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# Influence of transition metal alloy in gnd surface modification of the CdTe quantum dots on their optical properties, band structure and electrochemical activity

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## Abstract

We report a study of CdTe quantum dots modification by the alloying of with  $Zn^{2+}$  and  $Hg^{2+}$  ions and shell growth. Optical and cyclic voltammetry measurements were used to explain changes in the band structure of the particles via shell growth and during the alloying. Influence of stabilizer on the electrochemical behavior of the particles is also discussed. Obtained nanostructures demonstrate photoluminescence in the wider range of wavelengths than pure CdTe QDs.

**Keywords:** CdTe, quantum dots, transition metals, alloying, cyclic voltammetry, band structure.

## 1. Introduction

CdTe quantum dots (QDs) due to their unique size- and composition-dependent optical and electrical properties are promising materials for different applications such as chemical sensors, solar elements, LED devices, in vivo and in vitro biosensing imaging etc.

In addition to the widely known size- dependent optical properties of CdTe QDs there is an alternative method for tuning QDs optical and electrical properties by varying the QDs composition. Such doped/alloyed CdTe QDs have been produced via composition-dependent transition metals doping/alloying processes. The modifications of the optical and electrical properties of CdTe QDs can be achieved using different techniques. For instance, Chu and Van Hung [1, 2] demonstrated that optical and electrical properties of QDs can be changing by adjusted synthesis conditions. The incorporation of transition metals impurities into QDs is another useful technique used for tuning their optical properties [3, 4] due to the band structure changes. Also as shown by Doskaliuk [5] and Wang [6], prolonged heat treatment of the CdTe colloidal solutions leads to the significant shift of PL maximum to the long-wave region due to the CdS shell growth and the formation of type II core/shell CdTe/ CdS QDs.

For a wide range of applications based on CdTe QDs, it is important to understand the effects of synthesis conditions, impurities incorporation and CdS shell growth on the band structure changes. Analysis of Cyclic voltammetry (CV) data of oxidation and reduction reactions involving CdTe QDs enables calculation of the position of CdTe QDs bandgap energy levels and various impurities levels position [7]. In the present work, we summarize application of cyclic voltammetry in the monitoring of band structure changes of CdTe QDs during transition metal alloying and the shell growth.

## 2. Material and methods

The absorption and photoluminescence spectra were recorded at room temperature with OceanOptics USB-2000 spectrophotometer. The CV measurements were performed using a computer-controlled Potentiostat/Galvanostat PI-50-1. A three-electrode system with a glassy-carbon counter electrode, an Ag/AgCl reference electrode and the platinum electrode as the working electrode was used for the cyclic voltammetry measurements. The cyclic voltammograms were obtained by scanning the potential from  $-1.5$  to  $1.5$  V at a scan rate of  $100$  mV/s. The elemental analysis was carried out on C115M1 Atomic emission spectroscope (AES).

### 2.1. Synthesis of QDs

CdTe QDs stabilized by thioglycolic acid (TGA) were synthesized at room temperature in alkali aqueous solution by the reaction of  $CdSO_4$  and electrochemically generated  $H_2Te$  in the presence of thioglycolic acid. The oxygen was removed from the reaction system by bubbling

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