Overview

The impact of the COVID-19 pandemic on the semiconductors manufacturing industry leads to a necessity for typical research work. For this reason, our work chose molybdenum disulfide (MoS$_2$), an organic semiconductor with high neutral abundance, low cost, high carrier mobility, unique optical properties, fixable bandgap, and very low toxicity that make MoS$_2$ a very safe and sustainable material. This work successfully synthesizes MoS$_2$ quantum dots (MoS$_2$ QDs) by liquid exfoliation to fabricate MoS$_2$ QDs thin film by spray technique. The extract MoS$_2$ QDs were characterized using scanning electron microscopy (SEM), Fluorescence emission spectra (FES), UV-VIS spectroscopy, and Energy-dispersive X-Ray (EDX). The SEM images have shown the MoS$_2$ QDs with sizes ranging from (~ 4-11 nm), a spherical shape with a homogenous distribution. With strong UV absorption and bandgap=4.49eV corresponding to UV-VIS spectroscopy result. Moreover, the MoS$_2$ QDs show a fluorescence spectrum under excitation of 340 nm. The MoS$_2$ QDs are spray-coated onto a substrate to fabricate thin film. The Photoluminescence (PL) results show an expansion in emission with high sensitivity covering the whole visible light region (380-700 nm), which makes MoS$_2$ QDs thin films promising for optoelectronic devices such as solar cells and photodetectors.

Methods

1. Synthesis of n-MoS$_2$ QDs

   We successfully synthesized n-MoS$_2$ QDs through the liquid phase exfoliation method, as shown in Fig.1

   ![Fig.1 Process of synthesizing n-MoS$_2$ QDs](image)

2. Thin film deposition

   The device fabrication was achieved, and the Fabrication process illustrate in details in Fig.2

   ![Figure 2 Process of p-GaN/N-MoS$_2$ device fabrication](image)
Results

- The SEM images have shown the MoS$_2$ QDs with sizes ranging from (~ 4-11 nm), a spherical shape with a homogenous distribution shown in fig 3.

![Figure 3](image)

- Strong UV absorption and bandgap 4.49eV corresponding to UV- VIS spectroscopy result as shown in Fig. 4a. Moreover, the MoS$_2$ QDs show a fluorescence spectrum under excitation of 340 nm as shown in Fig. 4b and under UV light in Fig. 4c. while the PL peak of n-MoS$_2$ QDs lying in the range of nm the prepared sample was excited under different wavelengths $\lambda_{\text{excitation}}$ from 270nm to 450nm where maximum peak found at 408 nm corresponding to $\lambda_{\text{excitation}} = 350$nm as shown in Fig. 4d.

![Figure 4](image)

- The result shows a promising thin film for optoelectronic devices. For this reason, the p-GaN/n-MoS$_2$ QDs photodetector was fabricated and characterized. The PL results in Fig. 5a show expansion in the emission spectrum to cover the visible region, while the I-V characteristic in Fig. 5b shows photodiode behavior.

![Figure 5](image)

Conclusions

This work successfully synthesis n-MoS$_2$ QDs from bulk MoS$_2$ powder by liquid phase exfoliation in DMF. The samples were prepared at various temperatures where 90C exhibited the best result with strong quantum confinement, Eg4.49 eV, expanding absorbance, and fluorescence behavior at $\lambda_{\text{excitation}} = 340$nm. p-GaN/n-MoS$_2$ QDs photodetector was fabricated and characterized at [-2.5-2.5]; the device showed high performance with a responsivity of 7.069 mA/W and detectivity of $1.24 \times 10^{10}$ Jones at visible light region.