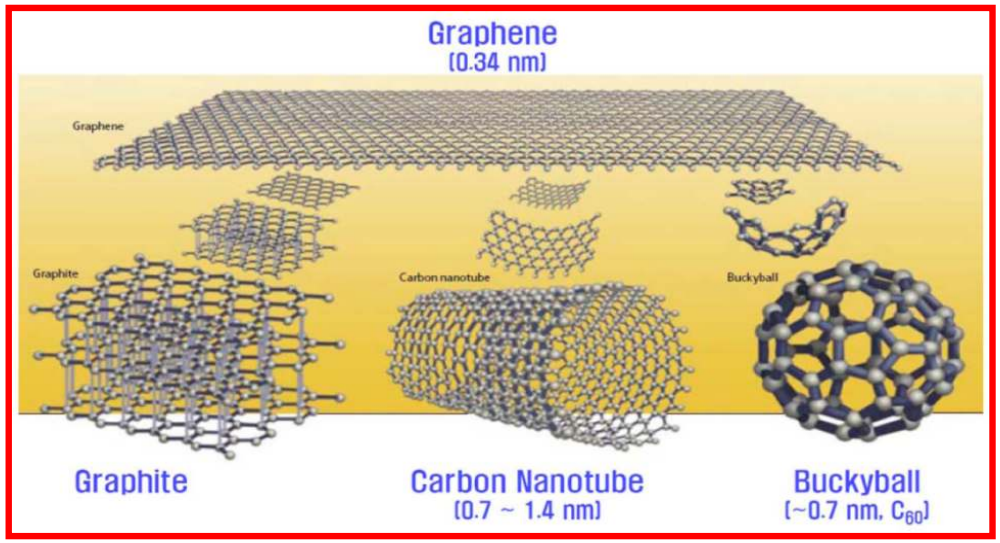
그라핀이 결합된 산화물 반도체 -그라핀 핵-껍질 양자점을 이용한 튜너블 발광소자

개발자: 최원국

Korea Institute of Science and Technology

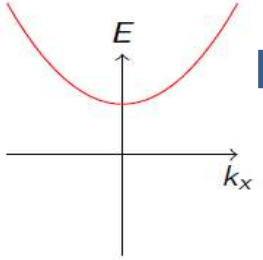
한국과학기술연구원

1. 기술의 개요

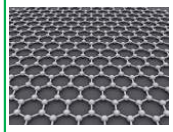


Usually Energy is given by

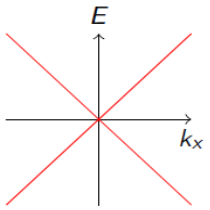
$$E = \frac{\hbar^2 k^2}{2m}$$



But because of fancy structure of Graphene,

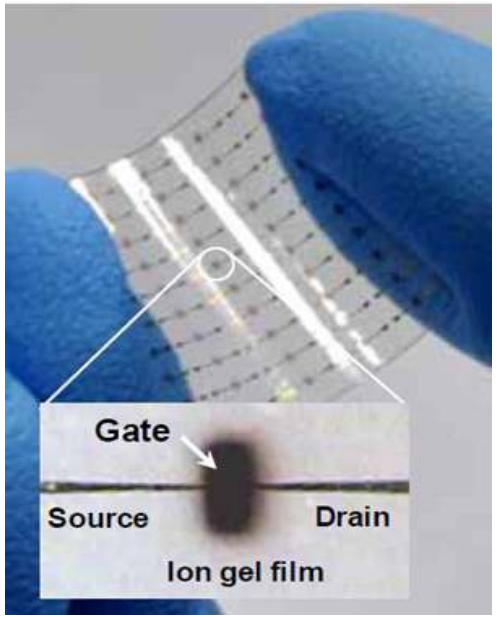


$E \propto k$

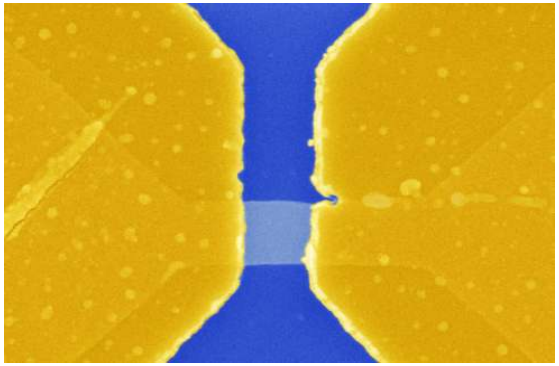


(You can refer the review paper [A. H. Castro Neto *et al.* "The electronic properties of graphene", Reviews of Modern Physics,2009])

