Synthesis and Characterization of Thermoluminescence Dosimetric Studies of Ge Doped SiO_2 Nanophosphor

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Introduction

Thermoluminescence(TL) Dosimeter: Used to detect amount of radiation exposure surrounding air or worker (radiation area)

TL measurement:

- Crucial for deciding the best TL dosimeter
- Determining the suitable material to use in the TL dosimeter

SiO_2 have excellent properties such as

- Easy preparation & widely used in various industrial applications
- Hardness, wear-resistance, anti-corrosion and also its optical properties.
- Previous study also reported that when SiO_2 exposed to ionizing radiation, it gives a positive space-charge buildup (Mitchell, J. P)

TL enhancer will produce better TL response. E.g: silica samples doped with metallic impurities which is Fe and Cu gives high response than pure silica. (Anaya, D.M. et al, 2003)

Ge enhancer can produce good TL-yield and have high TL sensitivity in optical fibers for low dose irradiation (Yaacob, et al 2011). Various dopant concentration will produce difference TL enhancement

SOL-GEL (WET CHEMICAL METHOD)

- One of the method used to synthesize nanoparticles
-Involved hydrolysis and condensation of metal alkoxides.

ADVANTAGES of using SOL-GEL method

- Simple apparatus requirement
- Economical materials
- Requires low temperature furnace
- Create fine powder
- Short time preparation
- Produce homogeneous & high-purity materials.

SiO_2 nanophosphor

- Many researchers have chosen silica to investigate the thermoluminescence phenomena since it has special properties that lead to high quality thermoluminescence dosimeter substance.

  Sol–gel processing steps in producing nanoparticles enable in producing homogeneously doped samples (yusoff et al, 2005)

  Linear TL-response had shown in the SiO_2 compound from sol-gel technique (Klosowicz et al, 2003)

- The shape and particle size of silica playing an important role in quality and performance of TL dosimeter.

  By varying the amount of ethanol in the mixture sample, a different particle size will be produced. Reported that smaller the particles will enhance in TL performance (Shafiqah et al, 2015)

