OPTICAL PROPERTIES IMPROVEMENT OF DYSPROSIUM DOPED TELLURITE GLASS VIA SILVER/TITANIUM NANOPARTICLES COEMBEDMENT

MOHD SYAMSUL AFFENDY BIN MOHD SAIDI

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Faculty of Science
Universiti Teknologi Malaysia

DECEMBER 2020

DEDICATION

This thesis is dedicated to my mother, who taught me that knowledge is the bridge of success. Patience and determination will distinguish us from the failure. It is also dedicated to my wife, who taught me that even a fool can be knowledgeable if you respect the educator. Actions speak louder than words.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and Most Merciful. Thank you Allah for giving me the strength to gain some knowledge and patience during my postgraduate journey.

I would like to thank and express my gratitude to my main supervisor, Associate Prof. Dr. Sib Krishna Ghoshal for all the advice and guidance provided over the past 7 years. Your enthusiasm, encouragement and positive attitude has taught me on how to become a good researcher rather than a follower. Your strong analytical and excellent communication skills are like speck of gold dust from my perspective. Besides the vast knowledge, the explanation of fundamentals and describing the unquestionable was pleasurable. I would also like to thank Associate Prof. Dr. Ramli Arifin and Dr. Khaidzir Hamzah for the financial support and advice.

Special thanks to my fellow postgraduate lab mate/friends, Shafiq, Khairil, Mustaqim, Luqman, Junaidi, Ahmad, Mundzir and Elham. The journey would be mundane without your presence. Not to forget, Dr. Asmahani, Dr. Ezza, Dr. Amlah, Dr. Huda, Dr. Hafizah and Kak Puzi for the guidance, tips and knowledge since the first day I joined the AOMRG group.

To my parents, Satiah Bt Mohsin and Mohd Saidi B Abd Rashid, thank you for the never-ending support since the day I was born. It would not have been possible without your prayers, guidance, financial and moral support. I hope I can make you proud here, and in the afterlife insyallah. Same goes to my parent in law Mohd Azmi B Zainuddin and Kamaliah Bt Omar. I love you so much.

To my wife, Nurul Athirah Bt Mohd Azmi, my daughter Aflah Syaheerah and my son Muhammad Aisar Syaatir, thank you for the endless love and moral support since the first day we become a family. No words can describe my affection towards the sacrifice and obligation of our family. I love you so much.

Lastly, all financial support especially by the Ministry of Education (MyBrain15) through my PhD program, research support from Ministry of Education, Malaysia and RMC, UTM via GUP/RU grants of Vote: 18H68, 17H19, 18H80, 18H90 and FRGS 4F892 are gratefully acknowledged.

ABSTRACT

In this study, some dysprosium ions (Dy^{3+})-doped zinc-magnesium tellurite glasses with the co-embedment of silver nanoparticles (ANPs) and titanium nanoparticles (TNPs) were prepared using the standard melt quenching method. The compositions of the glass series I and II were $(69.5-x)TeO_2-20ZnO-10MgO-0.5Dy-(x)AgCl$ ($0 \leq x \leq 1.0$ mol%) and $(69.3-y)TeO_2-20ZnO-10MgO-0.5Dy-0.2AgCl-(y)TiO_2$ ($0 \leq y \leq 0.6$ mol%), respectively. As-quenched glass samples were thoroughly characterized using different analytical techniques. The improvement in the optical, physical and structural properties of these glasses due to the co-embedment of two types of nanoparticles was determined. The optimum glass sample from both series was chosen to determine the influence of ANPs/TNPs inclusion on the optical, physical and structural characteristics. The ultraviolet-visible-infrared (UV-Vis-NIR) optical spectral analyses of the glass series I revealed an improvement in the absorption properties due to the addition of ANPs, while the glass series II (with ANPs and TNPs) showed a decrease in the absorption. Both glass series displayed six absorption bands due to the electronic transition from the ground state to various excited states of Dy^{3+}. The Judd-Ofelt intensity parameters, Ω_λ (λ=2, 4, 6) of the glasses were evaluated from the measured absorption spectra. The X−ray diffraction patterns of the as-quenched samples verified their amorphous nature. The high resolution transmission electron microscope (HRTEM) images revealed the presence of individual ANPs, TNPs and combined ANPs/TNPs in the glass matrix. The energy dispersive X-ray (EDX) spectra and mapping of the prepared glasses exhibited their appropriate elemental compositions. The incorporation of the ANPs/TNPs into the glasses was found to enhance their Raman and Fourier transformed infrared (FTIR) spectral intensities. The up-conversion and down-conversion photoluminescence spectra of both glass series showed three prominent emission bands at 482 nm (blue: $^4F_{9/2} \rightarrow {}^6H_{15/2}$), 574 nm (yellow: $^4F_{9/2} \rightarrow {}^6H_{13/2}$), and 664 nm (weak red: $^4F_{9/2} \rightarrow {}^6H_{11/2}$). In addition, the values of Ω_λ displayed the trend of $\Omega_2>\Omega_6>\Omega_4$ for the glass containing 0.1 mol% of TNPs, while all other glasses showed the trend of $\Omega_2>\Omega_4>\Omega_6$. The obtained results suggested that the optical properties of the Dy^{3+}-doped zinc-magnesium tellurite glasses can be improved via the co-embedment of ANPs/TNPs compared to one type of NPs embedment. It is asserted that the proposed glass system may be useful for the development of optoelectronic and solid-state devices needed for different applications.

ABSTRAK

Dalam kajian ini, beberapa kaca tellurit zink-magnesium didop ion dysprosium Dy^{3+} dengan penanaman bersama nanozarah perak (ANPs) dan nanozarah titanium (TNPs) telah disediakan melalui teknik piawai lindap-kejut leburan. Komposisi untuk siri kaca I dan II masing-masing ialah $(69.5-x)TeO_2-20ZnO-10MgO-0.5Dy-(x)AgCl$ $(0 \leq x \leq 1.0$ mol%) dan $(69.3-y)TeO_2-20ZnO-10MgO-0.5Dy-0.2AgCl-(y)TiO_2$ $(0 \leq y \leq 0.6$ mol%). Sampel kaca dicirikan dengan teliti menggunakan teknik analisis yang berbeza. Penambahbaikan dalam sifat optik, fizikal dan struktur kaca ini disebabkan oleh penanaman bersama dua jenis nanozarah telah ditentukan. Sampel kaca yang optimum dari kedua-dua siri telah dipilih untuk menentukan pengaruh kemasukan ANPs/TNPs terhadap sifat optik, fizikal dan struktur. Analisis spectrum optik ultralembayung-cahaya nampak-inframerah (UV-VIS-NIR) bagi siri kaca I menunjukkan penambahbaikan dalam sifat penyerapan disebabkan oleh penambahan ANPs, sementara siri kaca II (dengan ANPs dan TNPs) menunjukkan penurunan dalam penyerapan. Kedua-dua siri kaca ini memaparkan enam jalur penyerapan disebabkan oleh peralihan elektronik dari keadaan dasar ke pelbagai keadaan teruja Dy^{3+}. Parameter keamatan Judd-Ofelt Ω_λ (λ=2, 4, 6) bagi kaca telah dinilai daripada spektrum penyerapan yang dicerap. Corak pembelauan sinar-X sampel mengesahkan sifat amorfus kaca. Imej mikroskopi pancaran elektron beresolusi tinggi (HRTEM) mendedahkan kewujudan ANPs, TNPs tunggal dan gabungan ANPs/TNPs di dalam matrik kaca. Spektrum penyebaran tenaga sinar-X (EDX) dan pemetaan bagi kaca yang disediakan menunjukkan komposisi unsur yang sesuai. Pengabungan ANPs/TNPs didalam kaca didapati meningkatkan keamatan spektrum Raman dan Inframerah Fourier (FTIR). Spektrum fotoluminesen penukaran-atas dan penukaran-bawah dari kedua-dua siri kaca menunjukkan tiga jalur pancaran utama pada 482 nm (biru:${}^4F_{9/2}\rightarrow{}^6H_{15/2}$), 574 nm (kuning:${}^4F_{9/2}\rightarrow{}^6H_{13/2}$) dan 664 nm (merah lemah:${}^4F_{9/2}\rightarrow{}^6H_{11/2}$). Disamping itu, nilai Ω_λ menunjukkan tren $\Omega_2>\Omega_6>\Omega_4$ bagi kaca yang mengandungi 0.1 mol% TNPs, manakala kesemua kaca yang lain menunjukkan tren $\Omega_2>\Omega_4>\Omega_6$. Keputusan yang diperoleh mencadangkan bahawa sifat optik bagi kaca tellurit zink-magnesium didop Dy^{3+} mampu ditambahbaik melalui penanaman bersama ANPs/TNPs berbanding dengan penanaman sejenis nanozarah. Ia ditegaskan bahawa sistem kaca yang dicadangkan mungkin berguna untuk pembangunan peranti optoelektronik dan peranti keadaan pepejal bagi aplikasi yang berbeza.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANPs	-	Silver Nanoparticles
B	-	Blue emission
BDP	-	Bonding Dimer Plasmon
BO	-	Bridging Oxygen
CCT	-	Colour Correlated Temperature
CIE	-	Commission International de I'Eclairage
CR	-	Cross Relaxation
DC	-	Down-conversion
DDA	-	Discrete Dipole Approximation
EDX	-	Energy Dispersive X-ray
ESA	-	Excited State Absorption
ET	-	Energy Transfer
ETU	-	Excited Transfer Upconversion
FFT	-	Fourier Fast Transform
FTIR	-	Fourier Transform Infrared
GSA	-	Ground State Absorption
HRTEM	-	High Resolution Transmission Electron Microscopy
JCPDS	-	Joint Committee On Powder Diffraction Standard
LSPR	-	Localized Surface Plasmon Resonance
NBO	-	Non Bridging Oxygen
NR	-	Non Radiative
PL	-	Photoluminescence
RET	-	Resonance Energy Transfer
SAED	-	Small Angle Electron Diffraction
SEC	-	Stimulated Emission Cross section
SP	-	Surface Plasmon
TNPs	-	Titanium Nanoparticles
UC	-	Up conversion
UV-VIS-NIR	-	Ultra Violet visible near infrared
X−RD	-	X-ray diffraction

Y	-	Yellow emission

LIST OF SYMBOLS

$\boldsymbol{f_{exp}}$	-	Experimental oscillator strength
f_{cal}	-	Calculated oscillator strength
$\varepsilon(\nu)$	-	Molar absorptivity at a frequency (in cm^{-1})
$\vert(\boldsymbol{S},\boldsymbol{L})\boldsymbol{J}\rangle$	-	Absorption transition from initial state
$\vert(\boldsymbol{S'},\boldsymbol{L'})\boldsymbol{J'}\rangle$	-	Excited state
m	-	Electron mass
c	-	Velocity of light in vacuum
n	-	Refractive index of glass sample
J	-	Total angular momentum
$\boldsymbol{S_{ed}}$	-	Electric line strength
$\boldsymbol{S_{md}}$	-	Magnetic line strength
A_{ed}	-	Electric dipole contribution of the total spontaneous emission probability
A_R	-	Total radiative probability
$\boldsymbol{\tau_R}$	-	Radiative lifetime
$\boldsymbol{\beta_R}$	-	Branching ratio
$\boldsymbol{\sigma(\lambda_p)}$	-	Stimulated emission cross-section
$\boldsymbol{\lambda_p}$	-	Wavelength of the emission peak
$\Delta\boldsymbol{\lambda_{eff}}$	-	Effective line width
η	-	Quantum efficiency
$\boldsymbol{\varepsilon}_\infty$	-	Optical dielectric function of the metal
N	-	Free electron concentration
$\boldsymbol{\rho}$	-	Density
V_m	-	Molar volume
R_m	-	Molar refraction
α_e	-	Polarizabilities
Ω_x	-	Judd-Ofelt parameter
χ	-	Spectroscopic quality factors
β	-	Nephelauxetic ratio
δ	-	Bonding parameter

A_1, A_2	-	Weight factors
τ_1 ,τ_2	-	Fast and slow decay time
τ_{Exp}	-	Experimental lifetime
χ_c	-	Raman peak position
α	-	Amplitude
$\boldsymbol{E_{opt}}$	-	Optical band gap
θ	-	Angle of incident
W_a	-	Weight of sample in air
W_b	-	Weight of sample in immersion liquid
ρ_x	-	Density of immersion liquid

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Among conventional glasses, tellurite has a good reputation for lanthanide (rare earth) and plasmonic equation. It was realised that having rare earth doped as an activator could improve their properties toward potential applications, especially in photonic device since their lower phonon energy is resulting in a weaker non radiative (NR) transition. By having low phonon energy, obtaining high quantum efficiency were expected thus finding optimum composition can be achieved. However, achieving optimised properties could reach certain limits where the quenching effect occurs. Here, researcher found a way to enhance the optical properties by embedding metallic nanoparticles. Literature shows the enhancement towards radiative emission by using metallic nanoparticles particularly noble metal as the sensitizer. Enhancements occur due to the absorption of light by metallic nanoparticles which is the coherent oscillation of the conduction band electron, formed directly into the incident electromagnetic radiation. Sensitizer absorbs the energy thereby transfer it to the activator while producing enhanced field within the glass matrix (Som and Karmakar, 2010b). Some researchers reported that by addition of more than one type nanoparticles, the intensity of surface plasmon resonance can be enhanced thus enhancing the glass properties especially optical (radiative emission). However, finding the optimum composition of more than one nanoparticles in host glass matrix for improving optical properties are needed to be study and analyse in order to understand the effect of co-embedding nanoparticles.

