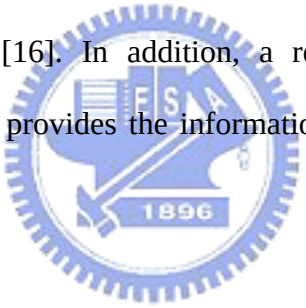
Chapter 1: Introduction

Nano material is defined as materials of size less than 100nm. It has attracted a great deal of attention since 1990 due its unique physical properties and potential applications. The unique properties of nano material can be roughly attributed to the quantum size effect, Coulomb blockade, surface effect, and quantum tunneling effect. For semiconductor nano-structure, the energy and density of state (DOS) is significantly different from the bulk semiconductors. Semiconductor nano-structure, or quantum dot (QD), has size smaller than the exciton Bohr radius (about few nanometers). It is often viewed as artificial atom because of its discrete level feature is similar to atom. Moreover, the emission energy of the optical spectra can be controlled by the tuning of QD size. The device application of QD includes single electron transistor (SET) [1], light emitting diode [2, 3, 4], QD laser [5], optical detector [6], quantum computation [7] and so on.

Chemical synthesis of colloidal QD is an important topic in the study of colloidal QD. The size and shape of colloidal QD can be precisely controlled by the growth duration, reaction temperature, and reagent adding rate. In order to improve the optical quality of QD, a few atomic layers of high energy band gap material is designed to grow on top of the QD. This capped QD is called core/shell QD. The core/shell QD can prevent the photo-oxidation and other chemical reactions and also enhance the quantum yield approximately to 90% [8]. Comparing with the molecular chromophorous (or “fluorophores”), the colloidal QD has characteristic of long lifetime (>10ns) [9], and narrow and symmetric emission line, but without red-tailed emission as that of most fluorophores. Furthermore, colloidal QD conjugates to the polymer ligand by immersing it in certain organic solvents, makes it to exhibit higher

quantum efficiency and stronger photostability [10]. High quantum efficiency and strong photostability of colloidal QD endow it a potential material for the application in optoelectronic device and biological labeling.

For optical study, single QDs (molecule) spectroscopy has been developed since 1989. The principal motivation of single molecule study is to identify the individual contributions from the ensemble average. Compare with QD ensemble, single QDs has the unique properties of extremely narrow luminescence line-width, spectra diffusion [11], fluorescence intermittency [12], and the existence of multiple long fluorescence lifetimes [13]. At present, single QDs has been probed by confocal microscopy [14], total internal reflection microscopy [15], or basic wide-field epi-fluorescence microscopy [16]. In addition, a related technique, fluorescence correlation spectroscopy [17], provides the information of the average QD size and brightness of per particle.



The fluorescence intermittency is an important and interesting issue for the study of optical properties of single QDs. It refers to the switching of on-off emission from sub-millisecond to hours, even under continuous excitation. This phenomenon was observed in fluorescent polymer, green fluorescent proteins, porous Si nano particles, surface-enhanced Raman spectroscopy, single dye molecules, and single quantum dot and so on. In single dye molecules, the on-off behavior results from the intersystem cross into the dark triplet state. In semiconductor nanocrystals, however, the on-off behavior comes from different mechanism. The initial model for semiconductor nano-crystal is proposed by Efros and Rosen [18]. They proposed that the quantum dot emits light by the e-h pair rapid recombination until it is ionized either thermally or by Auger process, and then initiating the off period. During the off period, the QD

is called dark QD. The dark QD will re-emit when the ejected electron (hole) which is localized in a deep trap returns to the quantum dot thermally. In this assumption, the electron (hole) transition in triplet level may be correlated with the QD surface defect or surrounding matrix. In this thesis, we study the influence of the excitation power and QD size on the fluorescence intermittency. We also investigated the emission of QD on insulating glass cover-slip and conducting (Au particle-coated glass) substrate. Furthermore, we tried to passivate the surface defect of CdSe or ZnS by the organic ligands. The experimental setup will be described in Chapter 2. In Chapter 3, the fundamental concepts will be illustrated. Results and discussion will be presented in Chapter 4. Finally, Chapter 5 summarizes current study.