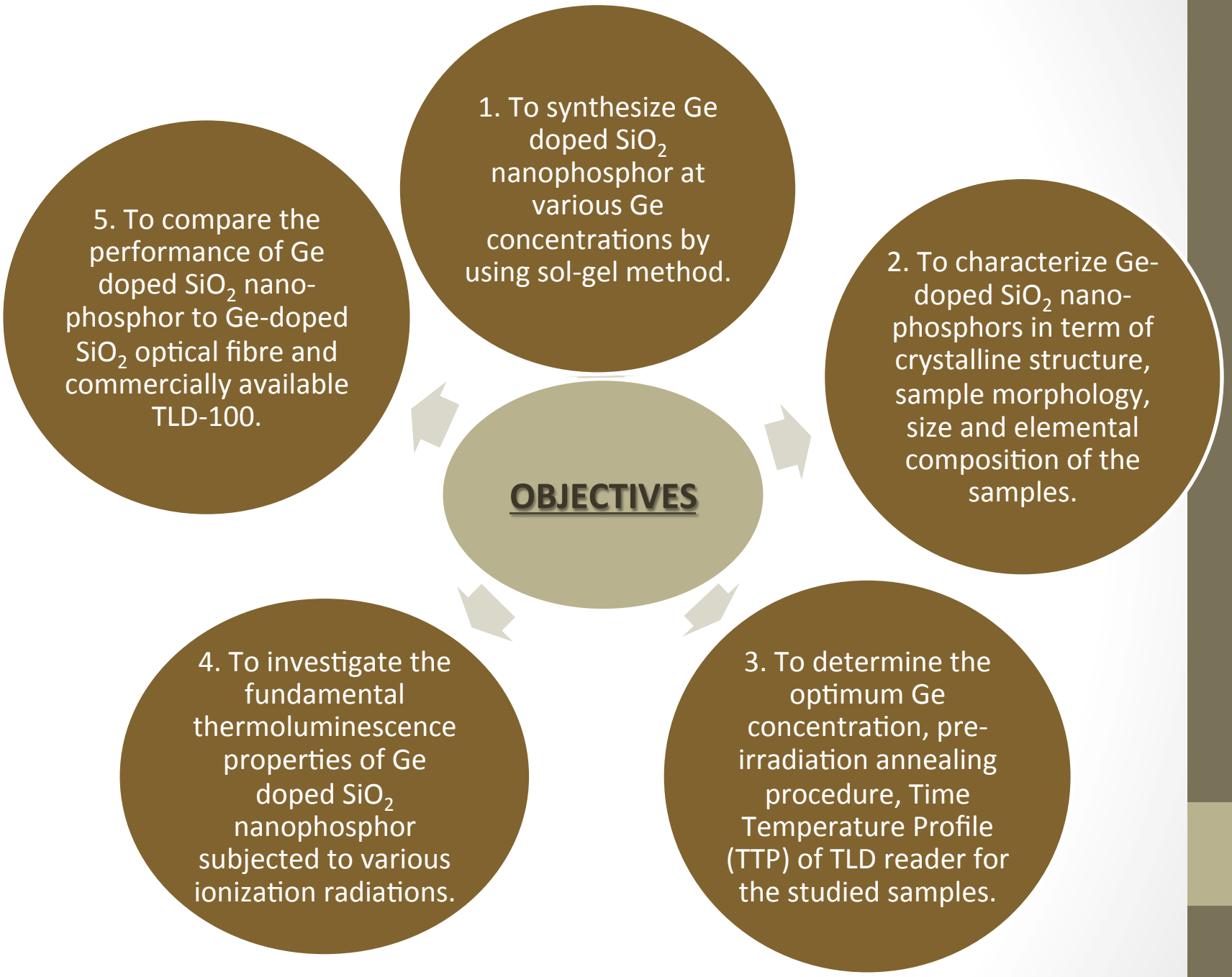
TL for Ge doped SiO_2 optical fiber

No	Year	Author	TL Propose
1	2010	Abdul Rahman et al	Syncrotron microbeam radiation theraphy dosimetry
2	2011	Yaakob et al	Good TL-response for low dose electron irradiation.
3	2012	Saeed et al	Good TL-response for X-ray irradiation
4	2013	Hossain et al	Good TL Response for external photon radiotherapeutic dose

Aim of The Research

- To propose the performance of this TLD material which can ensure the dose delivered to the patients and workers accurately in order to predict the level safety according to the International Commission on Radiological Protection (ICRP).

- To reveal the suitable and alternative way to produce TLD material based on sol-gel technique.


OBJECTIVES
1. To synthesize Ge doped SiO_2 nanophosphor at various Ge concentrations by using sol-gel method.
2. To characterize Ge-doped SiO_2 nano-phosphors in term of crystalline structure, sample morphology, size and elemental composition of the samples.
3. To determine the optimum Ge concentration, pre-irradiation annealing procedure, Time Temperature Profile (TTP) of TLD reader for the studied samples.
4. To investigate the fundamental thermoluminescence properties of Ge doped SiO_2 nanophosphor subjected to various ionization radiations.
5. To compare the performance of Ge doped SiO_2 nano-phosphor to Ge-doped SiO_2 optical fibre and commercially available TLD-100.