In order to observed the effect of co-embeddment nanoparticles towards the glass composition, the mol % of network modifier and dopant must be fixed. Any changes in optical, physical and structural will be due to the participation of sensitizer (single and co-embedded nanoparticles). From the literature it was found that zinc oxide and magnesium oxide provide good physical properties and stability for different host glass system. It is also recorded that by using zinc oxide as modifier, positive sign are showed for optical application such as low laser threshold and strong visible emission spectrum. To conclude, mol % for ZnO, MgO and Dy_2O_3 were fixed for Series I and Series II to observed the effect of sensitizer (single and co-embedded nanoparticles) can be shown mainly on the optical (emission), physical and structural properties. Since achieving upconversion emission are possible for the Dy^{3+} ions, the participation of co-embedding nanoparticles can provide current work with significant knowledge on tellurite glass properties particularly.

From previous literature of Judd-Ofelt theory, it was found that the addition of nanoparticles towards host glass matrix doped with rare earth ions shows modification towards the optical properties especially the radiative emission. However, up to our knowledge the co-embedding nanoparticles towards Judd- Ofelt analysis were not recorded well. We believe that our current work can determine the influence of mediated surface plasmon resonance in optical properties for validation of Judd- Ofelt theoretical analysis. Not to mention that Judd- Ofelt intensity parameter of Dy^{3+} was shown to be predominat where Ω_2 are sensitive to the local symmetry and glass composition. In fact, radiative properties and stimulated emission cross section also can be observed as the participation of co-embedding nanoparticles take place in the tellurite glass composition.

Composition of glass containing lanthanide and metallic nanoparticles can be classified as photoluminescence (PL) intensity enhancement, stimulated emission cross section and quality factors. Intense local electromagnetic field generated from the localized surface plasmon resonance (LSPR) has proven to amplify the emission which can be explained in terms of charge density fluctuation at the nanoparticle (NP) surfaces. Other than that, the strengthen of Raman signal with addition of NPs indicate that plasmonic reflected surface enhanced Raman scattering (SERS)(Lee et al, 2007). When the electric dipole of nanoparticle is similar to the excitonic mode, the signal can be detected by molecular spectroscopy. Tuning of plasmonic band through shape, size and concentration of nanoparticles can be achieved in order to fulfil the application objective (Lee and El-Sayed, 2006). For example, in vivo imaging and therapeutic, the SPR band must be in near-infrared region of the biological window, where the tissue transmissivity is at the highest (Jain *et al.*, 2006a).

Characterization of glass composition containing lanthanide with two type metallic nanoparticles are prepared in this project. Tellurite has been chosen for the host glass matrix due to its excellent properties, such as low multi phonon relaxation, large refractive index, great solubility towards rare earth ions (REI) and low melting point. Meanwhile, among REI candidate, we chose Dy^{3+} as the activator due to the multiple emissions near infrared region (0.9, 1.1, 1.3, 1.7 and 3 μm) which are valuable towards enhancing optical signal, telecommunication and visible light Upconversion (UC) solid state laser. From literature, it is revealed that Dy^{3+} displays two intense visible emission which are blue (482 nm) and yellow (574 nm) together with feeble red emission at (664 nm). By tuning the ratio between yellow and blue emission, we can generate white colour especially for LED according to Commission International de l´Eclairage (CIE) colour chromatic diagram. For nanoparticles candidate, we use silver (ANPs) and titanium (TNPs) nanoparticles for the co-embedding. Apart from the low production cost, silver nanoparticles also represent sharp features which particularly reflected in high refractive index (Martinsson *et al.*, 2013). Besides that, this sharp edged act as a light-harvesting nano-optical antennas converting visible light into a large localised electric field. Meanwhile TNPs are the pairs for co-embedded due to its excellent properties such as hydrophilic and photocatalytic characteristics. High surface volume ratio provides an increase in the surface area ratio at which photo induced reaction may occur, while light absorption rate enhance and surface photo induce carrier density (Lan *et al,* 2013).

Table 1.0 shows the numerous researches on the development using mono and two types of nanoparticles in enhancing optical, structural and photocatalytic activity characteristics. The selection of noble metal especially silver and gold nanoparticles is due to the unusual catalytic, electric and optical properties, which also possess a strong SPR band in the UV and infrared region. In particular, the presence of metallic nanoparticles in enhancing luminescence has already been recorded by the previous research due to the energy transfer between NPs and the lanthanide ions. Thus, co-embedding nanoparticles between silver and titanium can be one of the approach to enhance the optical and structural properties of tellurite glass.

Table 1.1 Previous literature review on using single and co-embedded nanoparticles

Year	**Researcher**	**Scope of Research**	**Nanoparticles**
2005	(Stranik *et al.*,)	Plasmonic enhancement of fluorescence for sensor applications	Polystyrene bead (fluorophore Cy_5)
2009	(Sepúlveda *et al.*)	LSPR based nanobiosensors	Gold, Au NPs
2007	(Lee *et al.*)	Origin of Surface Enhanced Raman Scattering	Silver nanowire, AgNWs
2009	(Tirtha and Basudeb)	Enhancing upconversion spectra of Nd^{3+} doped antimony glass	Gold, Au NPs
2006	(Kuhn *et al.*)	Enhancing fluorescence spectra	Gold, Au NPs
2008	(Awazu *et al.*)	Enhancing photocatalytic behaviour	Silver, Ag NPs
2005	(Hirakawa and Kamat)	Charge separation and catalytic activity	Core shell $Ag@TiO_2$
2007	(Cortie *et al.*)	Self-regulating plasmonic	Core shell $Au@VO_2$

2012	(Angkaew and Limsuwan)	Optical characteristic behaviour	Core shell Ag@TiO_2
2011	(Cortie and Mcdonagh)	Optical properties of hybrid and alloy plasmonic nanoparticles	Au and Ag NPs Hybrid/Alloy
2005	(Hubenthal *et al.*)	Tuning SPR band by manipulating thickness of core and shell	Au and Ag core shell/Alloy
2005	(Rodrı *et al.*)	Synthesis bimetallic and investigating on structural and optical properties	Au Ag NPs
1997	(Mizukoshi *et al.*)	Synthesized bimetallic nanoparticles	Au and Pd bimetallic
2009	(Seifert *et al.*)	Synthesized bimetallic nanoparticles using ion implantation	Ag and Au bimetallic
2005	(Aizpurua *et al.)*	Coupled metallic nanorod towards field enhanced spectroscopy on optical properties	Au nanorod pair
2012	(Rivera *et al.*)	Effect of photoluminescence towards plasmonic coupling	Ag NPs and Au NPs
2014	(Hooshmand *et al.*)	Hot spot investigation between two nanocube using Discrete Dipole Approximation (DDA) simulation	Au and Ag nanocubes
2016	(Oh *et al.*)	Hot spot engineering on nanopillar	ZnO, TiO_2 and NiO

		array	
2010	(Camargo *et al.*)	Measuring SERS enhancement from hot spot of different structure nanocubes	Silver nanocubes

1.2 Problem Statement

In recent times, different rare earth ions (REIs)-doped various binary and ternary oxide glasses and glass-ceramics (tellurite, phosphate, borate, silicate, etc) have widely been studied due to their potential for diverse applications in the ultraviolet to infrared region such as the optical amplifier, eye-safe solid state lasers, fibers and other optical devices. Several optical transitions in the 4f level of the REIs make them very useful when doped inside crystals, glasses and glass-ceramics. However, the low absorption and emission of cross-section of the REIs needs improvement for practical applications. To improve the optical absorption and emission characteristics of these REIs-doped glasses different researchers have embedded or incorporated various metal nanoparticles (for example Ag, Au, Cu, TiO_2, Fe, Mn, etc.) into these hosts. It is known that the surface plasmon resonance (SPR) of different metal nanoparticles can enhance the optical properties of the REIs when doped inside the glasses. Most of the earlier researches used one type of nanoparticles to improve the optical properties of different REIs mostly in phosphate and tellurite glasses. Among all the REIs (Er^{3+}, Sm^{3+}, Nd^{3+}, Dy^{3+}, Eu^{3+}, etc), due to intense yellow and blue emission shown by Dy^{3+} it became interesting as activator in tellurite and phosphate based glasses. So far, not many detail studies have been performed on the two types (silver and titanium) of nanoparticles co-sensitization or co-embedment on the optical properties improvement of Dy^{3+}-doped zinc-magnesium tellurite glasses. Thus, to improve the optical properties of the Dy^{3+}-doped zinc-magnesium tellurite glasses co-embedded with Ag and TiO_2 nanoparticles, careful preparation of such glasses and composition optimization through diverse characterizations are still necessary. Detail characterization of prepared glasses for their structural, physical and other properties are also required to select the optimum glass sample that produce the best optical properties. Therefore, one of the objectives this study is to optimize the composition of the dysprosium ions doped zinc-magnesium tellurite glasses co-embedded with silver/titanium nanoparticles via preparation and detailed characterizations.

Previous studies on different REIs-doped tellurite glasses with one type of nanoparticles embedment showed that the structural, physical, and optical properties of the glasses can be improve via nanoparticles sensitization. The observed improvements in the structural, physical and optical properties of such glass system were attributed to the localised surface plasmon resonance (LSPR)-mediated strong local field effect. It is believed that the strong local electric field and the energy transfer between nanoparticles and REIs play a significant role for the modification of overall properties of the glass system. However, no investigations have been made so far to evaluate the impact of the Ag/TiO_2 nanoparticles co-embedment on the structural, physical and optical properties (especially up-conversion and down-conversion emission traits) of the dysprosium ions-doped zinc-magnesium tellurite glass system. It is therefore important to determine the effect of Ag/TiO_2 nanoparticles co-embedment on the network structures and bonding, absorption and emission properties, and physical characteristics of the dysprosium-doped zinc-magnesium tellurite glasses. The detail understanding and knowledge of the structural of physical properties are essential to get the best optical properties and further validation of the experimental optical data through Judd-Ofelt theoretical calculations. Different structural parameters are also required for the Judd-Ofelt evaluation to support the experimentally measured optical properties. Detail literature review revealed that the emission mechanisms from the dysprosium ions with nanoparticles co-embedment into the magnesium-tellurite glasses are not fully understood. In this view, structural and physical properties are useful to predict the effects of nanoparticles co-embedment on the improved absorption and emission traits of the dysprosium-doped zinc-magnesium tellurite glasses.

Various studies revealed that the presence of the nanoparticles in the vicinity of the REIs inside glass matrix can modify the symmetry/asymmetry of the network bonding structure of the host wherein the number of non-bridging and bridging oxygen bonds gets altered. In addition, due to the presence of the strong signal with respect to the hot spot junction between silver and titanium nanoparticles, it is possible to apply the surface enhance Raman scattering (SERS) inside the prepared zinc-magnesium tellurite glasses with co-embedded nanoparticles. Therefore, the mechanism behind the optical properties improvement due to the incorporation of two types of nanoparticles is required for further application of these glasses in different photonic devices. To the best of our knowledge, the emission from the dysprosium ions in zinc-magnesium glasses with co-embeded nanoparticles are not well reported. The correlation between the LSPR and the emission especially the upconversion (UC) is far from being understood. To achieve this goal, three series of these glasses were prepared using the melt quenching technique and characterized. In order confirm the improvement in the absorption and emission properties of the optimum glass system useful for lasing, the Judd-Oflet intensity parameters and radiative properties were calculated. It is believed that this work might provide some new knowledge and information on the improved optical properties of the dysprosium-doped zinc-magnesium tellurite glasses containing single (Ag) and co-embedded (Ag/TiO_2) nanoparticles. The obtained results indicated that the modification in the fluorescence and structural properties of the dysprosium doped tellurite glasses due to the embedment of single (Ag) and two types (Ag/TiO_2) of nanoparticles. It provided some significant data especially on the radiative properties useful for the solid state laser and optoelectronic applications. In addition, this research was crucial in understanding the physics behind the nanoparticles co-embedding, particularly regarding the co-embedded nanoparticles SPR-mediated emission properties enhancement of the Dy^{3+}-doped zinc-magnesium tellurite glasses.

1.3 Research Objectives

The main aim of this study was to improve the optical absorption and PL emission (up-conversion and down-conversion) properties of the Dy^{3+}-doped zinc-magnesium tellurite glass by embedding single type of nanoparticles (Ag) and two types of nanoparticles (Ag/ TiO_2) via the preparation using melt quenching technique, composition optimization, characterizations and validation using Judd-Ofelt calculation. Based on above problem statement, the following objectives are proposed:

I. To optimize the composition of a series Dy^{3+}-doped zinc-magnesium tellurite glass included with single nanoparticles (Ag) and co-embedded nanoparticles (Ag/TiO_2) for improving the optical properties.

II. To determine the effect of silver nanoparticles (Ag) and co-embedded nanoparticles (Ag/TiO_2) on the physical and structural properties of the obtained glass system for getting the optimum glass sample.

III. To determine the influence of the embedded (Ag) and co-embedded (Ag/TiO_2) nanoparticles -mediated surface plasmon resonance field on the optical properties of the Dy^{3+}-doped zinc-magnesium tellurite glasses for the validation using Judd-Ofelt theoretical analysis.

1.4 Scope of Study

The prepared samples for this study involved two series of glasses which are (69.5-x)TeO_2−20ZnO−10MgO−0.5Dy−(x)AgCl, where (x= 0.2, 0.4, 0.6, 0.8 and 1.0) for series I. Meanwhile for series II will be (69.3-y)TeO_2−20ZnO−10MgO−0.5Dy−0.2AgCl –(y)TiO_2, where (y= 0.1, 0.2, 0.3, 0.4, and 0.5 and 0.6). Both series were sensitized using the conventional melt quenching technique. The usage of modifier for both compositions remain the same. The reason for the constant modifier is to observe that various nanoparticles affect the properties of prepared sample, rather than changing the network modifier. The selection of zinc and magnesium oxide as the modifier is due to the extensive studies regarding optical application especially ZnO−TeO_2 for various tellurite glass composition. The establishment of amorphous nature were proved by the diffraction pattern of XRD. Optical properties including absorption and emission radiation were analysed by using absorption spectroscopy, UV-VIS-NIR and photoluminescence spectroscopy. From the absorption band, we can calculate the Judd-Ofelt theory therefore determine the parameter and trend for each samples. Meanwhile, radiative emissions from the prepared samples can be evaluated to determine stimulated emission cross section until radiative decay.

