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Enhancing B-exciton emission in a few-layers MoS_2:$AgPO_3$ nanoheterojunctions

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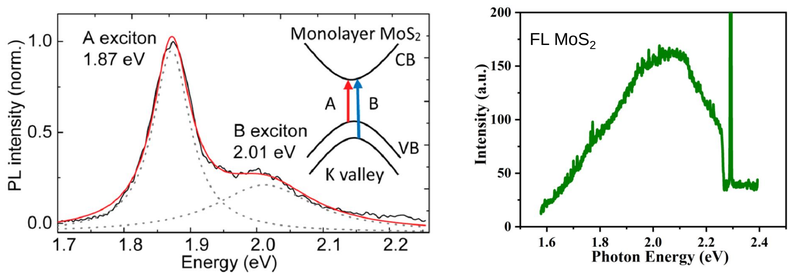
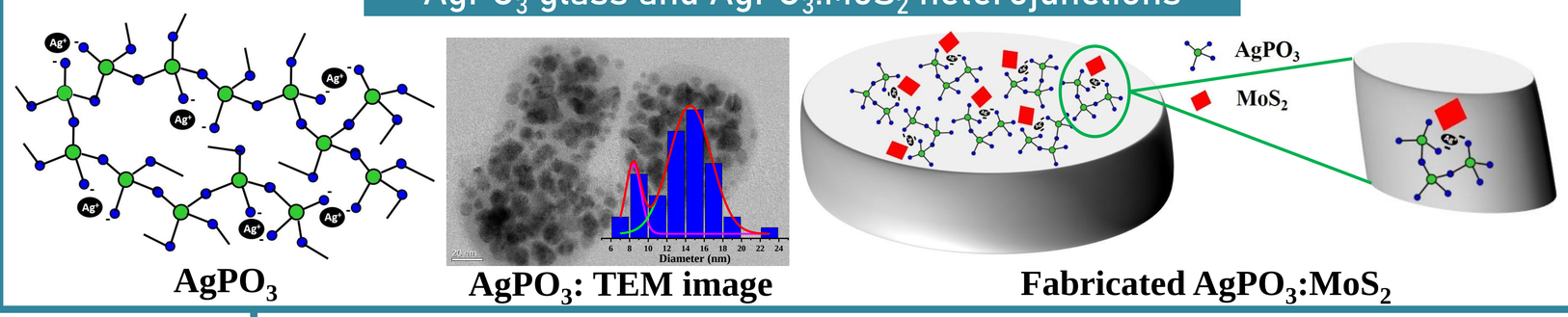
Abstract

Tailoring the photoluminescence (PL) in two dimensional (2D) transition metal dichalcogenide (TMDs) using external factors is one of remarkable interest for its use in emerging valleytronics, nanophotonic and optoelectronic applications.[1-3] Significant effort have been devoted to enhance or manipulate the excitonic emission in a monolayer MoS_2. However, it has limited to the nanoscale fundamental studies for nanoelectronics and photonics applications. Here, we present a novel van der Waal nano- hybrid/heterojunctions system fabricated with a non-lithographic process to manipulate the PL emission, which is composed of a few layer MoS_2 integrated into a transparent semiconducting silver metaphosphate glass matrix. Successful isolation and formation of heterojunction revealed the preservation of phase integrity and the crystallinity. The heterojunctions demonstrated exotic intrinsic A- and B- excitonic peak emission. More interestingly we are able to tailor a dominant B- excitonic emission over A exitonic emission. A significant 6-fold enhancement in PL spectrum (van der Waals hetrojunctions) over a control sample was recorded (Figure 1).[4] Furthermore, ternary silver-rich and binary sodium meta phosphate glass heterojunction were demonstrated to investigate the origin of the excitonic enhancement. Exciton plasmon coupling was under taken to demonstrate the enhancement in B-excitonic emission of the van der Waals nanoheterojunctions. Finally, ultrastfast time-resolved spectroscopy interpreted the plasmon-enhanced electron transfer that takes place in Ag nanoparticles-MoS_2 nanoheterojunctions is behind the enhancement of the excitonic emission. No doubt, the efficient coupling of exciton-plasmon and tunability of B- excitonic emission pave great attention in emerging valleytronic and light emitting devices working with B excitons.