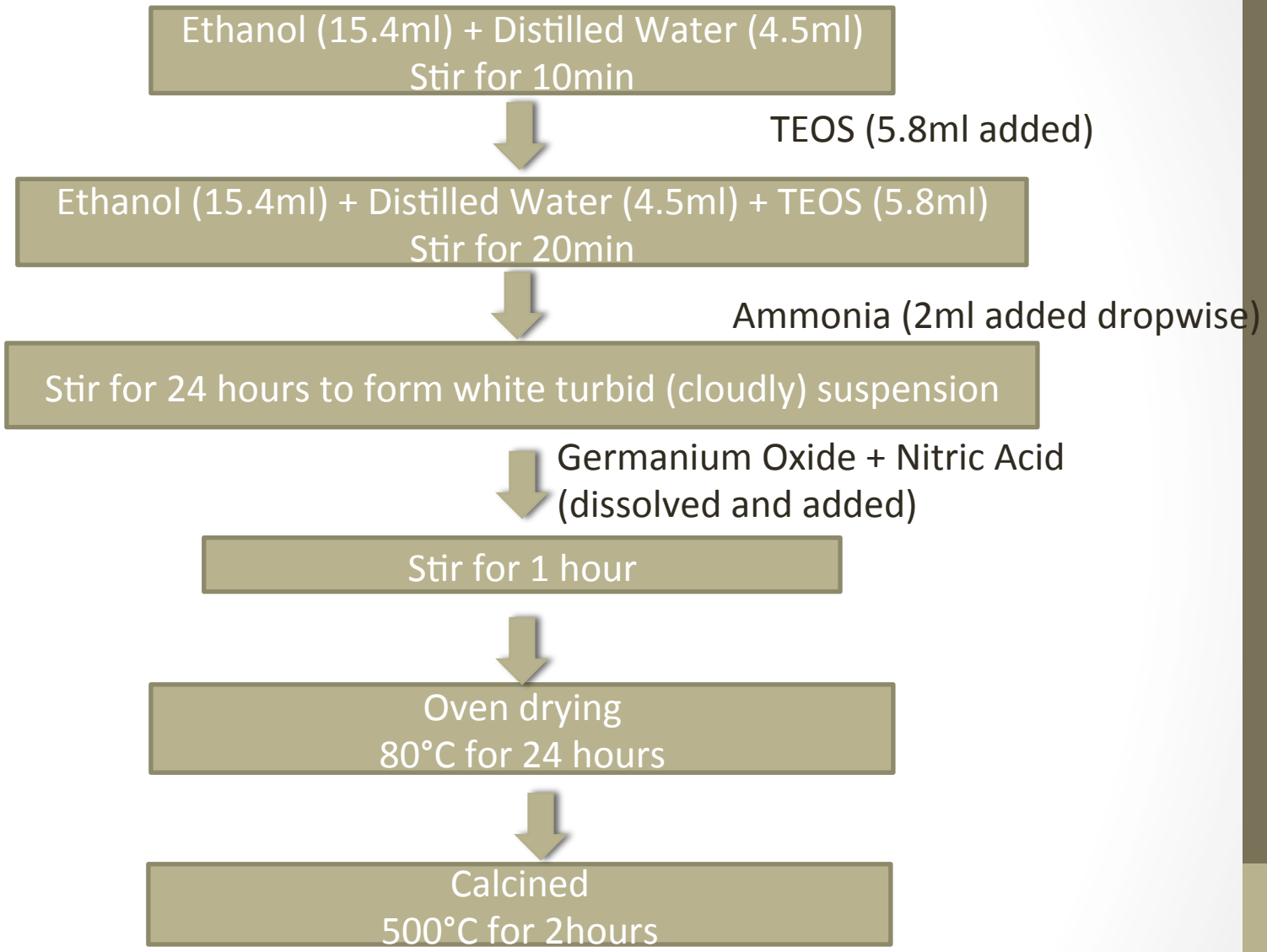
Methodology

1. Materials Identifications
2. Sample Preparation
3. Sample Characterization
4. Annealing procedure
5. Exposure to ionizing radiations
6. Thermoluminescence measurements
7. Data Analysis

. Materials Identification

- Tetraethylorthosilicate TEOS ($SiCOC_2H_5$)4)
- Ethanol (C_2H_6O)
- Distilled Water (H_2O)
- Ammonia (NH_3)
- Germanium Oxide (Ge_2O_3)
- Nitric Acid (HNO_3

2. SAMPLE PREPARATION



Dabbaghian, M. A. Babalou, A. A. Jannatdoust, E. (2010) Int. J. Nanosci. Neanotechnology 6(2): 104-113

3. Sample characterization

X-ray diffraction (XRD) analysis

Indicate the structure and particle size of SiO_2: Ge.

