# Quantum Dot

**Quantum Dot** is the nano meter sized semiconductor crystal with specific optical properties originates from the phenomenon which can be explained by the quantum chemistry and quantum mechanics. They have generally size range of 2-10 nm and possess 10-50 atoms in each particle. Band gap can be modified by controlling the size of colloidal nano crystal. Therefore, they exhibit specific luminescence emission light properties depending on the particle size. Quantum dot exhibits not only luminescence emission light wavelength modification and narrow spectral width but also have high quantum efficiency and absorb wide range of wavelength. The concept of energy level, band gap, conduction band, valence band can be applied to normal bulk sized semiconductor except one clear difference. In bulk status, the particle size of semiconductor is much larger than Exciton Bohr Radius and exciton can be reached to nature limit. On the other hand, when the particle size of semiconductor becomes closed the size of Excition Bohr Radius, electron energy level losses its continuity and becomes separate, namely small separation can be observed among energy level. This separated energy status is called quantum confinement and semiconductor materials becomes no longer bulk status but “quantum dot” status. In this situation, absorbance and light emission properties of semiconductor material is different. In quantum dot status, electron moves between the edge of band gap just like in bulk semiconductor status. In quantum dot status, luminescence emission light wavelength can be easily precisely modified by changing the particle size, by modifying the band gap size since emission light wavelength depends on the band gap energy.

In our technology, basically, quantum dot can be dispersed in solution (water, various type of organic solvent). Therefore, we can apply low cost printing and coating technology. Quantum dot shows bright strong luminescence emission light. In addition, emission light with wide range of wavelength can be irradiated with high efficiency, long life time and high attenuation coefficient.

Therefore, quantum dot can be expected to be utilized for various type of application including **medical experimental imaging, light source, display, solar cell, security tag, quantum dot laser, photonic material, transistor,**

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**thermoelectric material and quantum dot computer** etc…

## Solar Cell

Solar cell with high efficiency can be prepared by low cost printing technology. Fluorescent dye which has been used already, have tendency to decompose as time elapse. On the other hand, quantum dot is the inorganic material and stable in this sense. Moreover, silicon based solar cell can only absorb visible light. In addition, organic dye is not applied to utilizing infrared light region. In this regard, quantum dot can absorb infrared to ultraviolet light just by modifying the particle size. Quantum dot exhibits high light absorbing efficiency even under weak light irradiation on such as cloudy days.

## Bio Medical Imaging

Since quantum dot is extremely tiny particle, they can be delivered to anywhere in the body. Therefore, they can be used for medical imaging and bio sensor. Moreover, by coating bio compatible polymer with quantum dot, they can be dispersed in blood vessels too. In addition, by binding with specific substances such as antibody, they can be used as target cell. At the moment, organic dye with wide spectra is used for fluorescent bio sensor. However, fluorescent color choice is limited and fluorescent life time is short. In contrast, quantum dot is able to emission light at all range of wavelength region. Also, they exhibit high efficiency and long life time compared to existed organic dye.

## Electronics, Photonics

Quantum dot is in zero dimension so that density of states is very distinctively clear and sharp compared to high dimension structure. Because quantum dot is extremely small in size, electrons do not necessary have to move long distance compared to large particle, thus signal response becomes very quick in various type of electronic devices. Owing to these electronic properties, quantum dot can be applied to transistor, solar cell, ultrafast optical switching device, logical gate and quantum computer etc…in addition, high density solid memory chips, LED, white solid light, back light, displays, photonics ink

(security ink) and light detector etc…can be created based on quantum dot technology.

Generally, quantum dot is the semiconductor based on cadmium. However, these heavy metals are prohibited to be used in many industry areas. Therefore, demands are to develop cadmium free quantum dot which exhibits high light emitting efficiency and stability as good as cadmium based semiconductors. We are diligently researching and developing cadmium contained quantum dot and also, cadmium free quantum dots and we will continue to have more kinds of quantum dot products. In should be noted here that generally, to manufacture quantum dots in large industrial level have difficulty due to cost issue. Therefore, quantum dot is currently used for only in the field of bio medical imaging with small quantity business. In this regard, we are chasing technology to manufacture quantum dot in large industrial level in order to make quantum dot products with cheaper price.