Excitons in 1L and FL MoS_2



$AgPO_3$ glass and $AgPO_3$:MoS_2 heterojunctions



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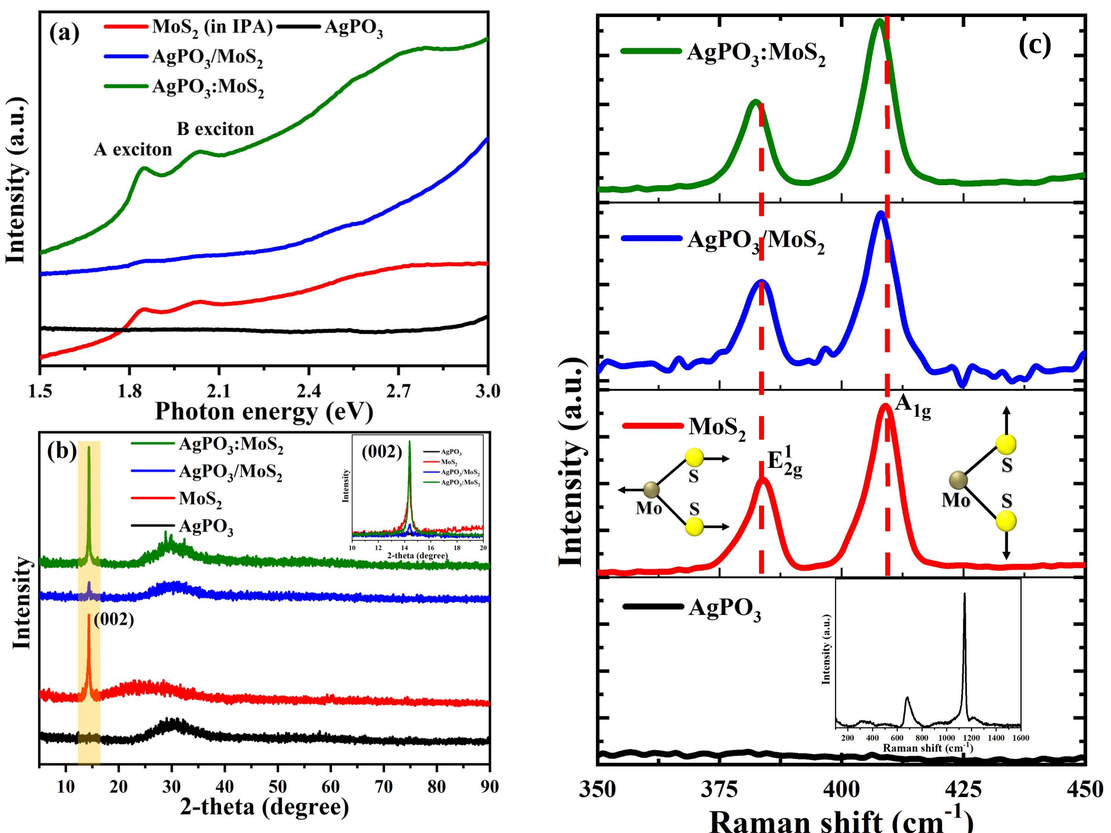
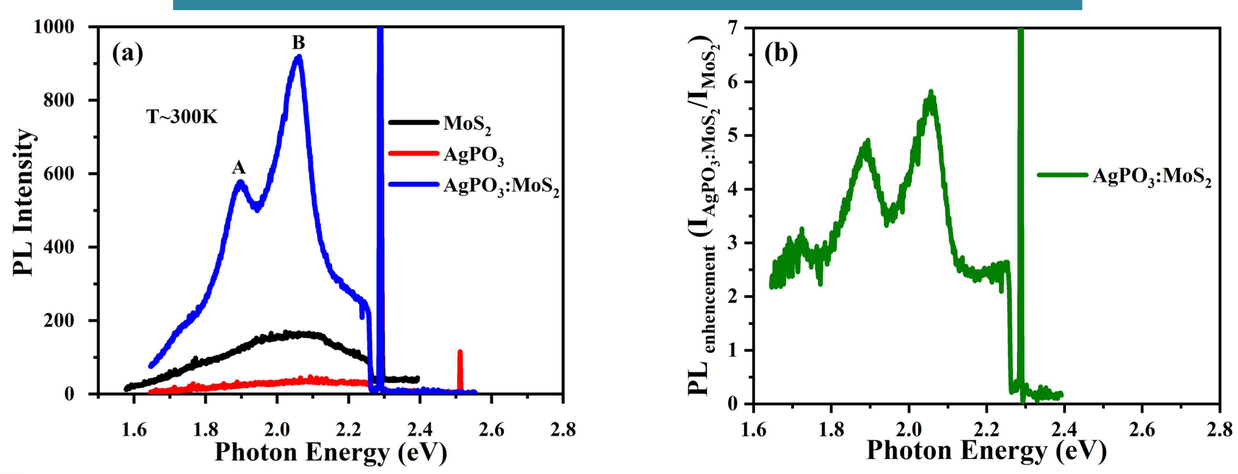


