Photoluminescence Enhancement of Fluorophores Assisted by Ion Implanted Gold Nanoparticles

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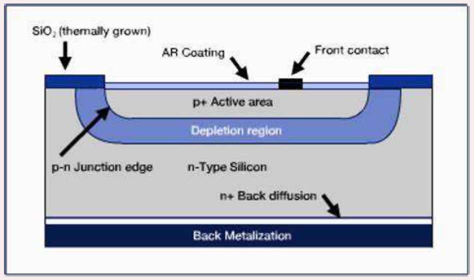
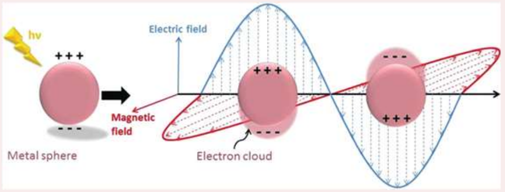
Abstract

A fluorophore is a molecule which may re-emit light upon light excitation. Photoluminescence (PL) fluorophores are under attention within the research community because of their applications in bioimaging and biosensing for the detection of disease. A complication in the effective use of PL fluorophores in technology is their weak intensities of light upon emission. The motivation of this research project is to enhance the PL light intensity of different fluorophores through a process called Metal Enhanced Photoluminescence (MEP). In this work, we will use ion implanted gold nanoparticles, fabricated by low energy ion implantation technique, to achieve MEP. Ion implantation of 70 keV gold ions in glass substrates at different ion concentrations (fluences) will be done to synthesize gold nanoparticles of different size distributions. The ion implanted gold nanoparticle samples will be characterized by optical absorption measurements. Rutherford Backscattering Spectrometry (RBS) measurements will be used to obtain the concentration, composition, and depth profile of gold nanoparticles within the glass substrate. MEP will be investigated using steady-state emission and excitation spectroscopy. Both atomic force microscopy and scanning electron microscopy will be used to study the substrate roughness of gold samples and to obtain average size distributions of gold nanoparticles. This work is valuable for potential applications in clinical diagnosis such as bio-imaging

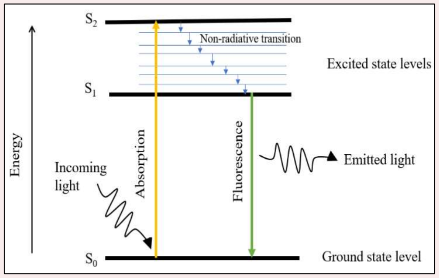
Background



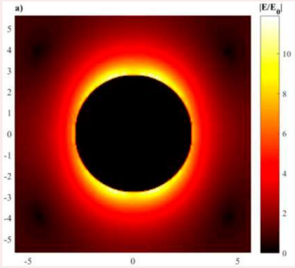
Enhancing the luminescence of PL fluorophores is necessary for better implementation of nanocomposites in biological and optical applications [1].



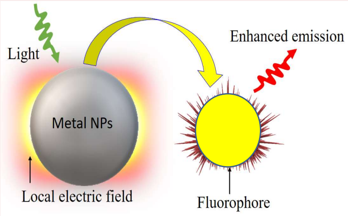
Localized Surface Plasmon Resonance (LSPR) of metal nanoparticle (MNP) due to coherent oscillations of conduction band electrons with incidental electromagnetic radiations of a specific wavelength. LSPR is generated in MNP the size of smaller than the wavelength of light [1].



Jabalonski diagram

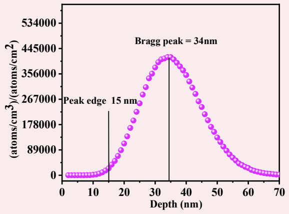


Plasmonic field enhancement due to hot spots for the spherical NPs [2].

