Quantum Dot Inks for Anti-Counterfeit Applications

Why Quantum Dots?

Quantum Dots (“QDs”) are **Photoluminescence** (“PL”) inorganic materials.

PL is the emission of **Electromagnetic Radiation** (“ER”) of a wavelength after absorption of ER of another wavelength. This happens due to photon excitation (absorption of photons) when various charge relaxation processes occur and cause photons of lower energy to be emitted. The duration between absorption and emission is called the **Time Period**. The difference between the energy of the absorbed photons and the energy of the emitted photons is known as **the Stokes Shift** and this varies widely across materials from ZERO to 1 eV. Time periods between absorption and emission can also vary and range from femtoseconds to milliseconds.

QD material chemistry and its particle size determines the wavelength of the light emitted, the **Stokes Shift** and the **Time Period** (“PL Period”). Furthermore, if the QD is exposed to a pulse of ER then the emitted light shows a decay pattern or the **PL life-time**. These properties together comprise the **PL Signature** of the QD. A device is needed for irradiating the mark and reading the PL signature.

QD batches can be produced with a selected particle size, so different batches can have different particles sizes with narrow particle size distributions and therefore, each batch has its own PL signature. Thus, QDs offer tuneable complexity in their PL signature with possibility of endless variation. This makes QD anti-counterfeit labels very difficult to copy.

Application Method

QDs of a very narrow particles size distribution are prepared. On the particles, there is a first coating of an inert inorganic material and a second coating of organic molecules. The first coating gives the QD **stability** and the second coating makes it possible to **disperse** the QDs in transparent coatings.

In one type of application, the QD ink can be printed on plastic sheet or on paper sheet in bar code, text or any form of mark. If necessary, the printed sheet can be protected with a protective coating or laminating a self-adhesive plastic sheet. The printed sheet can be die cut to produce individual labels that can then be adhesive bonded to the article to be protected. The labels can be read at the point of manufacture and their PL signature recorded. The label can then be read again at the point of sale to confirm that the article is not counterfeit (See Figure 1).

In another type of application, the QD signature can be incorporated into plastics used for credit cards or currency notes or into holographic coatings. This provides an additional layer of security via the PL signature.

The PL signature of the quantum dot clearly and unambiguously identifies the QD and distinguishes it from any other PL material that may be used by a counterfeiter.

Stability

The QD materials used in security applications are made stable by using stable chemistry and by the use of coatings on the QD particle itself.

Current Security Inks on the Market

The current generation of security inks and methods of their authentication have several drawbacks that limit their usefulness. **Firstly,** optical spectra alone can be easily copied by one or a combination of PL materials commonly available on the market. **Secondly,** one simple way to distinguish between common PL materials could be by measuring their PL life-time, but the problem is that the PL life-times of common PL materials are less than 30 nano seconds or longer than 100's of microseconds. However, it is known that measuring PL life-times of a tens of nano seconds is very difficult with current electronics. On the other hand, when the material has 100's of microsecond life-time, it takes too long to measure the life-time. These problems can be overcome with QD materials where it is possible to tailor life-time to suit the requirements of security applications.

What is required to market QD security inks productions?

1. A UV cured QD ink formulation with cost effective and stable QD materials.
2. A varying time pulsed irradiating device with optical reader (for measuring PL signature).
3. Building a data base of PL signatures of different particle size QD batches and accelerated aging studies (environmental aging).

Bricpoint can provide the technology needed to implement QD security ink solutions for brand protection and other anti-counterfeiting applications. Contact us for a discussion of your requirements.

用于防伪安全应用的量子点墨水

为什么量子点？

量子点（“QD”）是光致发光（“PL”）无机材料。

PL是吸收另一波长的ER后的波长的电磁辐射（“ER”）的发射。这是由于当各种电荷弛豫过程发生时光子激发（光子的吸收）并且导致发射较低能量的光子而发生的。吸收和发射之间的持续时间称为时间段。吸收的光子的能量和发射的光子的能量之间的差异被称为斯托克斯位移，并且这在从零到1eV的材料中变化很大。吸收和发射之间的时间段也可以变化，范围从飞秒到毫秒。

QD材料化学及其粒径决定了发光的波长，斯托克斯位移和时间周期（“PL周期”）。此外，如果QD暴露于ER的脉冲，则发射的光显示衰减模式或PL寿命。这些属性一起构成QD的PL签名。需要一种装置来照射标记并读取PL标记。

QD批次可以使用选定的粒度生产，因此不同的批次可以具有不同的粒度和窄的粒度分布，因此，每批具有其自己的PL特征。因此，QD在其PL签名中提供可调节的复杂性，具有无限变化的可能性。这使得QD防伪标签很难复制。

申请方法

制备非常窄的粒度分布的QD。在颗粒上，存在第一涂层的惰性无机材料和第二涂层的有机分子。第一涂层赋予QD稳定性，第二涂层使QD可以分散在透明涂层中。

在一种类型的应用中，QD墨水可以条形码，文本或任何形式的标记印刷在塑料片材或纸张上。如果需要，可以用保护涂层或层压自粘塑料片来保护印刷的片材。可以将印刷的片材冲切以产生单独的标签，然后可以将其粘合到要保护的制品上。可以在制造时读取标签并记录其PL签名。然后可以在销售点再次读取标签以确认该物品不是伪造品（参见图1）。

在另一种类型的应用中，QD标记可以结合到用于信用卡或纸币或全息涂层的塑料中。这通过PL签名提供了额外的安全层。

量子点的PL特征清楚且明确地识别QD并将其与可能由伪造者使用的任何其他PL材料区分开。

Bricpoint可以提供实施QD安全墨水解决方案所需的技术，用于品牌保护和其他防伪应用。联系Bricpoint进行技术转让服务。

Figure 1. The Authentication Process