Furthermore, structural analysis were done by using Raman and FTIR spectroscopy which demonstrate the bond and vibration intensity towards the influence of single and co-embedded nanoparticles to the host glass matrix. The existence and size distribution of both nanoparticles were also verified using HRTEM imaging technique. Elemental analysis regarding glass composition was done using EDX analysis and EDX mapping. Additionally, physical properties of the prepared samples were calculated by determining the density of each series. Archimedes method was applied to calculate the density, while Brewster angle system was implemented to determine the refractive index for each sample. By determine the refractive index from each glass composition, molar refraction and polarizability can be obtained and compared with previous literature results.

1.5 Significant of Study

Co-embedded of nanoparticles can be one of the methods in obtaining high emission intensity, particularly regarding lanthanide ions. Enhancing emission especially upconversion (UC) can be utilised through the small distant between silver (ANPs) and titanium nanoparticles (TNPs), which boost up the SPR signal. Current data shows that the enhancement from the prepared samples can be a good candidate for optoelectronic devices and optical fibre amplifier. In addition, improvement of UC intensity towards co-doped shows that the prepared sample can be used as a solid state laser by using IR diode laser (low energy) to produce high intense luminescence. Apart from that, upconversion also recently caught the attention in bio imaging and biosensors. The feature from upconversion that attracted bioimaging and biosensors is due to the minimum photo damage to the biomolecules, and enhancement of signal-to-noise ratio, thus improve the result of the detection. This feature of upconversion is contrary compared to down-conversion, which has the tendency to be phototoxic and damaging the samples. In fact, upconversion also proved to be highly sensitive towards biological tissue, resulting in a large penetration depth of samples. Furthermore, upconversion can also be utilised in ink security application for example, with codes embedded into microparticles towards bank note. By illuminating upconversion emission, the embedded code will be revealing the counterfeit/authentic tags.

In addition, co-embedding nanoparticles towards dysprosium ion also shows an enhancement towards vibrational analysis. This observe phenomenon might favour many applications particularly surface enhance Raman scattering (SERS). The strong improvement towards luminescence spectra suggests that the local field enhancements increased due to the co-embedding of nanoparticles towards dysprosium ion. The inelastic scattering of photon provides a crucial information at molecule level, thus by enhancing Raman signal, it enables the detection of biomolecules at low concentration and detection at single molecule might be achieved. By understanding the vibrational bond of co-embedded nanoparticles in host glass matrix, we believe that the significant finding will lead to the extent of knowledge where application involving glassy state will be well developed. As a matter of fact, co-embedding nanoparticles can be established as one of the approach to enhance the properties for related application. Current result of the co-embedding of nanoparticles towards dysprosium ion will possibly provide useful information regarding the enhancement mechanism of SERS especially on electromagnetic effect.

1.6 Thesis Outline

In this thesis, there are five chapters presenting the optical and structural characterizations of co-embedded silver (ANPs) and titanium (TNPs) nanoparticles into doped dysprosium zinc-magnesium tellurite glass. This work provides an alternative way to enhance the glass properties by using the melt quenching technique, thus contributes to the extent of knowledge regarding the correlation between LSPR effects and the glass composition.

Chapter 1 briefly explains the introduction to the motivation of this research. The research gap in this current project can be explained through problem statement and research objectives. The benefits and outline of this research work can also be found in this chapter.

Chapter 2 compresses literature review regarding host glass, network modifier, lanthanide ions, nanoparticles, optical and structural characterization properties. Detailed mechanisms regarding optical and structural properties related to co-embedded are explained briefly. This chapter includes a broad overview.

Chapter 3 explains the methodology in preparing glass sample using the melt quenching technique. In fact, analytical techniques regarding optical, structural and physical properties were highlighted. The theoretical and schematic diagram for all analytical technique were presented.

Chapter 4 presents the results of all analytical techniques from UV-VIS-NIR, PL, XRD, Raman, FTIR, HRTEM and EDX. For optical characterization, the Judd-Ofelt calculations and parameters have been shown up to a radiative lifetime and stimulated emission cross-section. For radiative emission, UC and DC were recorded for all prepared sample and optimized indicators were established. Co-embedded between ANPs and TNPs also has an impact on bonding and vibration intensity. The presence of both nanoparticles were confirmed by imaging and elemental analysis. A full discussion of each analysis was prepared.

Chapter 5 concludes the entire results for all analyses to ensure objectives are achieved. There are some topics related to the current project that are not included. However, future recommendations for further understanding regarding co-embedded nanoparticles were listed for future research. Certain important data such as calculations for sample composition were added in appendices. A list of publications and conferences attended were also attached for references.

REFERENCES

Ahmadi, F., Hussin, R. and Ghoshal, S. K. (2016) 'Optical transitions in Dy^{3+}-doped magnesium zinc sulfophosphate glass', *Journal of Non-Crystalline Solids*. Elsevier B.V., 452, pp. 266–272. doi: 10.1016/j.jnoncrysol.2016.09.005.

Ahmadi, F., Hussin, R. and Ghoshal, S. K. (2017) 'Spectral characteristics of Er^{3+} doped magnesium zinc sulfophosphate glasses', *Journal of Alloys and Compounds*. Elsevier B.V, 711, pp. 94–102. doi: 10.1016/j.jallcom.2017.03.212.

Aizpurua, J. G. Bryant, L. Ritcher, F. Garcia, B. K. Kelley, T. Mallouk (2005) 'Optical properties of coupled metallic nanorods for field-enhanced spectroscopy', *Physical Review B,* 71(25420), pp. 1–13. doi: 10.1103/PhysRevB.71.235420.

Alias, A. Y. Yaacob, Z. Zazibi. S. Alshurdin, N. Aini. (2018) 'General description of configurational coordinate model and kinetic of luminescence', *Journal of Fundamental and Applied Sciences,* 9(5S), p. 568. doi: 10.4314/jfas.v9i5s.40.

Aliyu, T. Y. (2017) *Structural and spectroscopic properties of zinc tellurite doped samarium glass embedded with gold nanoparticles*. PhD Thesis, Universiti Teknologi Malaysia.

Amiri, O., M. Salavati., M. Farangi, M. Mazaheri, S. Bagheri. (2015) 'Stable Plasmonic-Improved dye Sensitized Solar Cells by Silver Nanoparticles Between Titanium Dioxide Layers', *Electrochimica Acta*. Elsevier Ltd, 152, pp. 101–107. doi: 10.1016/j.electacta.2014.11.105.

Amjad, Muhamad. J. (2013) 'Effect of Silver Nanoparticle on Optical Properties of Erbium -Doped Magnesium Phosphate Glass', PhD Thesis, Universiti Teknologi Malaysia.

Amjad, Raja. J., M. Sahar., S. Ghoshal M. Dousti, R. Arifin . (2013) 'Synthesis and characterization of Dy^{3+} doped zinc – lead-phosphate glass', *Optical Materials,* 35(5), pp. 1103–1108. doi: 10.1016/j.optmat.2012.12.024.

Amjad, R. J., Dousti, M. R. and Sahar, M. R. (2015) 'Spectroscopic investigation and Judd-Ofelt analysis of silver nanoparticles embedded Er^{3+}-doped tellurite glass', *Current Applied Physics*. Elsevier B.V, 15(1), pp. 1–7. doi:

10.1016/j.cap.2014.10.022.

Anand, V., Singh, K. J. and Kaur, K. (2014) 'Evaluation of zinc and magnesium doped 45S5 mesoporous bioactive glass system for the growth of hydroxyl apatite layer', *Journal of Non-Crystalline Solids*, 406, pp. 88–94. doi: 10.1016/j.jnoncrysol.2014.09.050.

Anger, P., Bharadwaj, P. and Novotny, L. (2006) 'Enhancement and quenching of single-molecule fluorescence', *Physical Review Letters*, 96(11), pp. 3–6. doi: 10.1103/PhysRevLett.96.113002.

Angkaew, S. and Limsuwan, P. (2012) 'Preparation of silver-titanium dioxide core-shell (Ag@TiO_2) nanoparticles: Effect of Ti-Ag mole ratio', *Procedia Engineering*. Elsevier B.V., 32, pp. 649–655. doi: 10.1016/j.proeng.2012.01.1322.

Anjaiah, J. (2019) 'Influence Of Modifier Oxide On Spectroscopic Characteristics Of Neodymium Ion In Lithium Borate Glass System', *International Journal of Research in Advent Technology*, 7(3), pp. 1450–1457. Available at: www.ijrat.org.

Anwar, M., Abdelhalim, K. and Al-shamrani, B. M. (2017) 'The physical properties of phosphate calcium glass doped with titanium oxide nanoparticles', *Journal of Non-Crystalline Solids*. Elsevier, 470(March), pp. 8–13. doi: 10.1016/j.jnoncrysol.2017.04.039.

Ao, C. H. and Lee, S. C. (2004) 'Combination effect of activated carbon with TiO_2 for the photodegradation of binary pollutants at typical indoor air level', *Journal of Photochemistry and Photobiology A: Chemistry*, 161(2–3), pp. 131–140. doi: 10.1016/S1010-6030(03)00276-4.

Arifin, R., Sahar, M. R., & Sulhadi, S. (2007) 'FTIR spectroscopy study on tellurite doped Eu_2O_3 glass. Springer Verlag.', *Springer*, 15(1), pp. 122–126.

Arifin, R., Zulkifeli. N. A, Sahar. M. R, Ghoshal. S. K. (2014) 'Enhanced Luminescence from Erbium Doped Phosphate Glass Containing ZnO Nanoparticles', *Advanced Materials Research*, 895, pp. 241–244. doi: 10.4028/www.scientific.net/AMR.895.241.

Ashur Said Mahraz, Z., M. Sahar., S. Ghoshal, M. Dousti, R. Amjad. (2013) 'Silver nanoparticles enhanced luminescence of Er^{3+} ions in boro-tellurite glasses', *Materials Letters*. Elsevier, 112, pp. 136–138. doi: 10.1016/j.matlet.2013.08.131.

Aswathy, B., Sony, G. and Gopchandran, K. G. (2014) 'Shell Thickness-

Dependent Plasmon Coupling and Creation of SERS Hot Spots in Au @ Ag Core-Shell Nanostructures', *Plasmonics*, (9), pp. 1323–1331. doi: 10.1007/s11468-014-9745-9.

Auzel, F. (1990) 'Upconversion Processes in Coupled Ion Systems ', *Journal of Luminescence*, 45, pp. 341–345.

Auzel, F. (2002) 'Up-conversion in rare-earth-doped systems: past, present and future', in *XI Feofilov Symposium on Spectroscopy of Crystals Activated by Rare-Earth and Transition Metal Ions*, p. 179. doi: 10.1117/12.475333.

Awang, A., S. Ghosal., M. Sahar, M. Dousti, R. Amjad, F. Nawaz. (2013) 'Enhanced spectroscopic properties and Judd-Ofelt parameters of Er-doped tellurite glass: Effect of gold nanoparticles', *Current Applied Physics*. Elsevier B.V, 13(8), pp. 1813–1818. doi: 10.1016/j.cap.2013.06.025.

Awang, A. (2014) *Effect of nanoparticles on the structure and optical properties of Erbium doped zinc sodium tellurite glass*. PhD Thesis. Uniersiti Teknologi Malaysia.

Awang, A., S. Ghoshal., M. Sahar, M. Dousti, F. Nawaz. (2014) 'Growth of Au Nanoparticles Stimulate Spectroscopic Properties of Er^{3+} Doped TeO_2-ZnO-Na_2O Glasses', *Advanced Materials Research*, 895, pp. 254–259. doi: 10.4028/www.scientific.net/AMR.895.254.

Awazu, K., M. Fujimaki., C. Rockstuhl *et al.* (2008) 'A Plasmonic Photocatalyst Consisting of Silver Nanoparticles Embedded in Titanium Dioxide', *Journal American Chemical Society*, 130(4), pp. 1676–1680.

Azeem, P. A., Balaji, S. and Reddy, R. R. (2008) 'Spectroscopic properties of Dy^{3+} ions in NaF–B_2O_3–Al_2O_3 glasses', *Spectrochimica Acta - Part A*, 69, pp. 183–188. doi: 10.1016/j.saa.2007.03.028.

Azmi, S. A. M., Ghoshal. S. K and Arifin. R. (2015) 'Modification of structural and physical properties of samarium doped zinc phosphate glasses due to the inclusion of nickel oxide nanoparticles', *Journal of Non-Crystalline Solids*, 411, pp. 53–58. doi: 10.1016/j.jnoncrysol.2014.12.024.

Babu, P., K. Jang., E. Kim, L. Shi, R. Vijaya, V. Lavin, C. Jayasankar. (2010) 'Optical properties and energy transfer of Dy^{3+}-doped transparent oxyfluoride glasses and glass-ceramics', *Journal of Non-Crystalline Solids*. Elsevier B.V., 356(4–5), pp. 236–243. doi: 10.1016/j.jnoncrysol.2009.11.010.

Babu, S., A. Balakrishna., D. Rajesh, Y. Ratnakaram. (2014) 'Investigations on luminescence performance of Sm^{3+} ions activated in multi-component fluoro-phosphate glasses.', *Spectrochimica acta. Part A, Molecular and biomolecular spectroscopy*. Elsevier B.V., 122, pp. 639–48. doi: 10.1016/j.saa.2013.11.102.

Babu, S., P. Babu., C. Jayasankar, Th. Troster, W. Seivers, G. Wortmann. (2009) 'Optical properties of Dy^{3+}-doped phosphate and fluorophosphate glasses', *Optical Materials*. Elsevier B.V., 31(4), pp. 624–631. doi: 10.1016/j.optmat.2008.06.019.

Badawi, A., Al-Hosiny, N. and Abdallah, S. (2015) 'The photovoltaic performance of CdS quantum dots sensitized solar cell using graphene/TiO_2 working electrode', *Superlattices and Microstructures*. Elsevier Ltd, 81, pp. 88–96. doi: 10.1016/j.spmi.2015.01.024.