Scanning electron microscopy (SEM) analysis

Showing the micrograph of SiO_2: Ge

Energy dispersive X-ray (EDX) analysis

Reveal the presence of the constituent elements in the materials

4. Annealing procedure

- Erase the background signal accumulated during transportation and storage to minimize the detection threshold.
- Annealing test will be performed at temperatures below than 100,200,300,400^{o}C by using TLD-FURNACE (thermosoft computer program) to determine the optimal pre-exposure annealing procedure.
- The samples will then be left to reach room temperature inside the furnace over 24 hour period to avoid thermal stress.

5. Exposure to ionizing radiations

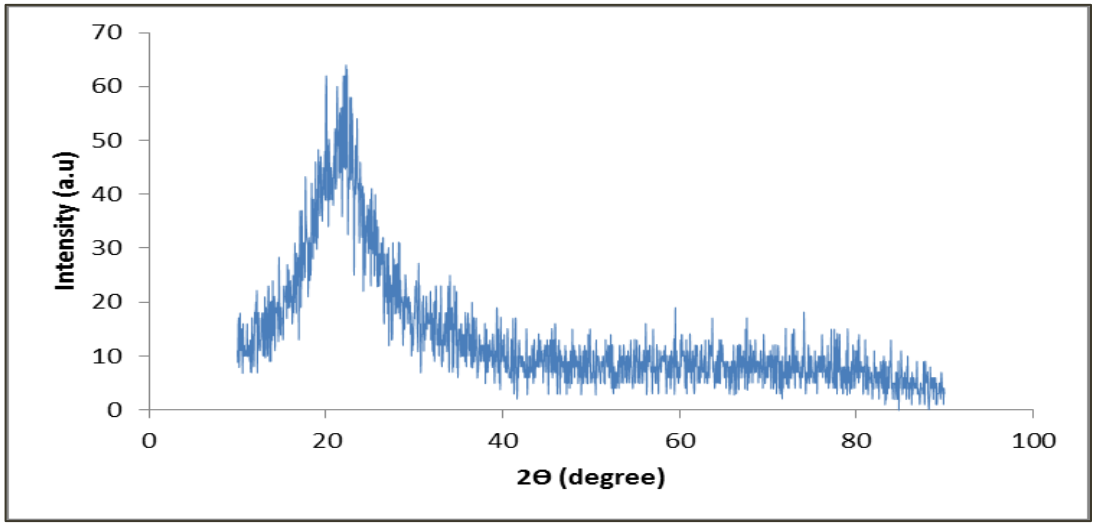
- The SiO2: Ge samples will be exposed to the various type of ionizing radiation by using irradiation facilities which is;
  - **Cobalt-60 Gamma rays source**
  - **Linear Accelerator (LINAC)**

6. Thermoluminescence measurements

- TL measurements will be made by using a model 3500/4500 Harshaw TLD reader.
- The TTP setting of the TLD reader will be optimized for the samples.
- TL properties (TL glow curve and its analysis, dose response, sensitivity, fading, reproducibility, minimum detection dose and the energy response) will be carried out through the measurement.

