**Quantum Dots?**

Quantum dots are nanometer-sized semiconductor crystals and have a characteristic that their energy band gap changes depending on their size and shape. When the semiconductor material is reduced to a very small nanometer size, the movement of electrons is spatially restricted, and exhibits unique characteristics different from those of large-sized materials due to quantum mechanical phenomena. The peculiar feature is that it shows a discontinuous energy level due to the quantum confinement effect depending on the size. These quantum dots can widely change the area where light comes out by controlling their size, so they can be said to be suitable materials for future highly efficient, bright, and flexible display applications.

**ZnO and ZnO-hybrid QDs**

When Blue LED was developed using gallium nitride (GaN) in the late 1990s, zinc oxide has been emerged as a material that can replace it since it has a similar direct band-gap (3.37 eV @RT) and emits light in the near UV region. SNEL members started to develop an epitaxial growth technology of ZnO using MBE and UHV sputtering into a single crystal thin film. For the first time in Korea, the optical properties were published in the Journal of the Korean Optical Society, and Cu-doped p-type ZnO was successfully made. It was also confirmed that cyan-blue light was generated by growing this p-type Cu:ZnO on n-type silicon carbide. Afterward, by hybridization of ZnO QDs with graphene QDs (GQDs), blue emission was firstly observed in the ZnO-Graphene QD LED, published in Nature Nanotechnology. Recently, research on the application of LED or solar cells by mixing oxide and nano-carbon materials is underway. In addition, research was conducted to increase the permittivity of polymer materials, such as making carbon nanotubes (CNTs) with excellent physical properties into a nanoring form and making CNT with high dispersibility. Recently blue emission independent of excitation wavelength through ZnO-GO QDs was also for the first time realized and quasi type II ZnO-functionalized PAHs (polyaromatic hydrocarbons) hybrid QDs such as ZnO@aminopyrene also showed bight and long lifetime blue emission.

**Barrier films**

Organic electronic devices such as organic light-emitting diodes (OLEDs), quantum dot LEDs, and organic photovoltaics have garnered extensive attention for future large-size and flexible optoelectronic devices because of their flexibility, thinness, and smoothness. However, the performance of these organic devices degrades over time because the organic materials are quite vulnerable to permeation of H2O and O2 molecules, and consequently, their lifetime is easily shortened in an ambient atmosphere. Because the lifetime of commercial OLEDs should exceed 10,000 h, the water vapor transmission rate (WVTR) and the oxygen transmission rate (OTR) must be less than 1 × 10–6 g/m2/day and 1 × 10–5 cm3/m2/day, respectively. Therefore ultrahigh barrier (UHB) films are highly demanded for flexible organic devices such as QLEDs perovskite solar cells, and thin film batteries.

**UHB films for flexible electronics**

The typical encapsulation method of OLEDs entails the use of a glass lid sealing or metal can with a UV curing adhesive. However, as encapsulation materials, glass and metal lids are not suitable for transparent and flexible OLEDs. In response, extremely advanced inorganic films with various densities have been widely investigated as a highly efficient barrier, such as SiNx, AlxOy, SiO2, and so forth, deposited by plasma-enhanced chemical vapor deposition (PECVD), thermal and atomic layer deposition (ALD), and magnetron sputtering. So far, most recent research has reported that ultrahigh barrier (UHBs) films, defined as films having a lower WVTR of ∼10–6 g/m2/day, have been successfully fabricated by adopting ALD. The ALD process is, however, not cost-effective because of the use of an expensive vacuum process and is also not highly productive because of quite a low deposition rate. In the multilayer stacks of inorganic/organic components, the thinner inorganic layer acts as a primary barrier forming the network and the thicker organic layer dissociates the pinholes and microcracks formed inside the inorganic component by filling the pores. Commercially known as Barix (Vitex), the Barix barrier film could achieve a WVTR of 10–6 g/m2/day. In SNEL, we report a simple synthetic process to prepare a flexible triple-layered (triad) a-SiNx:H/n-SiOxNy/h-SiOx multistructure barrier film deposited on both sides of a poly(ethylene terephthalate) (PET) substrate with an effective coating area of 210 mm × 297 mm using a combination of low-pressure PECVD (LP PECVD) and dip coating having a lower WVTR of ∼2x10–6 g/m2/day.

**SPT**

At present, these accelerators with closed-drift electrons and an extended acceleration region (also called Hall thrusters) generate quasineutral multi-ampere (~ 1-50 A) streams of ions of different species (from hydrogen to xenon) with particle energies of 50-1000 eV. They are mostly known as electric propulsion thrusters for spacecraft. Therefore, such devices are more frequently called “stationary plasma thrusters” (SPTs). SPTs were designed in 1960s from the basic idea of A. I. Morozov at the Kurchatov Atomic Energy Institute (AEI) (G. Ya. Shchepkin’s laboratory). They were first launched into space in 1971 and have since (most recently in 1997) been mounted onboard more than 50 Russian satellites. From 1999, these thrusters should be used on USA satellites and then perhaps on the satellites of other countries. (https://doi.org/10.1007/978-1-4615-4309-1\_2)

**Linear SPT**

Compared to the conventional circular type, the horse-track shaped proto-type linear stationary plasma thruster (LSPT) was designed and fabricated. Measured electron density is about 1.2 × 10e10/cm3 at the front of 5 cm from the channel and electron temperature is about 10 eV. This value is similar to the data of circular type closed drift ion source through 2D simulation. Plasma is ignited with a discharge voltage of 90 V and a discharge current of 2.8 A in case of Argon gas and 2.6 A in oxygen. Discharge current is proportional to discharge voltage for both gases and increases up to 16.3 A in Ar and 15.6 A in oxygen at the discharge voltage of Vd = 320 V. As the discharge current is lowered, the source transits into rather unstable operating mode with strong fluctuations known as “circuit oscillations”. The length of LSPT can be designed and constructed up to 780 mm.