Baia, L., D. Murusen., M. Baia, J. Popp, S. Simon. (2007) 'Structural properties of silver nanoclusters–phosphate glass composites', *Vibrational Spectroscopy*, 43(2), pp. 313–318. doi: 10.1016/j.vibspec.2006.03.006.

Balakrishna, A., Rajesh, D. and Ratnakaram, Y. C. (2012) 'Structural and photoluminescence properties of Dy^{3+} doped different modifier oxide-based lithium borate glasses', *Journal of Luminescence*. Elsevier, 132(11), pp. 2984–2991. doi: 10.1016/j.jlumin.2012.06.014.

Baldi, G., Fontana, A. and Rossi, F. (2011) 'Raman scattering investigation of the boson peak in a sodium silicate glass', *Philosophical Magazine*, 91(May), pp. 1801–1808. doi: 10.1080/14786435.2010.523020.

Bansal, A. and Verma, S. S. (2016) 'Optical properties of bimetallic (Ag-Cu) core-noble metal shell nanoparticles', *Journal of Optics (India)*, 45(1), pp. 7–10. doi: 10.1007/s12596-016-0319-4.

Barone, P., S. Stranges., M. Barberio. D. Renzeni. A. Bonanno, F. Xu. (2014) 'Study of band gap of silver nanoparticles - Titanium dioxide nanocomposites', *Journal of Chemistry*, 2014. doi: 10.1155/2014/589707.

Bedford, E., J. Spadavecchia., C. Pradier. F. Gu. (2012) 'Surface Plasmon Resonance Biosensors Incorporating Gold Nanoparticles', *Journal of Macromolecular Bioscience*, 12, pp. 724–739. doi: 10.1002/mabi.201100435.

Bian, X., Dunn, R. C. and Xie, X. S. (1995) 'Single molecule emission characteristics in near-field microscopy', *Physical Review Letters*, 75(26), pp. 4772–4776.

Blasse, G. and B. C. Grabmaier (1994) *Luminescent Materials (Springer-Verlag Telos, 1994)(ISBN 0387580190), G. Blasse, B. C. Grabmaier.pdf*. Edited by G. Blasse and B.C.Grabmaier. Springer-Verlag.

Brik, M. G., Z. M. Anric, K. Vukovic, M. D.Dramicanin. (2015) 'Judd - Ofelt Analysis of Eu^{3+} Emission in TiO_2 Anatase Nanoparticles', *materials transactions*, 56(9), pp. 1416–1418.

Calahoo, C. and Zwanziger, J. W. (2017) 'The mixed modifier effect in ionic conductivity and mechanical properties for xMgO-(50-x)CaO-50SiO_2 glasses', *Journal of Non-Crystalline Solids*, pp. 6–18. doi: 10.1016/j.jnoncrysol.2017.01.017.

Camargo, P., L. Lao., M. Rycenga, W. Li, Y. Xia. (2010) 'Measuring the SERS enhancement factors of dimers with different structures constructed from silver nanocubes', *Chemical Physics Letters*. Elsevier B.V., 484(4–6), pp. 304–308. doi: 10.1016/j.cplett.2009.12.002.

Carnall, W. T., Fields, P. R. and Rajnak, K. (1968) 'Electronic energy levels of the trivalent lanthanide aquo ions. IV. Eu^{8+}', *The Journal of Chemical Physics*, 49(10), pp. 4424–4442. doi: 10.1063/1.1669893.

Chander, N., P. Singh., A. Khan, V. Dutta, V. K. Komarala. (2014) 'Photocurrent enhancement by surface plasmon resonance of gold nanoparticles in spray deposited large area dye sensitized solar cells', *Thin Solid Films*. Elsevier B.V., 568, pp. 74–80. doi: 10.1016/j.tsf.2014.08.002.

Chandrasekhar, A. V., Radhapathy. A, Reddy. B. J and Ramamoorthy. L. (2003) 'Optical absorption spectrum of dysprosium doped zinc phosphate glass', 22, pp. 215–220. doi: 10.1016/S0925-3467(02)00267-7.

Cortie, M. B., A. Dowd., N. Harris, M. J. Ford. (2007) 'Core-shell nanoparticles with self-regulating plasmonic functionality', *Physical Review B*, 75(November 2006), pp. 1–4. doi: 10.1103/PhysRevB.75.113405.

Cortie, M. B. and Mcdonagh, A. M. (2011) 'Synthesis and Optical Properties of Hybrid and Alloy Plasmonic Nanoparticles', *Chemical Reviews*, 111, pp. 3713–3735.

Dadkhah, M., Salavati-Niasari, M. and Mir, N. (2014) 'Synthesis and characterization of TiO_2 nanoparticles by using new shape controllers and its application in dye sensitized solar cells', *Journal of Industrial and Engineering Chemistry*. The Korean Society of Industrial and Engineering Chemistry, 20(6), pp.

4039–4044. doi: 10.1016/j.jiec.2014.01.003.

Dahl, M., Liu, Y. and Yin, Y. (2014) 'Composite Titanium Dioxide Nanomaterials.pdf', *American Chemical Society,* (114), pp. 985–9889.

Damak, K., E. Sayed., C. Russel, R. Maalej. (2014) ' White light generation from Dy^{3+} doped tellurite glass', *Journal of Quantitative Spectroscopy and Radiative Transfer*. Elsevier, 134, pp. 55–63. doi: 10.1016/j.jqsrt.2013.10.013.

Damas, P., J. Coelho., G. Hungerford, N. S. Hussain. (2012) 'Structural studies of lithium boro tellurite glasses doped with praseodymium and samarium oxides', *Materials Research Bulletin*, 47(11), pp. 3489–3494. doi: 10.1016/j.materresbull.2012.06.071.

Damdee, B., Kirdsiri, K. and Kaewkhao, J. (2015) 'Optical spectroscopy of Dy^{3+} doped Lithium borate glasses for luminescence applications', 2015 4th Conference on Instrument, Communication, Information Tehnology and Biomedical Engineering epp. 260–263.

Damodaraiah, S., V. R. Prasad, S. Babu and Y. C. Ratnakaram *et al.* (2017) 'Structural and luminescence properties of Dy^{3+} doped bismuth phosphate glasses for greenish yellow light applications', *Optical Materials*. Elsevier Ltd, 67, pp. 14–24. doi: 10.1016/j.optmat.2017.03.023.

Davis, T., Gomez, D. E. and Vernon, K. . (2010) 'Simple Model for the Hybridization of Surface Plasmon Resonances in Metallic', *Nano Lett.*, (10), pp. 2618–2625. doi: 10.1021/nl101335z.

Devi, N. B. (2013) *Chapter 4 Surface Plasmon Resonance of Fabricated Bimetallic Nanostructures of Silver and Gold*. PhD Thesis, University of Delhi India.

Dexter, D. L. (1953) 'A theory of sensitized luminescence in solids', *The Journal of Chemical Physics*, 21(5), pp. 836–850. doi: 10.1063/1.1699044.

Dihingia, P. J. and Rai, S. (2012) 'Synthesis of TiO_2 nanoparticles and spectroscopic upconversion luminescence of Nd^{3+}-doped TiO_2–SiO_2 composite glass', *Luminescence*, 132, pp. 1243–1251. doi: 10.1016/j.jlumin.2011.12.008.

Dousti, M. R., M. Sahar., R. Amjad, S. K. Ghoshal, A. Awang. (2013) 'Surface Enhanced Raman Scattering and Up-Conversion Emission by Silver Nanoparticles in Erbium–Zinc–Tellurite glass', *Journal of Luminescence*. Elsevier, 143, pp. 368–373. doi: 10.1016/j.jlumin.2013.04.017.

Du, Mao-Hua. (2016) 'Using DFT Methods to Study Activators in Optical

Materials', *ECS Journal of Solid State Science and Technology*, 5(1), pp. R3007–R3018. doi: 10.1149/2.0011601jss.

Dugué, A., O. Dymshits., L. Cormie, B. Cochain, G. Lelong, S. Belin, A. Zhilin. (2015) 'Structural evolution of Ni environment in lithium, magnesium and zinc aluminosilicate glasses and glass-ceramics', *Journal of Non-Crystalline Solids*, pp. 24–33. doi: 10.1016/j.jnoncrysol.2015.01.011.

Dwivedi, Y. and Rai, S. B. (2010) 'Spectroscopic study of Sm:Ce ions co-doped in barium fluoroborate glass', *Journal of Non-Crystalline Solids*. Elsevier B.V., 356(33–34), pp. 1650–1654. doi: 10.1016/j.jnoncrysol.2010.06.013.

Ekmel Ozbay (2012) 'Plasmonics : Merging Photonics and Elecronics at Nanoscale Dimensions', *Science*, 311(2006). doi: 10.1126/science.1114849.

El-Deen, L. M. S., Salhi, M. S. A. and Elkholy, M. M. (2008) 'IR and UV spectral studies for rare earths-doped tellurite glasses', *Journal of Alloys and Compounds*, 465(1–2), pp. 333–339. doi: 10.1016/j.jallcom.2007.10.104.

El-Kady, A. M., A. Ali., R. Rizk, M. M. Ahmed. (2012) 'Synthesis, characterization and microbiological response of silver doped bioactive glass nanoparticles', *Ceramics International*. Elsevier Ltd and Techna Group S.r.l., 38(1), pp. 177–188. doi: 10.1016/j.ceramint.2011.05.158.

El-Mallawany, R. (2000) 'Structural interpretations on tellurite glasses', *Materials Chemistry and Physics*, 63(2), pp. 109–115. doi: 10.1016/S0254-0584(99)00196-0.

El-Mallawany, R. A. H. (2002) *Tellurite Glasses Handbook Physical Properties and Data*. CRC Press LLC.

El-Mallawany, R., Abdalla, M. D. and Ahmed, I. A. (2008) 'New tellurite glass : Optical properties', 109, pp. 291–296. doi: 10.1016/j.matchemphys.2007.11.040.

Elkholy, M. M. (2003) 'Thermoluminescence for rare-earths doped tellurite glasses', *Materials Chemistry and Physics*, 77(2), pp. 321–330. doi: 10.1016/S0254-0584(01)00538-7.

Elkhoshkhany, N., Essam, O. and Embaby, A. M. (2018) 'Optical, thermal and antibacterial properties of tellurite glass system doped with ZnO', *Materials Chemistry and Physics*. Elsevier B.V, 214, pp. 489–498. doi: 10.1016/j.matchemphys.2018.05.007.

Encina, E. R. and Coronado, E. A. (2007) 'Resonance conditions for multipole plasmon excitations in noble metal nanorods', *Journal of Physical Chemistry C*, 111(45), pp. 16796–16801. doi: 10.1021/jp075880j.

Encina, E. R. and Coronado, E. A. (2008) 'Plasmonic nanoantennas: Angular scattering properties of multipole resonances in noble metal nanorods', *Journal of Physical Chemistry C*, 112(26), pp. 9586–9594. doi: 10.1021/jp7120142.

Encina, E. R. and Coronado, E. A. (2010) 'Plasmon coupling in silver nanosphere pairs', *Journal of Physical Chemistry C*, 114(9), pp. 3918–3923. doi: 10.1021/jp912096v.

Enoch, S. and Bonod, N. (2012) *Plasmonics - From basics to advanced topics, Springer Series in Optical Sciences*. doi: 10.1007/978-3-642-28079-5.

Eraiah, B. and Bhat, S. G. (2007) 'Optical properties of samarium doped zinc–phosphate glasses', *Journal of Physics and Chemistry of Solids*, 68(4), pp. 581–585. doi: 10.1016/j.jpcs.2007.01.032.

Ferhi, M., C. Bouzidi., K. Horchani, H. Elhouichet, M. Ferid. (2014) 'Judd-Ofelt analysis and radiative properties of LiLa(1-x)Eu$(PO_3)_4$', *Optical Materials*. Elsevier B.V., 37(C), pp. 607–613. doi: 10.1016/j.optmat.2014.08.003.

Francois, A. (2004) 'Upconversion and anti-stokes processes with f and d ions in solids', *Chemical reviews*, 104(1), pp. 139–173.

Frechero, M. A., Quinzani, O. V and Pettigrosso, R. S. (2007) 'IR absorption spectra of lithium and silver vanadium – tellurite based glasses', *Journal of Non-Crystalline Solids*, 353, pp. 2919–2925. doi: 10.1016/j.jnoncrysol.2007.06.032.

Fujishima, A., Zhang, X. and Tryk, D. A. (2008) 'TiO_2 photocatalysis and related surface phenomena', *Surface Science Reports*, 63(12), pp. 515–582. doi: 10.1016/j.surfrep.2008.10.001.

Fultz, B. and Howe, J. (2013) *Transmission Electron Microscopy and Diffractometry of Materials*. Fourth Edi. Springer-Verlag Berlin Heidelberg. doi: 10.1007/978-3-642-29761-8.

Funston, A. M., C. Novo., T. Davis, P. Mulvaney. (2009) 'Plasmon coupling of gold nanorods at short distances and in different geometries', *Nano Letters*, 9(4), pp. 1651–1658. doi: 10.1021/nl900034v.

Garratt-Reed, A. J. and Bell, D. C. (2003) *Energy-Dispersive X-ray Analysis in the Electron Microscope*. First edit. BIOS Scientific Publishers Limited.

Geddes, C. D. (2012) *Reviews in Plasmonics 2010*. Springer. doi:

10.1007/978-1-4614-0884-0.

Ghoshal, S. K., A. Awang., M. Sahar. R. Arifin. (2015) 'Gold nanoparticles assisted surface enhanced Raman scattering and luminescence of Er^{3+}doped zinc-sodium tellurite glass', *Journal of Luminescence*, 159, pp. 265–273. doi: 10.1016/j.jlumin.2014.11.032.

