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Site-Selective Noble Metal Growth on CdSe Nanoplatelets

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Abstract
Au, Pt, and Pd noble metal domains have been grown site-selectively onto 5 monolayer (ML) thick CdSe nanoplatelets (NPLs). Depending on the metal and also on the reaction conditions, metal domains are found to grow only at the corners, shorter side edges and also all around the edges of the NPLs. The marriage of metal and semiconductor NPLs generates a novel class of materials which has potential application possibilities in the field of optoelectronics, photocatalysis, and fabrication of photovoltaic devices or as a sensors for chemical detection.

Introduction
The combination of metal and semiconductor materials in a single component helps the researchers to manipulate the properties of both the metal and the semiconductor in the same segment. Such nanoheterostructures have a broad range of possible applications, e.g. in pollutant degradations, solar to chemical energy conversion, photocatalytic water splitting.[1-3] Since the pioneer work of Prof. Banin to grow gold domains on CdSe nanorods and tetrapods, scientists have successfully extended metal domain growth (mainly Au, Pt, Co) on CdSe, CdS, PbSe, Cu_2ZnSnS_4,TiO_2 and many more systems.[1, 4-5] Recently, CdSe NPLs of few monolayer thicknesses (~1.2 to 1.8 nm) have attracted attention of many nano-researchers due to their unique optical properties such as extremely narrow photoluminescence emission spectra (full width at half maximum as narrow as ~9 nm), high quantum yields, and also ultrafast fluorescence radiative lifetimes leading to exciting applications in polarized light emitters and electroluminescence emitters even in room temperature lasing with very low energy thresholds.[6-7] However, to the best our knowledge there was no report so far regarding nanoheterostructures with these few monolayer thick, quasi 2 D II-VI semiconductor CdSe NPLs and metal domains. Therefore, we focused on the development of synthetic strategies to grow noble metal domains (Au, Pd, Pt) site selectively on 5 ML thick (~1.5 nm) CdSe NPLs. From transmission electron microscopic characterization of the nanoheteroplatelets, it can be inferred that depending on the type of metal precursors and also on the reaction parameters, quasi spherical domains have grown at the corners and the shorter side edges (in case of Au) along with all around the edges of CdSe NPLs (in case of Pt). Pd domains are found to grow only at the two shorter edges of the CdSe NPLs with a quasi flat rectangular morphology.[8] We believe that this novel class of nanoheteroplatelets will catch significant attention of material scientists to imply them in usable optoelectronic devices or in sensors.