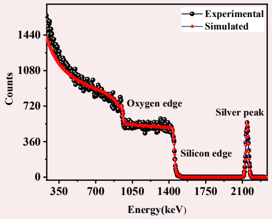


Plasmonic Field Enhancement

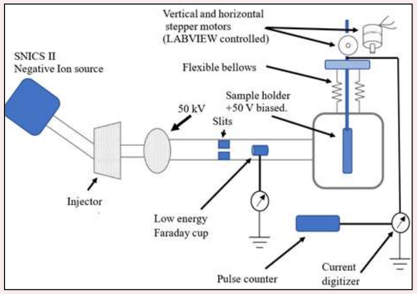
Methods



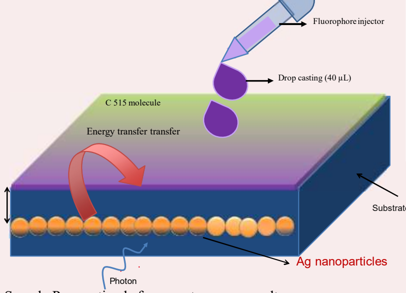
SRIM simulations of 70 keV Ag ions in quartz substrate with Bragg peak and peak edge at 34 nm and 15 nm, respectively [2].



Experimental and simulated RBS plots for the Ag-Implanted quartz substrate. The depth distribution of silver atoms found to be 16 nm [2].



Experimental setup for low energy Ion implantation technique



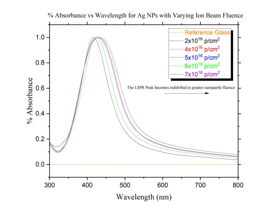
Sample Preparation before spectroscopy results

References

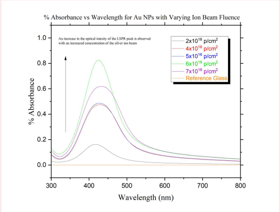
[1]: Kochuveedu, Saji Thomas, and Dong Ha Kim. "Surface plasmon resonance mediated photoluminescence properties of nanostructured multicomponent fluorophore systems." *Nanoscale*, vol. 6, no. 10, 2014, pp. 4966–4984, https://doi.org/10.1039/c4nr00241e.

[2]:Iqbal, Shahid, et al. "Ion-implanted silver nanoparticles for metal-enhanced fluorescence." *AIP Advances* 8.9 (2018): 095217.

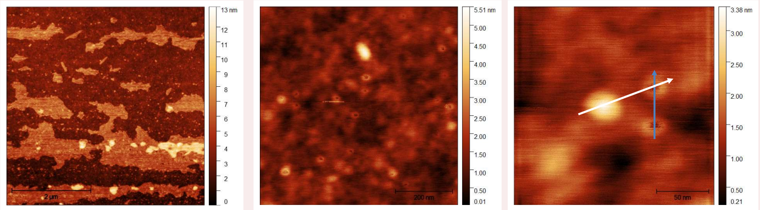
Results



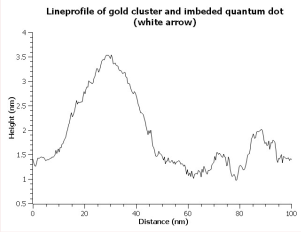
Absorption spectra and normalized spectra of Au implanted NPs within glass substrate for varying fluences. Absorption intensity increases as Au ion fluence increases.



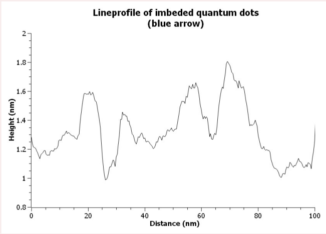
Normalized absorption spectra, clearly showing red-shift of the peak with increasing Au ion fluence. Indicative of a size increase of the particles and decrease of the inter-particle distance.



Atomic Force Microscopy (AFM) Images of Ion Implanted Au nanoparticles in a glass substrate



Lineprofile of Au gold cluster and imbedded quantum dot. (NP size ≈ 35nm)



Lineprofile of imbedded quantum dots. (QD size ≈ 15*nm*)

Conclusion

Embedded Au nanoparticles were synthesized in glass substrates via low energy ion implantation using 70 keV energy and different ion beam fluences. The formation of Au nanoparticles in glass substrate was confirmed by UV/Visible spectroscopy. AFM was used to study the surface morphology and obtain the size of nanoparticles; 35nm. An enhancement in the fluorescence of various florescence material such as laser dyes, quantum dots etc. will be investigated in the presence of silver nanoparticles. This project is Suitable for bio-imaging applications and optoelectronics.