الله

بسم الله الرحمن الرحيم

"وعلمك ما لم تكن تعلم وكان فضل الله عليك عظيما"

صدق الله العظيم

SOLID STATE NUCLEAR DETECTORS AND THEIR APPLICATIONS IN ENVIRONMENTAL RADIATION MEASUREMENTS

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SUMMARY

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Among different solid state nuclear detectors, thermoluminescence (TL) materials have the capability of storing energy when exposed to ionizing radiation. This energy can be re-emitted in the form of visible light when the materials are heated to a suitable temperature. In this work, this phenomena has been studied theoretically and experimentally to fulfill the following objectives:

1- To realize a good understanding of the thermoluminescence phenomenon specifically and to be familiar with the latest state of the art.

2- To gain some experiences in preparing a home-made $CaSO_4$:Dy TL material for the first time in Egypt and to study the various physical parameters which control its sensitivity and dosimetric characteristics.

3- To run a field application on this material as a part of a national environmental radiation monitoring program.

In this thesis, theoretical and experimental materials are given in five chapters.

Chapter one presents a general introduction about the following subjects:

- the natural and man-made sources of background radiation and their origins,

- an idea about solid state nuclear detectors in use such as scintillation detectors, semiconductor detectors, radiophotoluminescence dosimeters and thermoluminescence dosimeters,
- a discussion about the luminescence phenomena ,
- a review about the commonly used thermoluminescence phosphors in environmental measurements with special emphasis on $CaSO_4$ TL material with different types of activators,
- the objective of the present work.

Chapter two discusses the physical and the theoretical consideration of thermoluminescence. In this chapter the kinetic model which studies the defect properties as a tool for determining trapping parameter such as activation energy and frequency factors are reviewed.

Chapter three presents a detailed description of the preparation procedure of the home-made $CaSO_4$:Dy TL material. The instruments used in this study such as, the TL read-out system, the irradiation facilities, the dose rate meter and the annealing furnace are depicted. The measuring techniques, the measuring accuracy and the lower detection limit are also presented.

Chapter four includes the experimental results and discussions which can be summarized as follows:
- During sample preparation of $CaSO_4$:Dy TL material,

the continuous evaporation method produces a more senstivite phosphor than that in case of the interrupted evaporation method.

- The optimum concentration of Dy in $CaSO_4$ was found to be 0.19 mol %.

- A pre-irradiation heat treatment at 700°C for a period of 2 hours followed by cooling in air was considered as the optimum condition.

- The glow curve structures of the home-made $CaSO_4$:Dy TL phosphor include two main glow peaks at 110°C and 190°C and the dominant dosimetric stable peak is considered at 190°C.

- The response to gamma-rays was found to be linear over the range from 0.1 mGy up to 30 Gy followed by a saturation region. No supralinearity was observed.

- The natural fading was found to be 11% during the first 50 days.

- The over response at low photon energies was calculated and compensated by using a 0.3 mm lead shield.

- The TL signal of irradiated material was found to be reliable for gamma-ray dose estimation over the range from 0.1 mGy up to 30 Gy.

- For application in environmental radiation monitoring, the response below 0.1 mGy was checked and the results indicated that the response is linear in the dose range from 0.01 mGy up to 0.6 mGy.

- The results of a field application is about 42 locations in Cairo province indicate an average annual background dose of 699 ± 8.7 % μGy.

Chapter five presents the main conclusion drawn from the theoretical and experimental studies given in this work along with some recommended applications.

Finally, the main outcome of this work is the preparation of a home-made $CaSO_4$:Dy TL material for the first time in Egypt with suitable characteristics which make its application in personnel dosimetry, accidental dosimetry as well as environmental dosimetry quite reasonable.

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INTRODUCTION

1.1 GENERAL

Throughout history man has lived with ionizing radiation from natural sources and recently from man-made sources. By time, the second part has been integrated in the steady radiation environment. It is impossible for people to avoid exposures to radiation within their living environment which depends mainly on the type of dwelling they are living, their life style and the level of medical care they receive.

The average annual dose from natural source was found to be about 2.4 millisievert with individual doses ranging from 1 to 5 mSv per year and one Sv in some extreme cases [1]. Even so, there are well documented areas where people are exposed to exceptionally high levels of terrestrial radiation. In the coastal areas of Kerala and Tamil Nadu in India, Thorium rich Monazite sands result in dose rates that can be up to 1000 times higher than the normal radiation background. Also, in the Barzilian areas of Guarapari, Meaipe and Pocos de Caldas, dose rates can be as much as 100 times the normal level [1]. Therefore, detailed studies of natural radiation and its local and temporal variation are highly needed because of the possible biological hazard of such