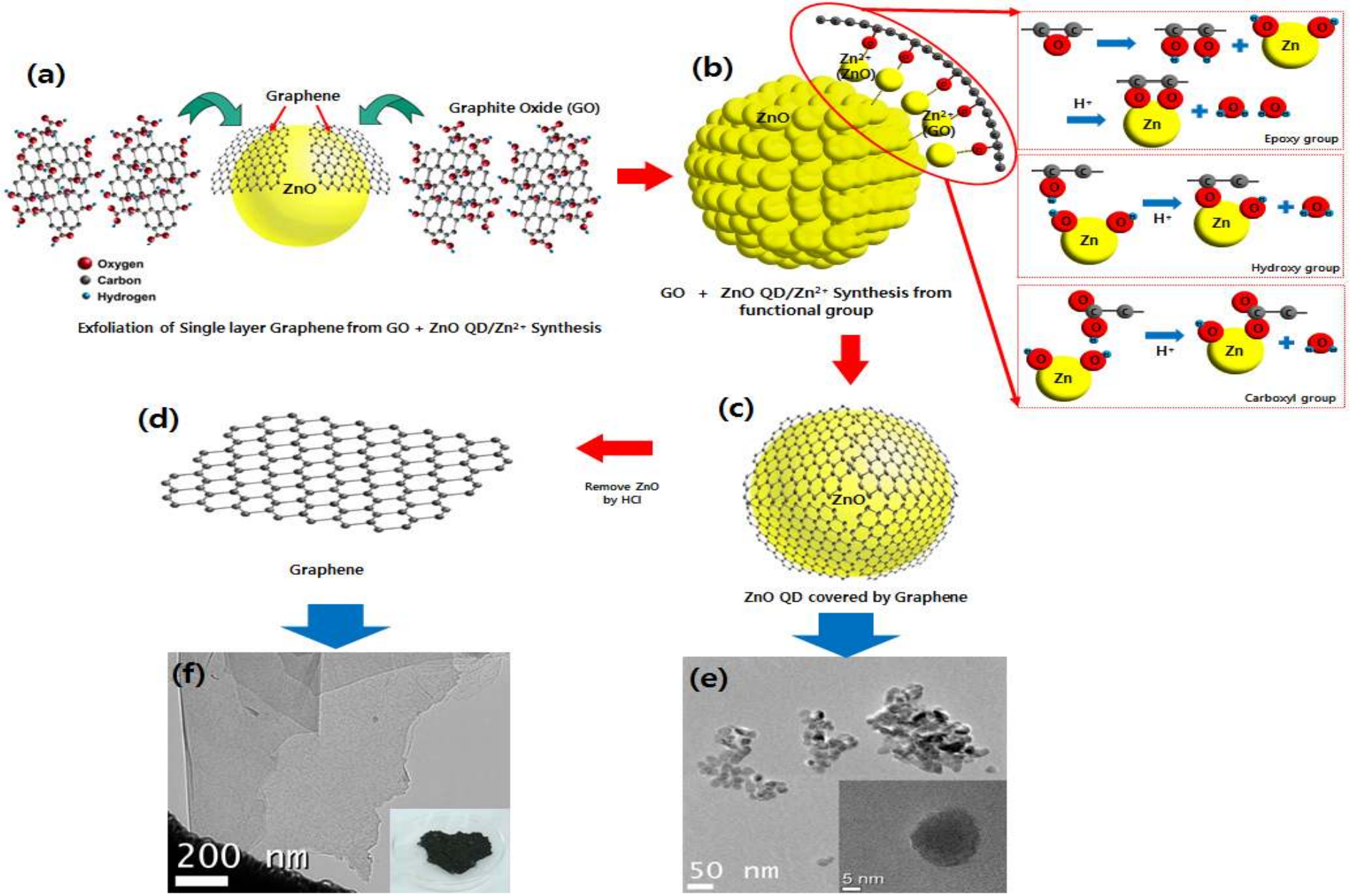
	a-Si	PEDOT: PSS	CNT	Graphene
Mobility(@RT) (cm^2/Vs)			1x10^5	2x10^5
Resistivity (ρ)(Ωcm)			1.6x10^{-6}	1.0x10^{-6}
Bandgap (eV)	1.1-1.4		0.5-1.0	0-0.3
Thermal conductivity (W/mK)			3000-3500	5300
Young's modulus (Tpa)			1-2	1
J_{max} (A/m_2)			10^6	10^8



