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Blinking of Colloidal Semiconductor Quantum Dots: Blinking Mechanisms

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INTRODUCTION

Colloidal semiconductor quantum dots are observed to blink on and off with a distribution of off times that obeys an inverse power law distribution. In this paper, a model describing mechanisms contributing to this blinking distribution is presented.

DISCUSSION

Wurtzite semiconductor quantum dots in colloidal suspensions are now realizable for a variety of semiconducting materials as shown to Figure 1. These colloidal suspensions of nanoscale quantum dots contain ions that constitute an electrolytic environment for the colloidal quantum dots. The fact that individual quantum dots are charged is responsible for a repulsive interaction between colloidal dots that allows them to remain in suspension. Moreover, the surface charge on each quantum dot attracts ions of opposite charge to form a double layer near the surface of each quantum dot. Such colloidal quantum dots are observed to blink with off times, τ, that obey an inverse-power-law distribution with the asymptotic form of a one-sided Lévy distribution:

$$p_\tau(\tau) = (k_B T / E_o)\,(\tau_o^{\mu}/\tau^{1+\mu}),$$

$\mu = k_B T/E_o$ and E_o is the energy associated with the barrier potential. In this work, different mechanisms for blinking are considered and it is shown that thermally-induced fluctuations in the double layer potential are a mechanism contributing to the observed blinking. By relating the fluctuations in the double layer potential to fluctuations in the surface charge density on the quantum dot, it is shown that associated fluctuations in the barrier potential have exactly the functional form needed to result in an inverse-power-law distribution for off times [1]. In addition, analytical results show that the distribution of off times, τ, scales as $1/\tau^{3/2}$ just as previously observed.

CONCLUSION

In this paper, the thermally-driven fluctuations in the double layer potential are related to the fluctuations in the surface charge density on the quantum dot. Moreover, it is shown that associated fluctuations in the barrier potential have exactly the functional form needed to explain the distribution of off times observed previously.

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REFERENCES

[1] Michael A. Stroscio and Mitra Dutta, *Biological Nanostructures and Applications of Nanostructures in Biology: Electrical, Mechanical & Optical Properties,* **(Kluwer Academic Publishers, New York, 2001)** provides a review of work on blinking of colloidal semiconductor quantum dots.

Compound Semicond.	Bandgap, (eV)	Spontaneous Polarization, (C/m^2)
AlN	6.2	- 0.081
CdS	2.4 E_g (A) 2.5 E_g (B) 2.55 E_g (C)	0.002
CdSe	1.76 E_g (A) 1.771 E_g (B) 2.17 E_g (C)	0.006
GaN	3.36	- 0.029
ZnO	3.35	- 0.07

Fig. 1. Wurtzite bandgaps and spontaneous polarizations.