

PROJECT PROFILE

OPTICAL PROPERTIES OF SENSITIZED TIN DIOXIDE THIN FILM PREPARED BY USING SOL-GEL SPIN COATING METHOD

Materials and Manufacturing

Prof. Dr Madzlan bin Aziz
Shahida Hanum bt Kamarullah
AMTEC, FKKKSA
Universiti Teknologi Malaysia
madzlan.aziz@gmail.com

ABSTRACT (120 words)

Undoped tin dioxide (SnO_2) thin films were prepared by sol-gel spin coating process using an alcoholic solution of tin chloride dihydrate ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$) as the precursor. The tin dioxide doped terbium (Tb^{3+}) and erbium (Er^{3+}) ion thin films were also prepared using sol gel method in order to form $\text{SnO}_2:\text{Tb}^{3+}$ and $\text{SnO}_2:\text{Er}^{3+}$ thin films. The concentration of Tb^{3+} and Er^{3+} is 5% in relation with the tin content in the sol. The doped and undoped SnO_2 films were sensitized with eosin Y. The diameter of particles in the SnO_2 film ranges from 20 to 46 nm with spherical morphology. The particle size of SnO_2 doped Tb^{3+} and SnO_2 doped Er^{3+} thin films are bigger than undoped SnO_2 thin films. SnO_2 thin films have tetragonal structure with prominent peaks corresponding to (110), (101) and (211) crystal lattice planes. The band gap energy is decreased with the addition of dopant (Tb^{3+} and Er^{3+} ion) in sensitized SnO_2 thin films. The PL emission peaks of $\text{SnO}_2:\text{Tb}^{3+}$ sensitized with eosin Y corresponding to the characteristic D \rightarrow F transitions between the energy levels of Tb^{3+} ion. The addition of erbium (Er^{3+}) to the SnO_2 sol results in PL emission peaks that are associated with G \rightarrow I and H \rightarrow I transitions in Er^{3+} ion.

1. INTRODUCTION

In this research, undoped SnO_2 thin film was preparing by using sol-gel spin coating method and sensitized with eosin dyes, preparation of the terbium ion and erbium ion doped tin dioxide thin films by using sol gel spin coating method and sensitized with eosin dyes. Finally, the objective is determine of the microstructure of crystallites and optical properties of sensitized SnO_2 thin films.

2. RESEARCH METHODOLOGY

7.898 g tin chloride dehydrate ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$) was dissolved in 100 mL absolute ethanol ($\text{C}_2\text{H}_5\text{OH}$). After magnetic stirring for 30 min, a complexing agent, acetylacetonone (AcAc) was added to stabilize the hydrolysis of SnCl_2 . After another 30 min, the solution was continuously refluxed at 80°C for 5 hr to form SnO_2 sol. About 1 mL of PEG was added in pure SnO_2 sol and the sol was aged for 72 hr at 30°C before coating. For doped samples, the sol was doped with terbium additive by adding terbium (III) nitrate pentahydrate ($\text{Tb}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$) or erbium (III) nitrate pentahydrate ($\text{Er}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$) to the SnO_2 sol. The concentration of Tb^{3+} or Er^{3+} was estimated to be 5% in relation with the tin content in the sol. About 1 mL of PEG was added into the resulting sol and the sol was aged for 48 hr at 30°C before coating.

In the preparation of thin films, pyrex glass substrates were ultrasonically cleaned by decon 90 dissolved in water for 15 min. The substrates were then rinsed with distilled water. The substrates were ultrasonically again with acetone for 10 min. The substrates were rinsed with distilled water. Finally, the substrates were dried in oven for 100°C for 1 hr. The thin films were sensitized by adding 10 mM Eosin Y was used to form dye sensitized solution. The undoped and doped SnO_2 films were immersed in the sensitising solutions for 1 hr. All films were dried at 100°C for 1 hr in an oven.

The SnO_2 thin films were characterized by Field Emission Scanning Electron Microscope (FESEM) Zeiss SupraTM 35VP, DR-UV Perkin-Elmer Lambda 800/900 Spectrophotometer and Photoluminescence of Perkin Elmer Luminescence Spectrometer LS50B.

3. LITERATURE REVIEW

Tin dioxide is widely used in many technological applications such as transparent electrodes due to its low electrical resistance associated with high reflectivity in the infrared region and transparency in the visible above 90%. Tin dioxide is a wide bandgap semiconductor (3.5–4 eV) which SnO_2 possesses rutile (tetragonal) crystal structure. The wide optical band gap of SnO_2 is due to the Burstein–Moss effect. A substantial increase in carrier density cause in filling of the lower levels in the conduction band. The wide bandgap semiconductor has a higher excitonic ionization energy, thus SnO_2 has been used as matrix for electrically activated emission and phosphorescent materials. Tin dioxide (SnO_2) presents high transparency in the visible spectral range above 90%, high reflectivity in the infrared, high electrical conductivity, stability superior chemical stability and chemical corrosion resistance.