Ghribi, N., M. Dutreikh., J. Duclere, T. Hayakawa, J. Carreaud, R Karray. (2015) 'Thermal, optical and structural properties of glasses within the TeO_2TiO_2ZnO system', *Journal of Alloys and Compounds*. Elsevier B.V., 622, pp. 333–340. doi: 10.1016/j.jallcom.2014.10.063.

Goel, A., S. Kapoor., A. Tilocca, R. R. Rajagopal, J. M. F. Ferreira. (2013) 'Structural role of zinc in biodegradation of alkali-free bioactive glasses', *Journal of Materials Chemistry B*, 1(24), pp. 3073–3082. doi: 10.1039/c3tb20163e.

Guidelli, E. J., Baffa, O. and Clarke, D. R. (2015) 'Enhanced UV Emission From Silver / ZnO And Gold / ZnO Core-Shell Nanoparticles : Radioluminescence , And Optically Stimulated Luminescence', *Scientific Reports*. Nature Publishing Group, (August), pp. 1–11. doi: 10.1038/srep14004.

Guofeng, W., Q. Weiping., W. Lili, W. Guodong, Z. Perfen, Z. Daisheng. (2009) 'Enhanced ultraviolet upconversion in YF^{3+}:Yb^{3+}/Tm^{3+} nanocrystals', *Journal of Rare Earths*. The Chinese Society of Rare Earths, 27(2), pp. 330–333. doi: 10.1016/S1002-0721(08)60245-8.

Hehlen, M. P., Brik, M. G. and Kramer, K. W. (2013) '50th anniversary of the Judd-Ofelt theory: An experimentalist's view of the formalism and its application', *Journal of Luminescence*, 136, pp. 221–239. doi: 10.1016/j.jlumin.2012.10.035.

Herrmann, A., M. Tewelde., S. Kuhn, M. Tiegel, C. Russel. (2018) 'The effect of glass composition on the luminescence properties of Sm^{3+} doped alumino silicate glasses', *Journal of Non-Crystalline Solids*, 502, pp. 190–197. doi: 10.1016/j.jnoncrysol.2018.09.008.

Hirakawa, T. and Kamat, P. V (2005) 'Charge Separation and Catalytic Activity of Ag@TiO_2 Core - Shell Composite Clusters under UV - Irradiation', *Journal of American Chemical Society*, (37), pp. 3928–3934.

Hohenau, A., Leitner, A. and Aussenegg, F. R. (2007) *Near-Field and Far-Field Properties of Nanoparticles Arrays*, Springer

Hooshmand, N., Bordley, J. A. and El-sayed, M. A. (2014) 'Are Hot Spots between Two Plasmonic Nanocubes of Silver or Gold Formed beteen Adjacent Corners or Adjacent Facets? A DDA Examination', *Physical Chemistry Letters*, (5), pp. 2229–2234.

Hooshmand, N., Bordley, J. A. and El-sayed, M. A. (2015) 'Plasmonic Spectroscopy: The Electromagnetic Field Strength and its Distribution Determine the Sensitivity Factor of Face-to-Face Ag Nanocube Dimers in Solution and on a Substrate', *Journal of Physical Chemistry C*, 119, pp. 15579–15587. doi: 10.1021/acs.jpcc.5b05395.

Huang, X., P. Jain., El- Sayed, M. A. El-Sayed. (2007) 'Gold nanoparticles: Interesting optical properties and recent applications in cancer diagnostics and therapy', *Nanomedicine*, 2(5), pp. 681–693. doi: 10.2217/17435889.2.5.681.

Hubenthal, F., T. Ziegler, C. Hendrich, M. Alschinger, F. Trager. (2005) 'Tuning the surface plasmon resonance by preparation of gold-core / silver-shell and alloy nanoparticles', *The European Physical Journal D*, 34, pp. 165–168. doi: 10.1140/epjd/e2005-00138-1.

Hussain, S., R. Amjad., M. Tanveer, M. Nadeem, H. Mahmood, A. Sattar. (2017) 'Optical Investigation of Sm^{3+} Doped in Phosphate Glass', *Glass Physics and Chemistry*, 43(6), pp. 538–547. doi: 10.1134/S1087659617060219.

Islam, M. A., M. Haiter., I. Khan, M. Islam. (2012) 'Optical and Structural Characterization of TiO_2 Nanoparticles', *IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)*, 3(2), pp. 18–24. doi: 10.9790/1676-0321824.

Ismail, S. F., Sahar, M. R. and Ghoshal, S. K. (2015) 'Effects of titanium nanoparticles on self-cleaning and structural features of zinc-magnesium-phosphate glass', *Materials Research Bulletin*. Elsevier Ltd, 74, pp. 502–506. doi: 10.1016/j.materresbull.2015.11.022.

Ismail, S. F., Sahar, M. R. and Ghoshal, S. K. (2016) 'Materials Characterization Physical and absorption properties of titanium nanoparticles incorporated into zinc magnesium phosphate glass', *Materials Characterization*. Elsevier Inc., 111, pp. 177–182. doi: 10.1016/j.matchar.2015.11.030.

Jain, P., K. Lee., El- Sayed, M. A. El-Sayed. (2006a) 'Calculated absorption and scattering properties of gold nanoparticles of different size, shape, and composition: Applications in biological imaging and biomedicine', *The Journal of Physical Chemistry B*, 110, pp. 7238–7248. doi: 10.1021/jp057170o.

Jain, P. K. and El-Sayed, M. A. (2010) ‘Plasmonic coupling in noble metal nanostructures’, *Chemical Physics Letters*. Elsevier B.V., 487(4–6), pp. 153–164. doi: 10.1016/j.cplett.2010.01.062.

Jain, P. K., Eustis, S. and El-Sayed, M. A. (2006b) ‘Plasmon coupling in nanorod assemblies: Optical absorption, discrete dipole approximation simulation, and exciton-coupling model’, *Journal of Physical Chemistry B*, 110(37), pp. 18243–18253. doi: 10.1021/jp063879z.

Jamalaiah, B. C., Kumar, M. V. V. and Gopal, K. R. (2011) ‘Fluorescence properties and energy transfer mechanism of Sm^{3+} ion in lead telluroborate glasses’, *Optical Materials*. Elsevier B.V., 33(11), pp. 1643–1647. doi: 10.1016/j.optmat.2011.04.030.

Jiang, Z., G. Wen., Y. Luo, X. Zhang, Q. Liu, A. Liang. (2014) ‘A new silver nanorod SPR probe for detection of trace benzoyl peroxide’, *Scientific Reports*, 4, pp. 4560–70. doi: 10.1038/srep05323.

Jlassi, I., H. Elhouchichet., M. Ferid, C. Barthou. (2010) ‘JuddOfelt analysis and improvement of thermal and optical properties of tellurite glasses by adding P_2O_5’, *Journal of Luminescence*. Elsevier, 130(12), pp. 2394–2401. doi: 10.1016/j.jlumin.2010.07.026.

Jorgensen, C. K. and Reisfeld, R. (1983) ‘Judd-Ofelt parameters and chemical bonding’, *Journal of The Less-Common Metals*, 93(1), pp. 107–112. doi: 10.1016/0022-5088(83)90454-X.

Jose. Garcia Sole, Luisa. E. B. and Daniel. J. (2005) *An Introduction to the Optical Spectroscopy of Inorganic Solids*. John Wiley & Sons Pte.Ltd.

Justin A.Bordley, Nasrin. H. and M. A. El- Sayed. (2015) ‘The Coupling between Gold or Silver Nanocubes in their Homo-Dimers : A New Coupling Mechanism at Short Separation Distances’, *Nano Letters*, 15(5), pp. 3391–3397. doi: 10.1021/acs.nanolett.5b00734.

Jyothi, L., G. Upender., R. Kuladeep, D. N. Rao. (2014) ‘Structural , thermal , optical properties and simulation of white light of titanium-tungstate-tellurite glasses doped with dysprosium’, *Materials Research Bulletin*. Elsevier Ltd, 50, pp. 424–431. doi: 10.1016/j.materresbull.2013.11.013.

Kalele, S., M. Tiwari., S. Gosavi, S. K. Kulkarni. (2007) ‘Plasmon-assisted photonics at the nanoscale’, *Journal of Nanophotonics*, 1(1), pp. 12501–12520. doi: 10.1117/1.2748429.

Kalisky, Y. (2009) *The Physics and Engineering of Solid State Lasers, , SPIE Press*. doi: 10.1117/3.660249.

Kam, C. H. and Buddhudu, S. (2003) 'NIR to visible upconversion emission from Dy^{3+} : ZBLYAN glasses', *Solid State Communications,* 128, pp. 309–313. doi: 10.1016/S0038-1098(03)00659-8.

Kan, F. (1991) *Optical and spectroscopic properties of glass.* Edited by F. Kan. Springer-Verlag.

Karunakaran, R. T., K. Marimuthu., S. Babu and Arumugam. S. (2009) 'Structural , optical and thermal investigations on Dy^{3+} doped NaF–Li_2O–B_2O_3 glasses', *Physica B: Physics of Condensed Matter*. Elsevier, 404(21), pp. 3995–4000. doi: 10.1016/j.physb.2009.07.160.

Karunakaran, R. T., Marimuthu. K, Babu. S. S and Arumugam. S. (2010) 'Dysprosium doped alkali fluoroborate glasses-Thermal, structural and optical investigations', *Journal of Luminescence*. Elsevier, 130(6), pp. 1067–1072. doi: 10.1016/j.jlumin.2010.01.026.

Kassab, L. R. P. (2007) 'Influence of silver nanoparticles in the luminescence efficiency of Pr^{3+}-doped tellurite glasses', *Journal of Applied Physics*, 102(10), pp. 4–7. doi: 10.1063/1.2817980.

Kassab, L., R. Almeida., D. Silve *et al.* (2008) 'Luminescence of Tb^{3+} doped TeO_2–ZnO–Na_2O–PbO glasses containing silver nanoparticles', *Journal of Applied Physics*, 104(9), p. 093531. doi: 10.1063/1.3010867.

Kassab, L. R. P., Da Silva, D. S. and De Araújo, C. B. (2010) 'Influence of metallic nanoparticles on electric-dipole and magnetic-dipole transitions of Eu^{3+} doped germanate glasses', *Journal of Applied Physics*, 107(11), p. 113506. doi: 10.1063/1.3431347.

Kaur, J., D. Chandrakar., V. Dubey. R. Shrivastara, Y Pargahina, N. S. Suryanayarana. (2016) 'Photoluminescence Characteristics of Dysprosium Doped CeO Phosphor for White Light Emission', *Journal of Display Technology*, 12(5), pp. 506–512.

Kelly, K. L., Coronado, E. and Schatz, L. L. Zao. and G. C. Schatz (2002) 'The Optical Properties of Metal Nanoparticles: The Influence of Size, Shape and Dielectric Environment', *Spectroscopy*, 107, pp. 910–927. doi: 10.1039/c3cc45319g.

Khor, S. F., Z. Talib., F. Malek, E. M. heng. (2013) 'Optical properties of ultraphosphate glasses containing mixed divalent zinc and magnesium ions', *Optical Materials*, 35(3), pp. 629–633. doi: 10.1016/j.optmat.2012.10.013.

Kuhn, S., U. Hakanson., L. Rogobete *et al.* (2006) 'Enhancement of single-molecule fluorescence using a gold nanoparticle as an optical nanoantenna', *Physical Review Letters*, 97(1), pp. 1–4. doi: 10.1103/PhysRevLett.97.017402.

Kumar, V. R. and Veeraiah, N. (1997) 'Infrared spectral investigations on ZnF_2-PbO-TeO_2 glasses', *Journal of Materials Science Letters*, 16, pp. 1816–1818.

Lakshminarayana, G., S. Baki., A. Lira, I. V. Kityk, U. Caldino, K. M. Kaky. (2017) 'Structural , thermal and optical investigations of Dy^{3+}-doped B_2O_3–WO_3–ZnO–Li_2O–Na_2O glasses for warm white light emitting applications', *Journal of Luminescence*. Elsevier B.V., 186, pp. 283–300. doi: 10.1016/j.jlumin.2017.02.049.

Lan, Y., Lu, Y. and Ren, Z. (2013) 'Mini review on photocatalysis of titanium dioxide nanoparticles and their solar applications', *Nano Energy*. Elsevier, 2(5), pp. 1031–1045. doi: 10.1016/j.nanoen.2013.04.002.

Lee, K. and El-Sayed, M. A. (2006) 'Gold and Silver Nanoparticles in Sensing and Imaging : Sensitivity of Plasmon Response to Size , Shape , and Metal Composition', *Journal Physical Chemical*, 110, pp. 19220–19225.

Lee, S. J., Z. Guan., H. Xu, M. Moskovits (2007) 'Surface-Enhanced Raman Spectroscopy and Nanogeometry : The Plasmonic Origin of SERS', *Journal of Physical Chemistry C Letters*, 111(SpectraPhysics 164), pp. 17985–17988.

Li, X. and He, J. (2013) 'Synthesis of Raspberry-Like SiO_2−TiO_2 Nanoparticles toward Anti reflective and Self-Cleaning Coatings', *ACS Appl. Mater. Interfaces*, 5, pp. 5282–5290. doi: 10.1021/am401124j.

Li, Y., Y. Chang., Y. Lin, Y. S. Chang, Y. J. Lin. (2007) 'Synthesis and luminescence properties of Ln^{3+} (Eu^{3+}, Sm^{3+}, Dy^{3+})- doped lanthanum aluminum germanate $LaAlGe_2O_7$ phosphors', 439, pp. 367–375. doi: 10.1016/j.jallcom.2006.08.269.

Li, Y., Q. Zhang., J. Song, X. Gao, W. Tang, A. Lu. (2017) 'Glass formation and spectral studies of PbO and Bi_2O_3 modified TeO_2-ZnO glasses', *Journal of Non-Crystalline Solids*, (October). doi: 10.1016/j.jnoncrysol.2017.12.053.

Lin, Y. M. J., Wei, L. F. Z. H. Y. and Qin, D. W. L. S. (2011) 'Optical properties of Ag nanoparticle embedded silicate glass prepared by field-assisted diffusion', pp. 521–525. doi: 10.1007/s00339-010-6166-2.

