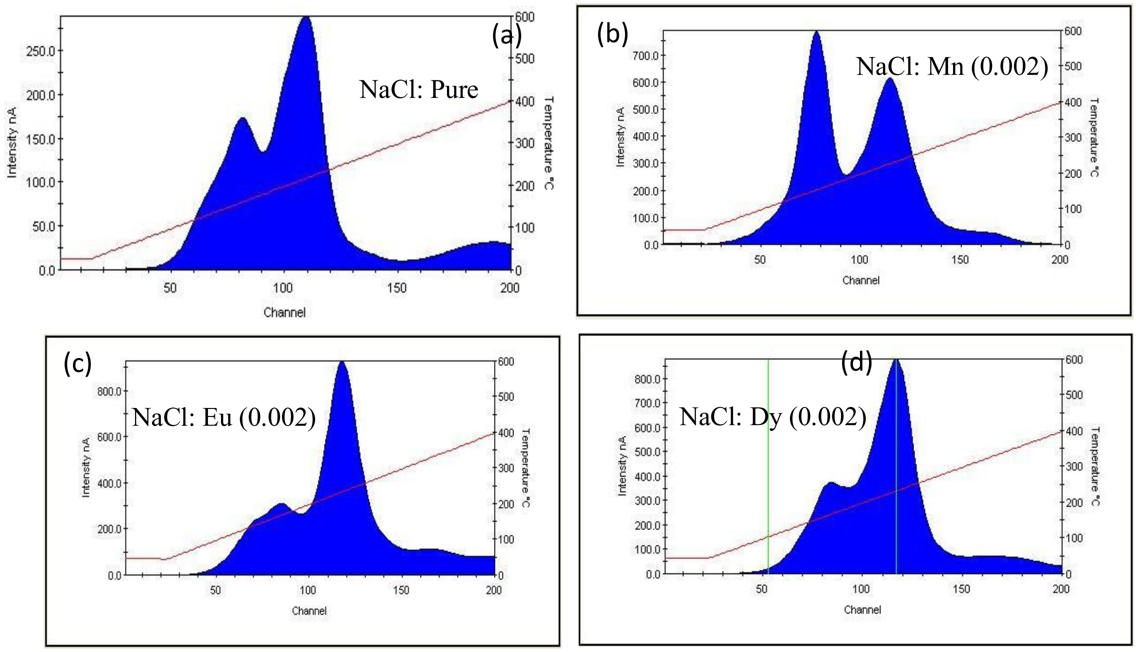

Figure 1: (a-d): Typical GL-curves as a function of channel for crystals of: (a) NaCl, (b) NaCl: Mn (0.002 mol%); (c) NaCl: Eu (0.002 mol%); (d) NaCl: Dy (0.002 mol%). These results are obtained from the Harshaw device after reading the samples directly. Measurements are recorded at a heating rate of 2ºC/s.

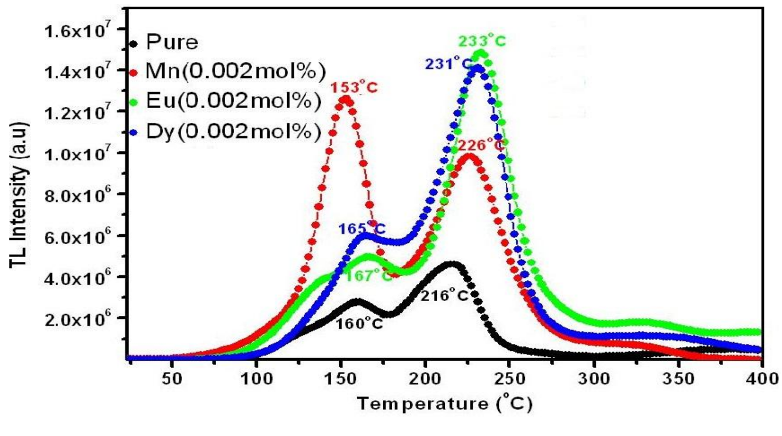

Figure 2: TL-Glow curves as a function of temperature, Convert the channel number (1 t0 200) to temperature (T0 to 400oC) according to the heating rate (β) equation (ΔT=β Δt) for crystals of: (a) NaCl, (b) NaCl: Mn (0.002 mol%); (c) NaCl: Eu (0.002 mol%); (d) NaCl: Dy (0.002 mol%). These results are obtained from the Harshaw device after reading the samples directly. Measurements are recorded at a heating rate of 2oC/s.

Conclusion

We have presented TL glow curves for natural salt crystal, both pure crystals and crystals incorporating various impurities are considered. Impurities have a stabilizing effect on TL glow curves and affect the intensity emission. The basic pattern of the glow curve is different in doped crystals and depend on the type of impurity. Changes are produced as a result of impurities effect on samples annealed temperature at 500 and irradiated with test dose1Gy. In doped crystals this often includes a shift in the temperature of a TL main peak near 230oC and changes in the overall TL emission intensity. Some reasons for this are suggested. Further work is needed before we can properly evaluate recently predicted effects of impurities such as the shift of glow peak temperatures with impurity ion size, (In process study). Good candidates for investigation appear to be NaCl single doped and co-doped with RE-ions as Europium (Eu) or Dysprosium ions.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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