Results and discussions

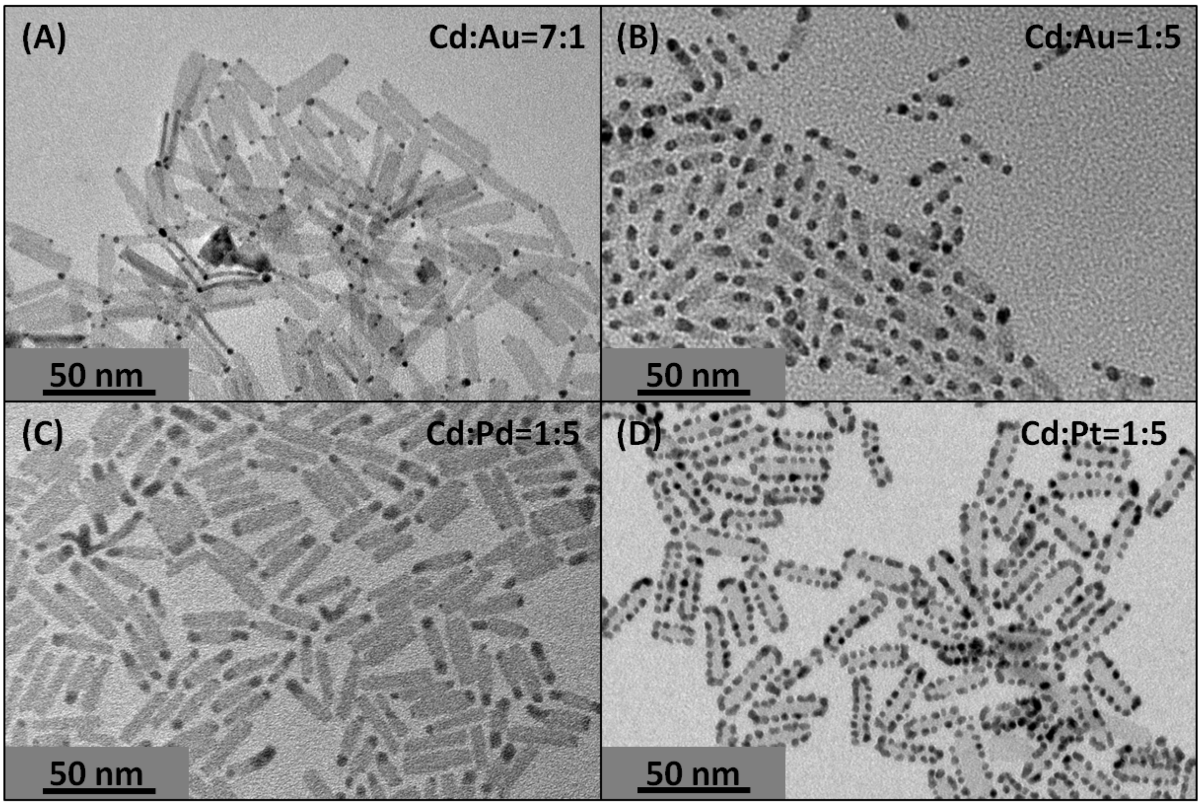
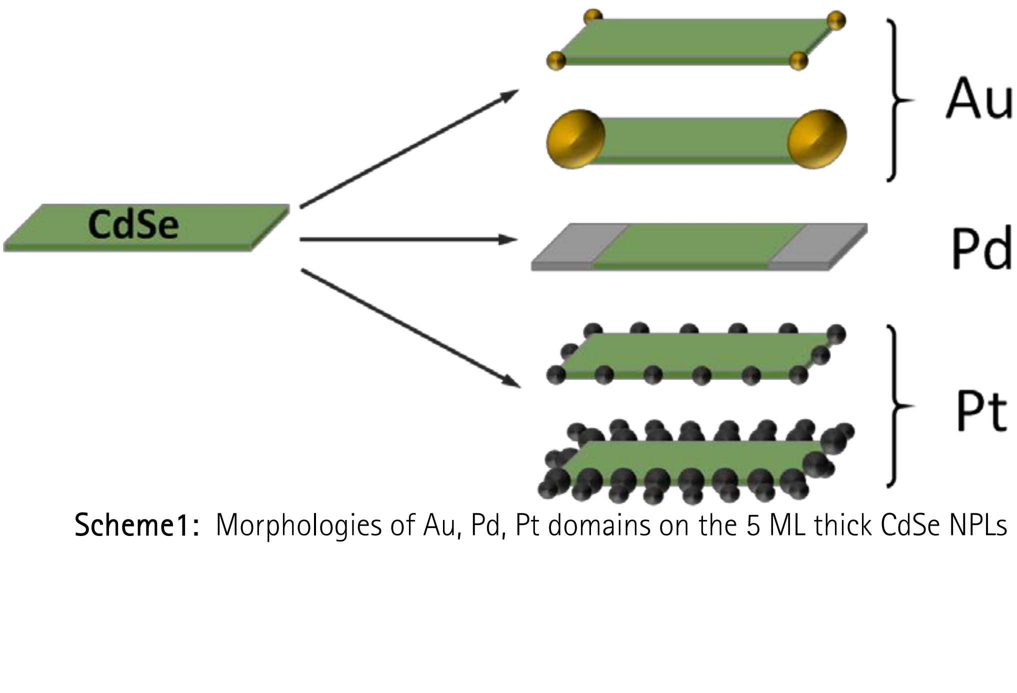


Figure 1: TEM micrographs of Au, Pd, and Pt decorated 5 ML CdSe NPLs. (A) and (B) are platelets with Au domains on 5 ML CdSe NPLs with a Cd:metal molar precursor ratio of 7:1 and 1:5, respectively. (C) and (D) are Pd and Pt domains on CdSe NPLs from a Cd:metal molar precursor ratio of 1:5.

Figure 1 shows the different growth behavior of Au, Pd and Pt metal domains on the CdSe NPLs. When the Au precursor concentration is low (molar precursor ratio Cd:Au = 7:1,) the quasi spherical domains are mainly observed at the corners, while with Cd:Au = 1:5 the domains are at the shorter edges of the NPLs. In the case of Pd with molar precursor ratio Cd:Pd = 1:5 the domains are quasi flat, having similar thickness as of the NPLs and have grown at the shorter edges of the NPLs. However, using $Pt(acac)_2$ as the precursor for Pt with Cd:Pt molar precursor ratio of 1:5 the quasi spherical Pt domains are found to grow all around the edges of the NPLs. Our findings are summarized in scheme 1 representing the various morphologies obtained by metal decoration on 5 ML thick CdSe NPLs.



Scheme1: Morphologies of Au, Pd, Pt domains on the 5 ML thick CdSe NPLs

Conclusion

In this work, we have grown Au, Pd, and Pt metal domains site-selectively on quasi 2D CdSe NPLs of 5 monolayer thickness. Au and Pd domains are found mainly at the corner and at the shorter edges of the NPLs, whereas the Pt domains are all around the edges of the NPLs. The different morphologies obtained for different metals are attributed to the type of metal precursor and to the varied reaction parameters.

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