Linganna, K., Rao, C. S. and Jayasankar, C. K. (2013) 'Journal of Quantitative Spectroscopy & Radiative Transfer Optical properties and generation of white light in Dy^{3+}-doped lead phosphate glasses', *Journal of Quantitative Spectroscopy and Radiative Transfer*. Elsevier, 118, pp. 40–48. doi: 10.1016/j.jqsrt.2012.12.002.

Liu, B. and Aydil, E. S. (2009) 'Growth of oriented single-crystalline rutile TiO_2 nanorods on transparent conducting substrates for dye-sensitized solar cells', *Journal of the American Chemical Society*, 131(11), pp. 3985–3990. doi: 10.1021/ja8078972.

Liu, S., G. Chen., P. Prasad, M. T. Swihart. (2011) 'Synthesis of Monodisperse Au, Ag, and Au-Ag Alloy Nanoparticles with Tunable Size and Surface Plasmon Resonance Frequency', *Chemistry of Materials*, (23), pp. 4098–4101.

Liz-Marza, L. M. (2006) 'Taikoring surface plasmons through the morphology and assembly of metal nanoparticles', *Langmuir*, 22, pp. 32–41.

Lucacel, R. C., Maier, M. and Simon, V. (2010) 'Structural and in vitro characterization of TiO_2-CaO-P_2O_5 bioglasses', *Non Crystalline Solids*, 356, pp. 2869–2874. doi: 10.1016/j.jnoncrysol.2010.09.019.

Ma, Y., Wu, X. and Zhang, G. (2017) 'Applied Catalysis B : Environmental Core-shell Ag@Pt nanoparticles supported on sepiolite nanofibers for the catalytic reduction of nitrophenols in water : Enhanced catalytic performance and DFT study', *'Applied Catalysis B, Environmental'*. Elsevier B.V., 205, pp. 262–270. doi: 10.1016/j.apcatb.2016.12.025.

Madhu, A. and Eraiah, B. (2018) 'The structural studies of vanadium substituted lithium-bismuth-boro-tellurite glass', *AIP Conference Proceedings*, 1953, pp. 1–5. doi: 10.1063/1.5032907.

Mahamuda, S. K., Swapna. K. Packiyaray. P and Rao. A. S. (2014) 'Lasing potentialities and white light generation capabilities of Dy^{3+} doped oxy- fl uoroborate glasses', *Journal of Luminescence*. Elsevier, 153, pp. 382–392. doi: 10.1016/j.jlumin.2014.03.009.

Mahato, K. K., Rai, A. and Rai, S. B. (2005) 'Optical properties of Dy^{3+} doped in oxyfluoroborate glass', *Journal of Spectrocimica Acta A Part A*. Elsevier, 61, pp. 431–436. doi: 10.1016/j.saa.2004.02.038.

Md. Rahim. Sahar, Hussein, A. W. M. A. and Rosli, H. (2007) 'Structural characteristic of $Na_2OP_2O_5GeO_2$ glass systems', *Journal of Non-Crystalline Solids*, 353(11–12), pp. 1134–1140. doi: 10.1016/j.jnoncrysol.2006.12.032.

Mallin, M. P. and Murphy, C. J. (2002) 'Solution-Phase Synthesis of Sub-10 nm Au − Ag Alloy Nanoparticles', *Nano Letters*, 2(11), pp. 1235–1237.

Martinsson, E., M. Shahjamali., K. Enander, F. Boey, . Xue,, D. Aili. (2013) 'Local Refractive Index Sensing Based on Edge Gold-Coated Silver Nanoprisms', *Physical Chemistry C*, (117), pp. 23148–23154.

Mishra, L., Sharma. A. Vishwakarma. A. K. Jha. K and Jayasimhadri. M. (2016) 'White light emission and color tunability of dysprosium doped barium silicate glasses', *Journal of Luminescence*. Elsevier, 169, pp. 121–127. doi: 10.1016/j.jlumin.2015.08.063.

Mizukoshi, Y., K. Okitsu., Y. Maeda, T. A. Yamamoto, R. Oshima, X. Nagata. (1997) 'Sonochemical Preparation of Bimetallic Nanoparticles of Gold/Palladium in Aqueous', *Physical Chemistry B*, 101(36), pp. 6–10.

Mohamed, E. A., Moustafa, M. G. and Kashif, I. (2018) 'Microstructure, thermal, optical and dielectric properties of new glass nanocomposites of $SrTiO_3$nanoparticles/clusters in tellurite glass matrix', *Journal of Non-Crystalline Solids*. Elsevier, 482(November), pp. 223–229. doi: 10.1016/j.jnoncrysol.2017.12.048.

Mohd Saidi, M. S. A., S. Ghoshal., R. Arifin, M. K. Roslan, R. Muhammad, W. N. W. Shamsuri. (2018a) 'Spectroscopic properties of Dy^{3+} doped tellurite glass with Ag/TiO_2 nanoparticles inclusion : Judd-Ofelt analysis', *Journal of Alloys and Compounds*, 754, pp. 171–183. doi: 10.1016/j.jallcom.2018.04.280.

Mohd Saidi, M. S. A., S. Ghoshal., K. Hamzah, R. Arifin, M. F. Omar, M. K. Roslan. (2018b) 'Visible light emission from Dy^{3+}doped tellurite glass: Role of silver and titania nanoparticles co-embedment', *Journal of Non-Crystalline Solids*, 502(July), pp. 198–209. doi: 10.1016/j.jnoncrysol.2018.09.012.

Moores, A. and Goettmann, F. (2006) 'The plasmon band in noble metal nanoparticles: an introduction to theory and applications', *New Journal of Chemistry*, 30(8), pp. 1121–1132. doi: 10.1039/B604038C.

Mošner, P., K. Vosejpkova., L. Koudelka, L Montagne, B. Revel. (2011) 'Structure and properties of glasses in $ZnO-P_2O_5-TeO_2$ system', *Journal of Non-*

Crystalline Solids, 357(14), pp. 2648–2652. doi: 10.1016/j.jnoncrysol.2010.12.052.

Moustafa, S. Y., Sahar, M. R. and Ghoshal, S. K. (2017) ‘Spectroscopic attributes of Er^{3+} ions in antimony phosphate glass incorporated with Ag nanoparticles : Judd-Ofelt analysis’, *Journal of Alloys and Compounds*. Elsevier B.V, 712, pp. 781–794. doi: 10.1016/j.jallcom.2017.04.106.

Muduli, S., O. Game., V. Dhas, K. Vijayamohanan, K. A. Bogle. (2012) ‘TiO_2-Au plasmonic nanocomposite for enhanced dye-sensitized solar cell (DSSC) performance’, *Solar Energy*. Elsevier Ltd, 86(5), pp. 1428–1434. doi: 10.1016/j.solener.2012.02.002.

Nawaz, F., M. Sahar., S. Ghoshal, R. Amjad, M. Dousti, A. Awang. (2013) ‘Spectral investigation of Sm^{3+}/Yb^{3+} co-doped sodium tellurite glass’, *Chinese Optics Letters*, 11(6), pp. 1–4. doi: 10.3788/COL201311.061605.Tellurite.

Nayab, S., Moorthy, L. R. and Jayasankar, C. K. (2013) ‘Optical and luminescence properties of Dy^{3+} ions in phosphate based glasses’, *Solid State Sciences*. Elsevier Masson SAS, 22, pp. 82–90. doi: 10.1016/j.solidstatesciences.2013.05.013.

Nazabal, V., S. Todoroki., A. Nukui, T. Matsumoto, S. Suehara, T. Hondo. (2003) ‘Oxyfluoride Tellurite Glasses Doped by Erbium: Thermal Analysis, Structural Organization and Spectral Properties’, *Journal of Non-Crystalline Solids*, 325(1–3), pp. 85–102. doi: 10.1016/S0022-3093(03)00313-2.

Ngo, Y. H., D. Li., G. Simon, G. Garnier. (2011) ‘Paper surfaces functionalized by nanoparticles.’, *Advances in colloid and interface science*. Elsevier B.V., 163(1), pp. 23–38. doi: 10.1016/j.cis.2011.01.004.

Noorazlan, A. M., Kamari. H. M. Baki. S. O and Mohamad. D. W. (2015) ‘Green Emission of Tellurite Based Glass Containing Erbium Oxide Nanoparticles’, *Journal of Nanomaterials*, 2015. doi: 10.1155/2015/952308.

Nordlander, P., C. Oubre., E. Prodan, K. Li, M. I. Stockman. (2004) ‘Plasmon hybridization in nanoparticle dimers’, *Nano Letters*, 4(5), pp. 899–903. doi: 10.1021/nl049681c.

Norrbo, I., Hyppänen, I. and Lastusaari, M. (2017) ‘Up-conversion luminescence – A new property in tenebrescent and persistent luminescent hackmanites’, *Journal of Luminescence*. Elsevier. doi: 10.1016/j.jlumin.2017.02.046.

Oh, Y., M. Kang., M. Park, K. H. Jeong. (2016) ‘Engineering Hot Spots on

Plasmonic Nanopillar Arrays for SERS : A Review', *Journal of BioChip,* 10(4), pp. 297–309. doi: 10.1007/s13206-016-0406-2.

Oueslati Omrani, R., A. Kaoutar., A. El. Jazouli, S. Krimi, J. Khattech, M. Jemal. (2015) 'Structural and thermochemical properties of sodium magnesium phosphate glasses', *Journal of Alloys and Compounds,* pp. 766–771. doi: 10.1016/j.jallcom.2015.01.297.

Padlyak, B. V., Pieprzyk. B. Drzewiecki. A. and Adamiv. V. T. (2012) 'Synthesis and optical spectroscopy of borate glasses, doped with terbium and dysprosium', *International Conference on Oxide Materials for Electronic Engineering (OMEE),* 20, pp. 207–208. doi: 10.1109/OMEE.2012.6464898.

Pavani, P. G., Sadhana, K. and Mouli, V. C. (2011) 'Optical , physical and structural studies of boro-zinc tellurite glasses', *Physica B: Physics of Condensed Matter*. Elsevier, 406(6–7), pp. 1242–1247. doi: 10.1016/j.physb.2011.01.006.

Pérez-González, O., N. Zabala., A. Borisov, N. Halas, P. Nordlander. (2010) 'Optical spectroscopy of conductive junctions in plasmonic cavities', *Nano Letters,* 10(8), pp. 3090–3095. doi: 10.1021/nl1017173.

Pisarski, W., J. Pisarska., G. Dominiak, W. R. Romanowski. (2009) 'Transition metal (Cr^{3+}) and rare earth (Eu^{3+}, Dy^{3+}) ions used as a spectroscopic probe in compositional-dependent lead borate glasses', *Journal of Alloys and Compounds,* 484(1–2), pp. 45–49. doi: 10.1016/j.jallcom.2009.05.039.

Plotnichenko, V. G., Sokolov. V. O. Koltashev. V. V and Dianov. E. M. (2005) 'Raman band intensities of tellurite glasses', *Optics Letters,* 30(10), p. 1156. doi: 10.1364/OL.30.001156.

Prabhudev, S., M. Pugnet., G. Zhu, C. Bock, G. A. Button. (2015) 'Surface Segregation of Fe in Pt–Fe Alloy Nanoparticles : Its Precedence and Effect on the Ordered-Phase Evolution during Thermal Annealing', *ChemCatChem,* (7), pp. 3655–3664. doi: 10.1002/cctc.201500380.

Praveena, R., Vijaya, R. and Jayasankar, C. K. (2008) 'Photoluminescence and energy transfer studies of Dy^{3+}-doped fluorophosphate glasses', *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy,* 70(3), pp. 577–586. doi: 10.1016/j.saa.2007.08.001.

Rada, S., Culea, M. and Culea, E. (2008) 'Structure of TeO_2-B_2O_3 glasses inferred from infrared spectroscopy and DFT calculations', *Journal of Non-*

Crystalline Solids. Elsevier B.V., 354(52–54), pp. 5491–5495. doi: 10.1016/j.jnoncrysol.2008.09.009.

Radko, I., V. Volkov., J. Beermann *et al.* (2009) 'Plasmonic metasurfaces for waveguiding and field enhancement', *Laser and Photonic Reviews*, 590(6), pp. 575–590. doi: 10.1002/lpor.200810071.

Rai, S. and Fanai, A. L. (2014) 'Spectroscopic studies of Ho^{3+} doped SiO_2-TiO_2 nanoparticle for photonic applications', 14(3), pp. 112–117.

Rai, V. K. and Rai, S. B. (2004) 'Optical transitions of Dy^{3+} in tellurite glass : observation of upconversion', *Solid State Communications*, 132, pp. 647–652. doi: 10.1016/j.ssc.2004.07.067.

Rai, V. K., Rai, S. B. and Rai, D. K. (2006) 'Optical studies of Dy^{3+} doped tellurite glass : Observation of yellow-green upconversion', *Optics Communications*, 257, pp. 112–119. doi: 10.1016/j.optcom.2005.07.022.

Rajeswari, R., Babu, S. S. and Jayasankar, C. K. (2010) 'Spectroscopic characterization of alkali modified zinc-tellurite glasses doped with neodymium', *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*, 77(1), pp. 135–140. doi: 10.1016/j.saa.2010.04.040.

Ramachari, D., Moorthy, L. R. and Jayasankar, C. K. (2014) 'Energy transfer and photoluminescence properties of Dy^{3+}/Tb^{3+} co-doped oxyfluorosilicate glass – ceramics for solid-state white lighting', *Ceramics International*. Elsevier, 40(7), pp. 11115–11121. doi: 10.1016/j.ceramint.2014.03.136.

Ravi, O., C. Madhukar., L. Manoj, B. Deva. (2012) 'Structural and optical studies of Sm^{3+} ions doped niobium borotellurite glasses', *Journal of Molecular Structure*. Elsevier B.V., 1029, pp. 53–59. doi: 10.1016/j.molstruc.2012.06.059.