Current Status

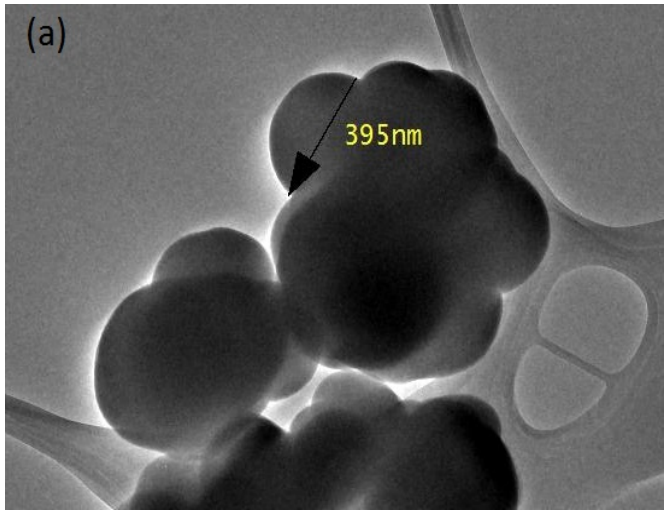
- X-ray Diffraction Analysis



XRD pattern of SiO_2 (undoped)

- The XRD pattern of SiO_2 nanoparticles synthesized by sol-gel method reveals that it is amorphous
- This result is good agreement with the previous experiment on SiO_2 by sol-gel method and indicates that the maximum of SiO_2 nanoparticles are amorphous.

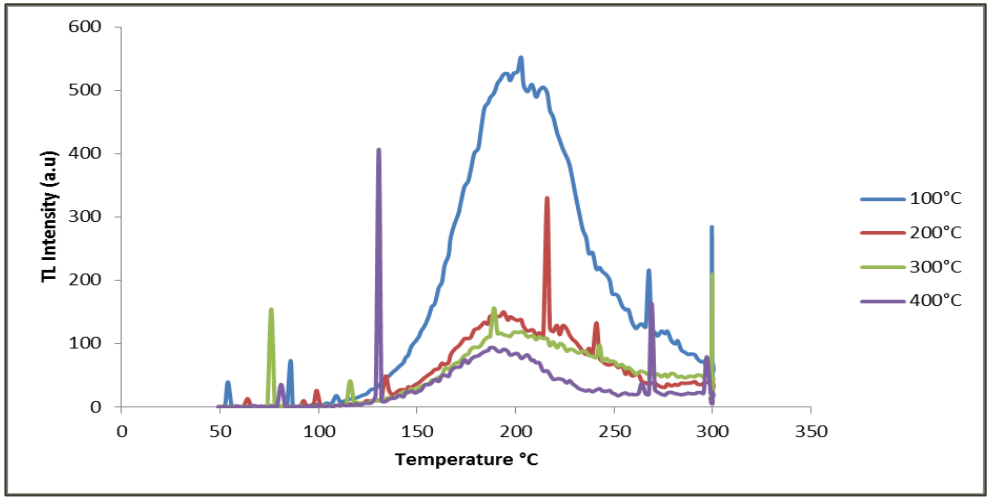
- TEM analysis



XRD pattern of SiO_2 (undoped)

- The TEM image shows the average particles in the range of <400nm for SiO_2 nanoparticles synthesized by sol-gel method.
- The images is found to be not well dispersed because the particles were agglomerate. It can be overcomes by longer the time of sonicating process in sample preparation for TEM analysis..

- **TL analysis**



XRD pattern of SiO_2 (undoped)

- Different annealing temperatue from 100°C to 400°C have been done for 1 hr each by using oven annealing (Harshaw) connected to readout system to identify the suitable temperature for the dosimeter material.
- The samples then being exposed to 50Gy of γ-ray to see the best intensity. Based on the TL detectors by Harshaw 3500 TLD reader, sample with 100°C annealing temperature has higher intensity.
- The result shows the faulty feature in glow curve shape which is spikes occur. This is may due to electrical interference, material weightness, electronics of the card-reading instrument or heating profile used for read out.

Next to do

- Determine optimum annealing time.
- Determine the optimum heating rate
- TL measurement
  - Linearity
  - Fading
  - Reproducibility
- Continue steps with SiO_2:Ge
- Compare result with commercial TLD:100

Gantt Chart

- **Gantt chart of Research Activities and Milestone.**