Gold-Catalyzed Growth of Colloidal Cadmium Chalcogenide Worm-like Nanostructures

Albert Figuerola,[a] Víctor Fernàndez-Altable,[a] and Andrea Falqui [b]

[a] Dept.Inorganic Chemistry, University of Barcelona, Martí i Franqués 1-11, 08028 Barcelona, Spain
[b] Istituto Italiano di Tecnologia, via Morego 30, 16163 Genoa, Italy
albert.figuerola@qi.ub.es

Abstract

Semiconductor inorganic nanocrystals are promising materials for a variety of applications, such as photovoltaics, photocatalysis, and opto-electronics. Cadmium chalcogenides (CdX, where X = S, Se or Te) are among the most well known semiconductor nanocrystals: quantum dots, nanorods, tetrapods, and recently also octapods have been extensively studied from a synthetic point of view as well as their properties and performance tested in several devices.[1] Elongated CdX nanocrystals show unique properties as compared to their spherical analogues due to the confinement of their excitons in two dimensions. They enhance charge carriers separation after light illumination, which can be of special interest in any of the applications mentioned above. The selective growth of metal domains on the tips of CdX nanorods has been devised as an alternative strategy to improve the separation of the carriers. Unfortunately, the selectivity in the Au growth onto the tips of CdX nanorods is relatively poor and can only be improved by a subsequent irradiation or thermal treatment.[2]
In this work, the possibility of obtaining elongated hybrid metal-semiconductor nanostructures has been investigated for the case of gold and cadmium chalcogenides by using spherical Au nanocrystals and CdX quantum dots as starting materials in high boiling point solvents. This approach opens up the possibility of obtaining elongated CdX nanostrutures epitaxially grown on Au nanocrystals, which circumvents the use of seeded-growth techniques and/or expensive surfactant molecules usually required in order to induce anisotropy during CdX growth. The growth mechanism is based on the surfactant-assisted dismantling of the initial CdX spherical nanocrystals followed by their Au-catalyzed recrystallization, which leads to well-defined Au-CdX head-tail nanoworms with a precise and reproducible location of each domain in the crystal. These results suggest a sort of Solution-Liquid-Solid growth mechanism as the one observed previously by Buhro et al. and Korgel et al. for other systems.[3] The reaction temperature and the amount of quantum dots injected allow to tune the aspect ratio of the final nanoworms. Their crystallinity and their Au-CdX epitaxy have been assessed by means of high resolution TEM analysis and XRD, while their optical properties have been checked by UV-Visible absorption and photoluminiscence measurements.

References

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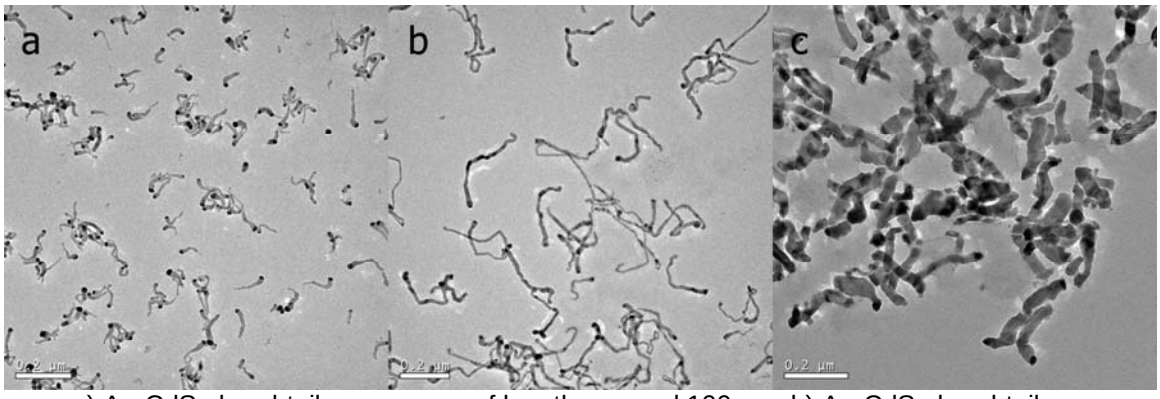

Figure. a) Au-CdSe head-tail nanoworms of lengths around 100 nm; b) Au-CdSe head-tail nanoworms of lengths around 300 nm; c) Au-CdTe head-tail nanoworms of lengths around 200 nm.