The Effect of Dopant Ions on the Morphology, Structure, and Properties of Nanomaterials

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Intentional doping of semiconductor nanostructures with selected impurities represents an effective means of imparting new properties into these promising materials [1] thereby expanding their intrinsic functionalities. Semiconductors doped with transition-metal ions, known as diluted magnetic semiconductors (DMSs), have been identified as potentially key components for spin-electronics (spintronics) technologies, which rely on the mutual interactions between electron spins and charges [2]. Wide band gap semiconductors, particularly oxides and nitrides, have attracted much attention as host lattices for DMSs having high ferromagnetic phase transition temperatures (T_C), due to their favorable optical, electrical, and mechanical properties [3]. The advances in synthesis and understanding of bulk transparent magnetic semiconductors have stimulated research efforts on preparation and properties of analogous nanostructured systems [4]. Internal doping of nanostructures has proven, however, to be a challenging task due, in part, to the large surface areas of these materials, kinetics and difficulties in distinguishing between internally-doped and surface-bound dopant impurities.

In this talk I will describe our recent work [5-7] on the controlled synthesis and structural characterization of transition-metal-doped In_2O_3 and GaN nanostructures (nanocrystals and nanowires). Using a combination of optical and electron microscopy techniques we studied the dopant incorporation into different nanostructures, and the effect of dopant impurities on the morphology and growth of the nanostructured host materials. The doping mechanism generally involves a critical step of transition-metal binding to the nanostructure surfaces, for both solution and gas phase syntheses. This process has significant consequences on the growth, faceting and crystal structure of the obtained nanomaterials, and demonstrates that dopant ions can be used to manipulate the properties of nanostructures.

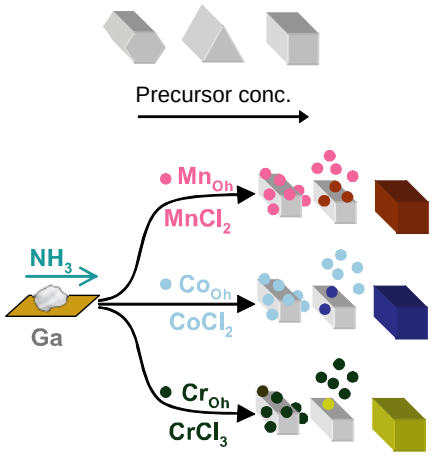

Figure 1. Top: Schematics of the change in GaN nanowire morphology with increasing dopant precursor concentration. Bottom: Schematics of the dopant incorporation for different transition-metal ions.

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