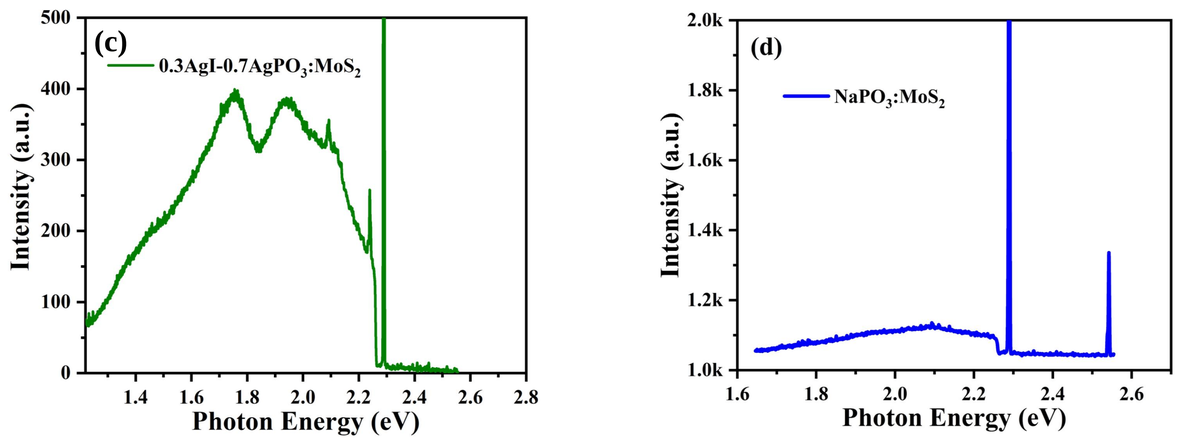
Fig. (a) Absorption spectra (b) XRD spectra and (c) Raman spectra

- ❑ **Enhanced in $AgPO_3$:MoS_2 nanoheterojunctions absorption**
- ❑ **Semiconducting nature in $AgPO_3$:MoS_2**
- ❑ **Few layer MoS_2 with frequency difference ($\Delta\omega$) 24 -25 cm^{-1}**
- ❑ **A signature of induced strain in the system**