Undoped tin oxide (SnO_2) is an n-type semiconductor due to oxygen vacancies and/or interstitial tin atoms that act as donor sites or centers. In general, the inherent oxygen vacancy is n-type dopant. The oxygen vacancies are also known to be radiative centers and common defect in the luminescence properties of the metal oxide semiconductors. The introducing oxygen vacancies or interstitial tin atoms cause the deviations from the stoichiometric composition that leads to high conductivity with maintaining transparency. When excited with suitable input energy, this semiconductor has potential of emitting light.

The wide band gap of SnO_2 result in only a small ultraviolet fraction of solar light (3–5%) can be utilized. By combining a wide band-gap semiconductor with a sensitizer (a dye), the process of optical absorption and the charge-carrier transport of electrons are separated. As the sensitizers are photoexcited, electrons are ultrafastly injected into the conduction band of the SnO_2 semiconductor. The eosin dyes as sensitizer acts as a light harvester and may increase the power conversion efficiencies. Sensitization with eosin dye is also expected to improve luminescence properties. However, SnO_2 thin film sensitized with eosin dye has not been widely studied.

4. FINDINGS

4.1 FESEM

FESEM analysis shows the particle nano-sized of SnO_2 doped Tb^{3+} ion and SnO_2 doped Er^{3+} ion thin films is increased compare to undoped SnO_2 thin films which indicate the influence of dopant atoms on the morphology of SnO_2 thin films. The nano-sized particle of SnO_2 films sensitized with Eosin B is slightly decreased than films sensitized with Eosin Y.

4.2 DR-UV

The band gap energy is decreased with the addition of dopant (Tb^{3+} and Er^{3+} ion) in SnO_2 thin films. The band gap of pure and doping sensitized SnO_2 thin films are increase when sensitized with eosin B.

4.3 PHOTOLUMINESCENCE

Emission bands of SnO_2 doped terbium ion thin films sensitized with eosin Y and eosin B corresponding to the characteristic $^5\text{D}_4 \rightarrow ^7\text{F}_4$ transitions between the energy levels of Tb^{3+} ion. The PL emission peak for SnO_2 doped erbium ion thin films sensitized with eosin Y and eosin B corresponding to the $^3\text{G}_{11/2} \rightarrow ^4\text{I}_{15/2}$, $^3\text{H}_{9/2} \rightarrow ^4\text{I}_{15/2}$, and $^2\text{H}_{11/2} \rightarrow ^4\text{I}_{15/2}$ transitions in Er^{3+} ion.

4. CONCLUSION

Tin dioxide (SnO_2), tin dioxide doped terbium ion ($\text{SnO}_2:\text{Tb}^{3+}$) and tin dioxide doped erbium ion ($\text{SnO}_2:\text{Er}^{3+}$) thin films which sensitized with eosin Y and B have been successfully prepared by sol-gel technique with spin-coating process. It can be concluded that FESEM analysis shows the particle nano-sized of SnO_2 doped Tb^{3+} ion and SnO_2 doped Er^{3+} ion thin films is increased compare to undoped SnO_2 thin films which indicate the influence of dopant atoms on the morphology of SnO_2 thin films. The nano-sized particle of SnO_2 films sensitized with Eosin B is slightly decreased than films sensitized with Eosin Y.

The band gap energy is decreased with the addition of dopant (Tb^{3+} and Er^{3+} ion) in SnO_2 thin films. The band gap of pure and doping sensitized SnO_2 thin films are increase when sensitized with eosin B. The PL emission peaks of undoped SnO_2 thin films are attributed to the different charge states of oxygen vacancies. Emission bands of SnO_2 doped terbium ion thin films sensitized with eosin Y and eosin B corresponding to the characteristic $^5\text{D}_4 \rightarrow ^7\text{F}_4$ transitions between the energy levels of Tb^{3+} ion. The PL emission peak for SnO_2 doped erbium ion thin films sensitized with eosin Y and eosin B corresponding to the $^4\text{G}_{11/2} \rightarrow ^4\text{I}_{15/2}$, $^2\text{H}_{9/2} \rightarrow ^4\text{I}_{15/2}$, and $^2\text{H}_{11/2} \rightarrow ^4\text{I}_{15/2}$ transitions in Er^{3+} ion. The presence of eosin Y gives no significant effect on luminescence properties of sensitized SnO_2 thin film. The PL result of sensitized SnO_2 thin film has not much different compare to SnO_2 thin film without dye. Therefore, luminescence properties do not depend on dye sensitizing

5. RESEARCH OUTPUT

5.1 3rd International Conference on Solid State Science & Technology

6. HUMAN CAPITAL DEVELOPMENT

6.1 MSc (Postgraduate Student) – 1

Shahida Hanum binti Kamarullah

7. AWARDS / ACHIEVEMENT

REFERENCES

APPENDIXES