Rayappan, A., Maheshvaran. K. Babu. S. S. and Marimuthu. K. (2012) 'Dysprosium doped lead fluoroborate glasses: Structural, optical, and thermal investigations', *Physica Status Solidi A*, 578(3), pp. 570–578. doi: 10.1002/pssa.201127386.

Rechberger, W., A. Hohenau., A. Leitner, J. K. Krenn, B. Camprecht, F. R. Aussenegg. (2003) 'Optical properties of two interacting gold nanoparticles', *Optics Communications*, 220(1–3), pp. 137–141. doi: 10.1016/S0030-4018(03)01357-9.

Reddy, B., M. Kadukar., H. Hwang, B. S. Ham, S. Sailaja, U. Rambahu. (2015) 'Emission analysis of RE^{3+} (RE= Eu, Sm , Dy): $MgY_4Si_3O_{13}$ phosphors', *Physica B: Physics of Condensed Matter*. Elsevier, 463, pp. 39–47. doi: 10.1016/j.physb.2015.01.029.

Reisfeld, R. (1984) 'Spectroscopy and nonradiative phenomena of rare earths in glasses: Future applications', *Inorganica Chimica Acta*, 95(2), pp. 69–74. doi: 10.1016/S0020-1693(00)87369-7.

Reza Dousti, M., M. Sahar., S. Ghoshal, R. Amjad, A. R. Samavati . (2013) 'Effect of AgCl on spectroscopic properties of erbium doped zinc tellurite glass', *Journal of Molecular Structure*. Elsevier B.V., 1035, pp. 6–12. doi: 10.1016/j.molstruc.2012.09.023.

Reza Dousti, M. (2014) 'Plasmonic effect of silver nanoparticles on the upconversion emissions of Sm^{3+}-doped sodium-borosilicate glass', *Measurement*. Elsevier Ltd, 56, pp. 117–120. doi: 10.1016/j.measurement.2014.06.024.

Reza Dousti, M., R. J. Amjad., R. Hosseinian, M. Salehi, M. R. Sahar. (2015) 'Photoluminescence study of Sm^{3+}–Yb^{3+}co-doped tellurite glass embedding silver nanoparticles', *Journal of Luminescence*. Elsevier, 159, pp. 100–104. doi: 10.1016/j.jlumin.2014.10.060.

Ringe, E., S. Collins., C. Desantis, S. E. Skrabalak, P. A. Midgley. (2014) 'Plasmon and compositional mapping of plasmonic nanostructures', in, pp. 1–10. doi: 10.1117/12.2073886.

Ringe, E., C. Desantis., S. Collins, M. Duchamp, R. E Dunin. (2015) 'Resonances of nanoparticles with poor plasmonic metal tips', *Scientific Reports*. Nature Publishing Group, 5, pp. 1–9. doi: 10.1038/srep17431.

Rivera, V. A. G., S. Osorio., D. Manzani, Y. Messaddeq, L. A. O. Nunes. (2011) 'Growth of silver nano-particle embedded in tellurite glass : Interaction between localised surface plasmon resonance and Er^{3+} ions', *Optical Materials*. Elsevier B.V., 33(6), pp. 888–892. doi: 10.1016/j.optmat.2011.01.015.

Rivera, V. A. G., Y. Ledemi., S. Osorio, D. Manzani, Y. Messaddeq, L. A. O. Nunes. (2012) 'Efficient plasmonic coupling between Er^{3+}:(Ag/Au) in tellurite glasses', *Journal of Non-Crystalline Solids*. Elsevier B.V., 358(2), pp. 399–405. doi: 10.1016/j.jnoncrysol.2011.10.008.

Rodrı, B., A. Burrows., M. Watanabe, C. J. Kiely, L. M. L. Marzan. (2005) 'Multishell bimetallic AuAg nanoparticles : synthesis , structure and optical properties', *Journal of Materials Chemistry*, 15, pp. 1755–1759. doi: 10.1039/b500556f.

Romero, I., Aizpurua, J., Bryant, G. W. and Abajo, F. J. G. De (2006) ‘Plasmons in nearly touching metallic nanoparticles : singular response in the limit of touching dimers’, *Journal of Optics Express,* 14(21), pp. 1627–1631. doi: 10.1364/OE.14.009988

Ronda, C. (2007) *Luminescence From Theory to Applications*. Edited by C. Ronda. Wiley-VCH.

Rozra, J., Saini. I. Aggarwal. S and Sharma. A. (2013) ‘Spectroscopic analysis of Ag nanoparticles embedded in glass’, *Advanced Materials Letters*, 4(8), pp. 598–604. doi: 10.5185/amlett.2013.1402.

Ruan, X. L. and Kaviany, M. (2005) ‘Enhanced nonradiative relaxation and photoluminescence quenching in random, doped nanocrystalline powders’, *Journal of Applied Physics*, 97(10). doi: 10.1063/1.1900937.

Sahar, M. R., Jaafar, E. and Ghoshal, S. K. (2014) ‘Luminescence Spectra of Erbium Doped Zinc Tellurite Glass Embedded with Gold Nanoparticles’, *Advanced Materials Research*, 895, pp. 231–235. doi: 10.4028/www.scientific.net/AMR.895.231.

Sánchez-Ramírez, J. F. and Pal, U. (2001) ‘Optical absorption of colloidal dispersion of bimetallic nanoparticles Au/Pd’, *Superficies y Vacio*, 13, pp. 114–116.

Saleem, S. A., Jamalaiah. B. C. Jayasimhadri. M. Rao. A. S and Jang. K. (2011) ‘Journal of Quantitative Spectroscopy & Radiative Transfer Luminescent studies of Dy^{3+} ion in alkali lead tellurofluoroborate glasses’, *Journal of Quantitative Spectroscopy and Radiative Transfer*. Elsevier, 112(1), pp. 78–84. doi: 10.1016/j.jqsrt.2010.08.017.

Sasi, M. V., D. Rajesh., A. Balkrishna, Y. C. Ratnakaram. (2013) ‘Optical absorption and photoluminescence properties of Dy^{3+} doped heavy metal borate glasses – Effect of modifier oxides’, *Journal of Molecular Structure*. Elsevier B.V., 1041, pp. 100–105. doi: 10.1016/j.molstruc.2013.03.009.

Sasikala, T., L. R. Moorthy., A. M. Babu, T S. Rao. (2013) ‘Effect of co-doping Tm^{3+} ions on the emission properties of Dy^{3+} ions in tellurite glasses’, *Journal of Solid State Chemistry*. Elsevier, 203, pp. 55–59. doi: 10.1016/j.jssc.2013.03.058.

Sastri. V. S, Jean-Claude Bunzil and Rao, V. R. (2003) ‘Modern Aspects of

Rare Earth and Their Complexes’, in. Elsevier Science B.V.

Sazali, E. S., M. Sahar., S. Ghoshal, R. Arifn, M. S. Rohani, A. Awang. (2014) ‘Optical properties of gold nanoparticle embedded Er^{3+} doped lead-tellurite glasses’, *Journal of Alloys and Compounds*. Elsevier B.V., 607, pp. 85–90. doi: 10.1016/j.jallcom.2014.03.175.

Sazali, E. S., M. Sahar., S. Ghosal *et al.* (2015) ‘Efficient optical enhancement of Er^{3+} doped lead–tellurite glass embedded with gold nanoparticles: role of heat-treatment’, *Journal of Non-Crystalline Solids*, 410, pp. 174–179. doi: 10.1016/j.jnoncrysol.2014.11.036.

Sazali, E. S., Sahar, M. R. and Rohani, M. S. (2015) *Optical Investigation of Erbium Doped Lead Tellurite Glass: Judd-Ofelt Analysis, Materials Today: Proceedings*. Elsevier Ltd. doi: 10.1016/j.matpr.2015.11.029.

Scheps, R. (1996) ‘Upconversion laser processes’, *Progreess in Quantum Electronics*, 20(4), pp. 271–358. doi: 10.1016/0079-6727(95)00007-0.

Schnell, M., A. G. Etxarri, J. Alkorta, J Aizpurua, R. Hillenrand. (2010) ‘Phase-resolved mapping of the near-field vector and polarization state in nanoscale antenna gaps’, *Nano Letters*, 10(9), pp. 3524–3528. doi: 10.1021/nl101693a.

Seifert, G., A. Stalmashonak., H. Hofmeister *et al.* (2009) ‘Laser-Induced, Polarization Dependent Shape Transformation of Au/Ag Nanoparticles in Glass.’, *Nanoscale Research Letters*, 4(11), pp. 1380–1383. doi: 10.1007/s11671-009-9408-5.

Sekiya. T, Mochida. N, Ohtsuka. A, Tonokawa. M. (1992) ‘Raman spectra of $MO_{1/2}TeO_2$ (M = Li, Na, K, Rb, Cs and Tl) glasses’, *Journal of Non-Crystalline Solids*, 144, pp. 128–144.

Selvaraju, K. and Marimuthu, K. (2012) ‘Structural and spectroscopic studies on concentration dependent Er^{3+} doped boro-tellurite glasses’, *Journal of Luminescence*. Elsevier, 132(5), pp. 1171–1178. doi: 10.1016/j.jlumin.2011.12.056.

Selvi, S., G. Venkataiah., S. Arunkumar *et al.* (2014) ‘Structural and luminescence studies on Dy^{3+} doped lead boro-telluro-phosphate glasses’, *Physica B: Condensed Matter*. Elsevier, 454, pp. 72–81. doi: 10.1016/j.physb.2014.07.018.

Sepúlveda, B., P. Angelome., L. Lechuga, M. Luis, M. Liz. (2009) ‘LSPR-based nanobiosensors’, *Nano Today*, 4(3), pp. 244–251. doi: 10.1016/j.nantod.2009.04.001.

Shaltout, I. and Badr, Y. (2006) ‘Effects of Sm^{3+}/Yb^{3+} co-doping and temperature on the Raman, IR spectra and structure of [TeO_2–GeO_2–K_2O–Sm_2O_3/Yb_2O_3] glasses’, *Physica B: Condensed Matter*, 381(1–2), pp. 187–193. doi: 10.1016/j.physb.2006.01.006.

Shen, S. and Jha, A. (2008) ‘Raman spectroscopic and DTA studies of TeO_2 - ZnO-Na_2O tellurite glasses’, *materials science and engineering*, 40, pp. 159–164. doi: 10.4028/www.scientific.net/AMR.39-40.159.

Shi, J., Zheng, J. and Wu, P. (2009) ‘Preparation , characterization and photocatalytic activities of holmium-doped titanium dioxide nanoparticles’, *Hazardous Materials*, 161, pp. 416–422. doi: 10.1016/j.jhazmat.2008.03.114.

Sidek, H.A.A.A., S. Rosmawati, Z.A. Talib, et al. (2009) ‘Synthesis and Optical Properties of ZnO-TeO_2 Glass System, *American Journal of Applied Science*, 6(8), pp. 1489–1494.

Silva. D C. M., Bueno, L. A. and Gouveia-Neto, A. S. (2015) ‘Er^{3+}/Sm^{3+}- and Tb^{3+}/Sm^{3+}-doped glass phosphors for application in warm white light-emitting diode’, *Journal of Non-Crystalline Solids*. Elsevier B.V., 410, pp. 151–154. doi: 10.1016/j.jnoncrysol.2014.08.054.

Singh, J., Satpati, B. and Mohapatra, S. (2017) ‘Structural , Optical and Plasmonic Properties of Ag-TiO_2 Hybrid Plasmonic Nanostructures with Enhanced Photocatalytic Activity’. Plasmonics, pp. 877–888. doi: 10.1007/s11468-016-0339-6.

Singh, S. K., N. Giri., D. Rai, S. B. Rai. (2010) ‘Enhanced upconversion emission in Er^{3+} -doped tellurite glass containing silver nanoparticles’, *Solid State Sciences*. Elsevier Masson SAS, 12(8), pp. 1480–1483. doi: 10.1016/j.solidstatesciences.2010.06.011.

Som, T. and Karmakar, B. (2009) ‘Core-shell Au-Ag nanoparticles in dielectric nanocomposites with plasmon-enhanced fluorescence: A new paradigm in antimony glasses’, *Nano Research*, 2(8), pp. 607–616. doi: 10.1007/s12274-009-9061-4.

Som, T. and Karmakar, B. (2010a) ‘Enhanced frequency upconversion of Sm^{3+} ions by elliptical Au nanoparticles in dichroic Sm^{3+}: Au-antimony glass nanocomposites’, *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*, 75(2), pp. 640–646. doi: 10.1016/j.saa.2009.11.032.

Som, T. and Karmakar, B. (2010b) ‘Surface plasmon resonance and enhanced fluorescence application of single-step synthesized elliptical nano gold-embedded antimony glass dichroic nanocomposites', *Plasmonics*, 5(2), pp. 149–159. doi: 10.1007/s11468-010-9129-8.

Som, T. and Karmakar, B. (2011) 'Nano silver:antimony glass hybrid nanocomposites and their enhanced fluorescence application', *Solid State Sciences*. Elsevier Masson SAS, 13(5), pp. 887–895. doi: 10.1016/j.solidstatesciences.2011.02.021.

Sonnefraud, Y., A. Koh., D. Mccomb, S. A. Maier. (2012) 'Nanoplasmonics : Engineering and observation of localised plasmon modes', *Laser and Photonic Reviews*, 295(3), pp. 277–295. doi: 10.1002/lpor.201100027.

Sreedhar, V. B., Ramachari, D. and Jayasankar, C. K. (2013) 'Optical properties of zincfluorophosphate glasses doped with Dy^{3+} ions', *Physica B: Physics of Condensed Matter*. Elsevier, 408, pp. 158–163. doi: 10.1016/j.physb.2012.09.047.

Stranik, O., H. Mcevoy., C. Mcdonagh, B. D. Maccraith. (2005) 'Plasmonic enhancement of fluorescence for sensor applications', *Sensors and Actuators b*, 107, pp. 148–153. doi: 10.1016/j.snb.2004.08.032.