Solvent used is mainly water and various type of organic solvent. Please consult with us anytime if you have particular idea which solvent should be used. Also, if you need finer particle size modification, please let us know. We are currently working on to develop other quantum dots besides following products such as **Ag based, Te based, Ni based, Mo based, silicon quantum dot, quantum rod** etc… Below table presents the kind of quantum dot we have at the moment. We are constantly improving quantum efficiency and also developing other type of quantum dots as described above.

Please consult technical detail with us anytime.

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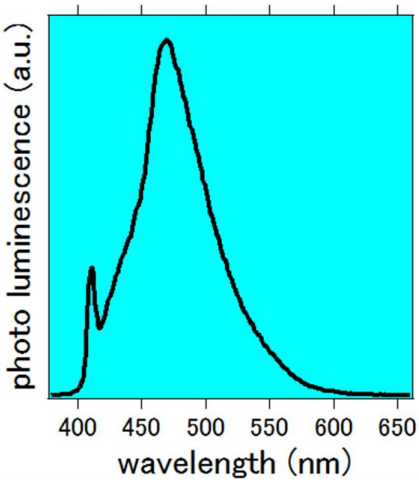
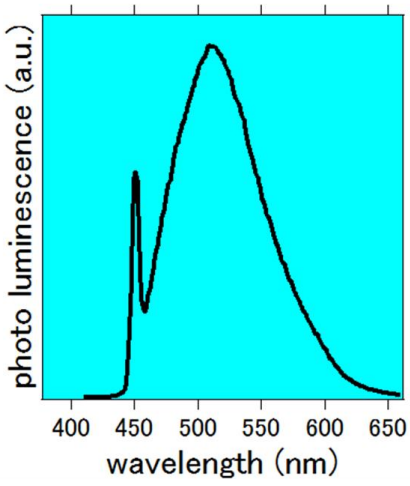
CdSe Quantum Dots

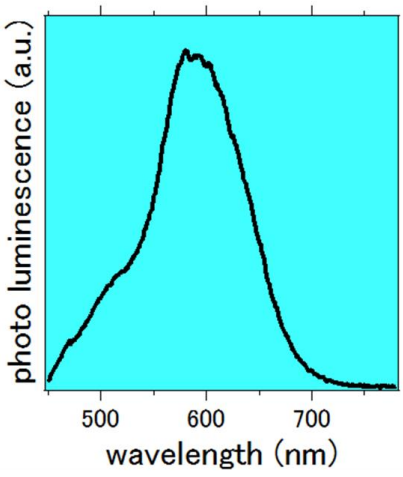
InP/ZnS Quantum Dots




InP/ZnS Blue




InP/ZnS Green




CIS/ZnS Red

Photo luminescence spectra of emission light 420 – 460 nm

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# GS TECHNICAL INFORMATION

| Quantum Dot | Excitation Wavelength （QY Max ） | Emmision Peak Wavelength （QY Max） | QY Quantum Efficiency (%) | Half Width (nm) | Solvent |
|---|---|---|---|---|---|
| ZnS | 460 | 520 | 15 > | 32 ± 5 | Octadecene Toluene Ethyle Glycol Alcohol Ketone etc… |
| CdSe | 490 | 580 | 35 > | 31 ± 5 | |
| CdSe/ZnS | 350 | 400 | 25 > | 54 ± 5 | |
| InP/ZnS-Gr. | 420 | 450 - 470 | 50 > | 38 ± 5 | |
| InP/ZnS-Gr. | 420 | 500 - 520 | 50 > | 38 ± 5 | |
| InP/ZnS-Red | 460 | 580 - 610 | 50 > | 39 ± 5 | |
| CuInS2/ZnS | 450 | 610 - 620 | 40 > | 45 ± 5 | |
| AgS | 420 | 580 - 610 | 40 > | 45 ± 5 | |
| PbS | 450 | 610 - 720 | 40 > | 45 ± 5 | |
| Carbon | 360 | 440 | 45 > | 35 ± 5 | Water |
| Graphene | 360 | 440 | 80 > | 35 ± 5 | |

If you need other type of quantum dots besides above table, please consult with us anytime.　We will synthesize quantum dots as you request.

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