PL enhencement in A- and B- excitons

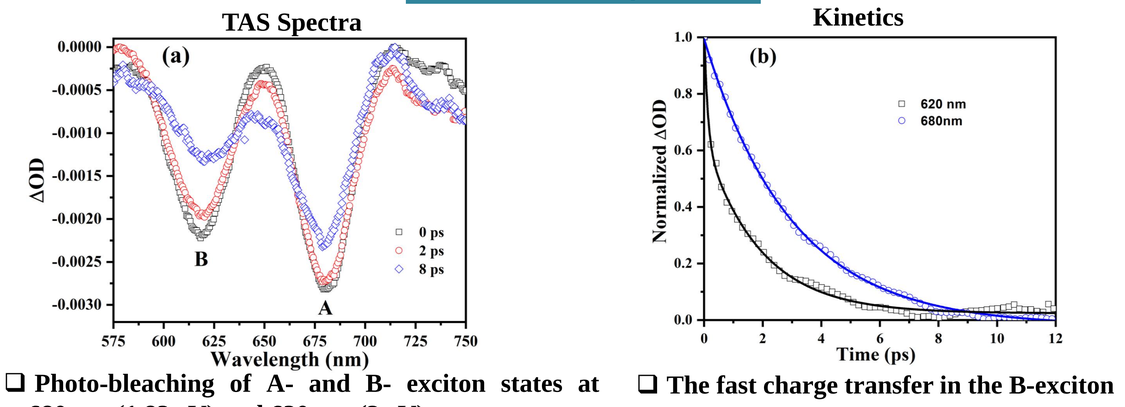


- ❑ **A six-fold enhancement factor for the intrinsically weak B- exciton emission**



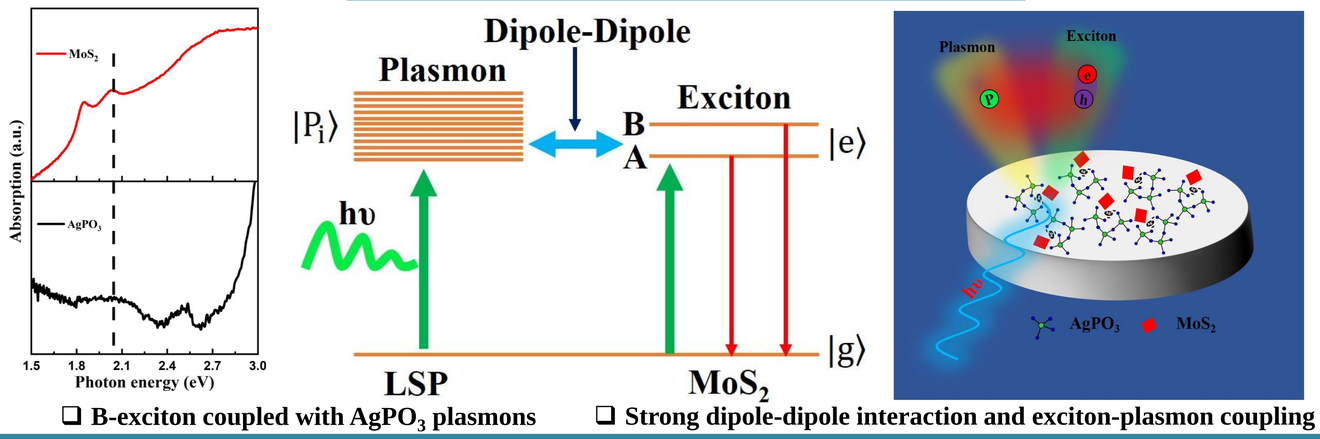
- ❑ **Non plasmon meta phosphate glass does not show any influence on PL spectra**
- ❑ **PL enhancement is primary due to Ag nanostructures in $AgPO_3$**

TAS Analysis



- ❑ **Photo-bleaching of A- and B- exciton states at 680 nm (1.82 eV) and 620 nm (2 eV)**
- ❑ **The fast charge transfer in the B-exciton**

Model behind PL enhencement



- ❑ **B-exciton coupled with $AgPO_3$ plasmons**
- ❑ **Strong dipole-dipole interaction and exciton-plasmon coupling**

Conclusion

- ❑ **Fabricated and demonstrated novel hybrid nanoscale heterojunctions of layered MoS_2 and metaphosphate glasses**
- ❑ **A strong modification of A- and B- exciton peak intensity by plasmonic nanostructure has been adopted**
- ❑ **Obtained a six-fold enhancement factor for the intrinsically weak B exciton peak**
- ❑ **The dipole–dipole interaction via exciton–plasmon coupling is enhancing the B- exciton emission**
- ❑ **Ultrafast electron transfer process and carrier-carrier interaction in the nanoheterojunctions system**
- ❑ **Tunability of B- excitonic emission could be useful in emerging valleytronic devices working with B excitons**

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