Suthanthirakumar, P. and Marimuthu, K. (2016) 'Investigations on spectroscopic properties of Dy^{3+} doped zinc tellurofluoroborate glasses for laser and white LED applications', *Journal of Molecular Structure*. Elsevier B.V, 1125, pp. 443–452. doi: 10.1016/j.molstruc.2016.06.080.

Swapna, K., S. Mahamuda., A. Srinivasa, M. Jayasimhadri, T. Sasikala, L. R. Moorthy. (2013) 'Visible fluorescence characteristics of Dy^{3+} doped zinc alumino bismuth borate glasses for optoelectronic devices', *Ceramics International*. Elsevier, 39(7), pp. 8459–8465. doi: 10.1016/j.ceramint.2013.04.028.

Tabor, C., R. Murali., Mahmoud, M. A. El-Sayed. (2009) 'On the use of plasmonic nanoparticle pairs as a plasmon ruler: The dependence of the near-field dipole plasmon coupling on nanoparticle size and shape', *Journal of Physical Chemistry A*, 113(10), pp. 1946–1953. doi: 10.1021/jp807904s.

Tagiara, N. S., D. Palles., E. Simandiras, V. Psycharis, A. Kyritis, E. I. Kamitsos. (2017) 'Synthesis, thermal and structural properties of pure TeO2 glass and zinc-tellurite glasses', *Journal of Non-Crystalline Solids*. Elsevier B.V., 457, pp. 116–125. doi: 10.1016/j.jnoncrysol.2016.11.033.

Tanabe, S. (1999) 'Optical transitions of rare earth ions for amplifiers: How the local structure works in glass', *Journal of Non-Crystalline Solids*, 259(1–3), pp.

1–9. doi: 10.1016/S0022-3093(99)00490-1.

Tanabe, S. (2002) 'Rare-earth-doped glasses for fibre amplifiers in broadband telecommunication', *Comptes Rendus Chimie*, 5(12), pp. 815–824. doi: 10.1016/S1631-0748(02)01449-2.

Tiegel, M., A. Herrmann, S. Kuhn, C. Russel, J. Korner, D. Klopfel, R. Seifert. (2014) 'Fluorescence and thermal stress properties of Yb^{3+}-doped alumino silicate glasses for ultra high peak power laser applications', *Laser Physics Letters*, 11(11). doi: 10.1088/1612-2011/11/11/115811.

Tiegel, M., R. Hosseinabadi., S. Kuhn, A. Hermann, C. Russel. (2015) 'Young's modulus, Vickers hardness and indentation fracture toughness of alumino silicate glasses', *Ceramics International*, 41(6), pp. 7267–7275. doi: 10.1016/j.ceramint.2015.01.144.

Tikhomirov, V. K., A. Jha., A. Perakis, E. Sarantopoulou, M. Naftaly, V. Krasteva, R. Li (1999) 'An interpretation of the Boson peak in rare-earth ion doped glasses', *Journal of Non-Crystalline Solids*, 257, pp. 89–94.

Tirtha, S. and Basudeb, K. (2009) 'Nano Au enhanced upconversion in dichroic Nd^{3+}:Au–antimony glass nanocomposites', *Solid State Sciences*. Elsevier Masson SAS, 11(5), pp. 1044–1051. doi: 10.1016/j.solidstatesciences.2009.02.007.

Tripathi, G., Rai, V. K. and Rai, S. B. (2005) 'Spectroscopy and upconversion of Dy^{3+} doped in sodium zinc phosphate glass', *Spectrochimica Acta - Part A*, 62, pp. 1120–1124. doi: 10.1016/j.saa.2005.03.028.

Uma, V., K. Maheshvaran., K. Marimuthu, G. Muralidharan. (2016) 'Structural and optical investigations on Dy^{3+} doped lithium tellurofluoroborate glasses for white light applications', *Journal of Luminescence*. Elsevier, 176, pp. 15–24. doi: 10.1016/j.jlumin.2016.03.016.

Upender. G., Ramesh, S., M. Prasad, V. G. Sathe, V. C. Mouli. (2010a) 'Optical band gap , glass transition temperature and structural studies of (100−2x)TeO_2–xAg_2O– xWO_3 glass system', *Journal of Alloys and Compounds*, 504, pp. 468–474. doi: 10.1016/j.jallcom.2010.06.006.

Upender. G., Vardhani. C., S. Suresh, A. M. Awasthi, V. C. Mouli. (2010b) 'Structure , physical and thermal properties of WO_3–GeO_2–TeO_2 glasses', *Materials Chemistry and Physics*, 121, pp. 335–341. doi: 10.1016/j.matchemphys.2010.01.050.

Upender. G., Sathe. V. G., and Mouli. V. C. (2010c) 'Raman spectroscopic characterization of tellurite glasses containing heavy metal oxides', *Physica B:*

Physics of Condensed Matter. Elsevier, 405(5), pp. 1269–1273. doi: 10.1016/j.physb.2009.11.063.

Venkataiah, G. and Jayasankar, C. K. (2015) 'Dy^{3+} -doped tellurite based tungsten-zirconium glasses : Spectroscopic study', *Journal of Molecular Structure*. Elsevier B.V., 1084, pp. 182–189. doi: 10.1016/j.molstruc.2014.11.062.

Venkatarao. K, M. Seshadri, C. V. and Y. C. Ratnakaram. (2009) 'Spectroscopic properties and Judd-Ofelt analaysis of Sm^{3+} and Dy^{3+} doped chlorophosphate glasses', *iop publishing ltd*. doi: 10.1088/1757-899X/2/1/012045.

Vijaya, N., Kumar, K. U. and Jayasankar, C. K. (2013) 'Dy^{3+} -doped zinc fluorophosphate glasses for white luminescence applications', *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*. Elsevier B.V., 113, pp. 145–153. doi: 10.1016/j.saa.2013.04.036.

Vijayakumar, M. and Marimuthu, K. (2015) 'Structural and luminescence properties of Dy^{3+} doped oxyfluoro-borophosphate glasses for lasing materials and white LEDs', *Journal of Alloys and Compounds*. Elsevier B.V., 629, pp. 230–241. doi: 10.1016/j.jallcom.2014.12.214.

Vijayakumar, R. and Marimuthu, K. (2016) 'Luminescence studies on Ag nanoparticles embedded Eu^{3+}doped boro-phosphate glasses', *Journal of Alloys and Compounds*. Elsevier B.V, 665, pp. 294–303. doi: 10.1016/j.jallcom.2016.01.049.

Walsh, Brian M. (2006) 'Judd-Ofelt theory: principles and practices', *Advances in Spectrocopy for Lasers and Sensing*, pp. 403–433. doi: 10.1007/1-4020-4789-4_21.

Wang, G., W. Qin., G. Wei *et al.* (2009) 'Synthesis and upconversion luminescence properties of YF_3:Yb^{3+}/Tm^{3+} octahedral nanocrystals', 130, pp. 158–161. doi: 10.1016/j.jfluchem.2008.09.009.

Weihs, D. (1973) 'Controlled Nucleation for the Regulation of the Particle Size in Monodisperse Gold Suspensions', *Nature Physical Science*, 242, pp. 117–118. doi: 10.1038/227680a0.

Wen, X., Z. Xi., X. Xiao, W. Yu, G. Xue, D Zhang. (2013) 'Plasmonic Coupling Effect in Ag Nanocap – Nanohole Pairs for Surface-Enhanced Raman Scattering', *Plasmonis*, 8, pp. 225–231. doi: 10.1007/s11468-012-9379-8.

Wu, D. J., Xu, X. D. and Liu, X. J. (2008) 'Electric field enhancement in bimetallic gold and silver nanoshells', *Solid State Communications*, 148(3–4), pp. 163–167. doi: 10.1016/j.ssc.2008.07.030.

Yamane, M. and Asahara, Y. (1981) *Glasses for Photonics*, *Camridge University Press*. Cambridge University Press.

Yang, Y., L. Liu., S. Cai, F. Jiao, C. Mi, X. Su. J. Zhang. (2014) 'Up-conversion luminescence and near-infrared quantum cutting', *Journal of Luminescence*. Elsevier, 146, pp. 284–287. doi: 10.1016/j.jlumin.2013.09.069.

Yu, Y., F. Song., C. Ming, J. Liu, W. Li, X. Liu, H. Zhao. (2013) 'Color-tunable emision and energy transfer in $Tm^{3+}/Dy^{3+}/Sm^{3+}$ tri-doped phosphate glass for white light emitting diodes', *Optics Communications*. Elsevier, 303, pp. 62–66. doi: 10.1016/j.optcom.2013.04.017.

Yusoff. N. and Sahar. M. (2015a) 'Effect of silver nanoparticles incorporated with samarium-doped magnesium tellurite glasses', *Physica B: Condensed Matter*. Elsevier, 456, pp. 191–196. doi: 10.1016/j.physb.2014.08.039.

Yusoff. N., S. Ghoshal., R. Arifin *et al.* (2018) 'Self-cleaning and spectral attributes of erbium doped sodium-zinc-tellurite glass: Role of titania nanoparticles', *Journal of Non-Crystalline Solids*, 481(August), pp. 225–238. doi: 10.1016/j.jnoncrysol.2017.10.044.

Yusof. N., S. Ghoshal., and Azlan. M. N. (2017) 'Optical properties of titania nanoparticles embedded Er^{3+}-doped tellurite glass: Judd-Ofelt analysis', *Journal of Alloys and Compounds*. Elsevier B.V., 724, pp. 1083–1092. doi: 10.1016/j.jallcom.2017.07.102.

Yusoff. N. M., and Sahar. M. R. (2015b) 'The incorporation of silver nanoparticles in samarium doped magnesium tellurite glass: Effect on the characteristic of bonding and local structure', *Physica B: Physic of Condensed Matter*. Elsevier, 470–471, pp. 6–14. doi: 10.1016/j.physb.2015.04.029.

Yusoff. N. M., Sahar. M. R., and Ghoshal. S. K. (2015c) 'Sm^{3+}:Ag NPs assisted modification in absorption features of magnesium tellurite glass', *Journal of Molecular Structure*. Elsevier B.V., 1079, pp. 167–172. doi: 10.1016/j.molstruc.2014.09.039.

Zhitomirsky, D., J. Roether., A. Boccaccini, I. Zhitomirsky (2009) 'Electrophoretic deposition of bioactive glass/polymer composite coatings with and without HA nanoparticle inclusions for biomedical applications', *Journal of Materials Processing Technology*, 209(4), pp. 1853–1860. doi: 10.1016/j.jmatprotec.2008.04.034.

Zhong, J. (2009) '*Optical Properties and Spectroscopy of Nanomaterials*', World Scientific. doi: 10.1117/1.3271380.

Zhou, Y., Lin, J. and Wang, S. (2003) ‘Energy transfer and upconversion luminescence properties of Y2O3:Sm and Gd2O3:Sm phosphors’, *Journal of Solid State Chemistry*, 171(1–2), pp. 391–395. doi: 10.1016/S0022-4596(02)00219-0.

Appendix I

List of Publications

Journal with impact factors

1. **Mohd Saidi, M. S. A.**, Ghoshal, S. K, Arifin. R, Roslan. M. K, Muhammad. R, Shamsuri. W. N. W, M. Abdullah, Shaharin. M. S. (2018). Spectroscopic properties of Dy^{3+} doped tellurite glass with Ag/TiO2 nanoparticles inclusion : Judd-Ofelt analysis. *Journal of Alloys and Compounds, 754,* 171–183. http://doi.org/10.1016/j.jallcom.2018.04.280. **(Q1, IF:4.12)**
2. **Mohd Saidi, M. S. A**., Ghoshal, S. K., Hamzah, K., Arifin, R., Omar, M. F., Roslan, M. K., & Sazali, E. S. (2018). Visible light emission from Dy3+doped tellurite glass: Role of silver and titania nanoparticles co-embedment. *Journal of Non-Crystalline Solids*, *502*(July), 198–209. http://doi.org/10.1016/j.jnoncrysol.2018.09.012. **(Q1, IF:2.488)**
3. **Mohd Saidi., M.S.A**. Ghoshal. S.K, R. Arifin, M.K. Roslan. (2017). Absorption and raman spectra of Dy^{3+} doped tellurite glass: Combined effects of silver and titanium nanoparticles. *Solid state phenomenon, 268 (111−116).* *http://doi.org/10.4028/www.scientific.net/ssp.268.111*. **(Q4, IF:0.16)**

Indexed Journal

1. **Mohd Saidi., Mohd Syamsul Affendy**, S.K.Ghoshal, R.A. and A.Awang., 2016. Improved spectral features of silver nanoparticles sensitized samarium doped zinc-sodium-tellurite glass. *Solid State Science and Technology*, 24(1), pp.163–170. **(Indexed by SCOPUS)**

Appendix J

Calculation of density and uncertainty

Example Series II TZMDyAg0.2Ti$O_2$0.4

Density = $\rho_{glass} = \rho_L \left(\frac{W_{air}}{W_{air} - W_{liquid}}\right)$

- $\rho_{glass} = 0.999\left(\frac{4.2541}{4.2541 - 3.5768}\right)$
- $\rho_{glass} = 6.2747$

Uncertainty = $\Delta\rho_{glass} = \left(\frac{\Delta\rho_L}{\rho_L} + \frac{\Delta W_{air}}{W_{air}} + \frac{\Delta(W_{air} - W_{liquid})}{W_{air-Wliquid}}\right) \times \rho_{glass}$

- $Since\ the\ \rho_L = standard\ value, \Delta\rho_L = 0$
- $\Delta\rho_{glass} = \left(\frac{0.0003}{4.541} + \frac{\Delta(0.0003 - 0.0003)}{4.2541 - 3.5768}\right) \times 6.2747$
- $\Delta\rho_L$= 0.0004

  Therefore for sample Series II TZMDyAg0.2Ti0.4 the density is (6.2747±0.0004) gcm^{-3}