$$\mu = \frac{q}{m^*} t$$



1. 기술의 개요

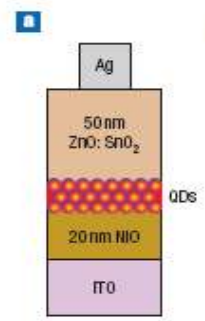

(a)
Graphene
Graphite Oxide (GO)
ZnO
Oxygen
Carbon
Hydrogen
Exfoliation of Single layer Graphene from GO + ZnO QD/Zn²⁺ Synthesis
(b)
ZnO
Zn²⁺ (ZnO)
Zn²⁺ (GO)
GO + ZnO QD/Zn²⁺ Synthesis from functional group
H⁺
Zn
Epoxy group
Hydroxy group
Carboxyl group
(c)
ZnO
ZnO QD covered by Graphene
Remove ZnO by HCl
(d)
Graphene
(e)
50 nm
5 nm
(f)
200 nm

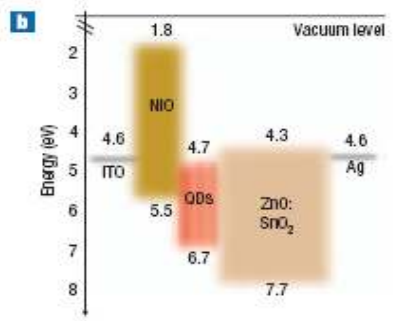
2. 기술의 적용분야 및 응용제품

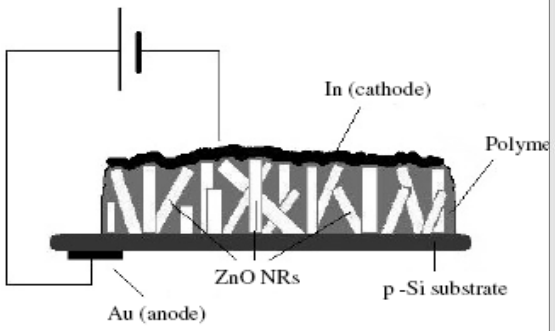
정의: 물리 증착, 화학 증착, 용액 법, inkjet법 등을 이용한 저가의 대면적 구현이 가능한 무기질(Inogrganic)/유기물(Organic) Hybrid 면광원 소재 및 디바이스 기술

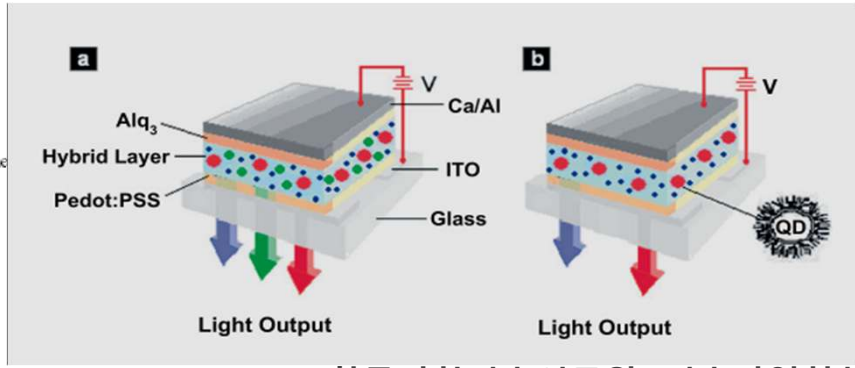
- 전세계 전기사용량 20%: 조명 임
- 현재, 대표적 OLED: 5000 cd/m^{2}의 높은 휘도, 그러나 수분 및 산소에 의한 유기물 층의 열화 및 금속전극과의 불안정성(수명 저하 요인)
- 현재, GaN LED: 시장이 급속도로 팽창되고 있으나 고가이며 대면적화에 어려움
- 따라서, 고분자 OLED 나 현재의 LED 점광원을 대체할 미래의 광원은 산화물 반도체 나노로드가 대안이 되나 현재 빛 나오는 정도만 확인: 10 cd/m^2(국내)

대안: Oxide/QDs(NRs) (air stable QLED(AS-QLED) & QD-polymer hybrid QLED (F-QLED)



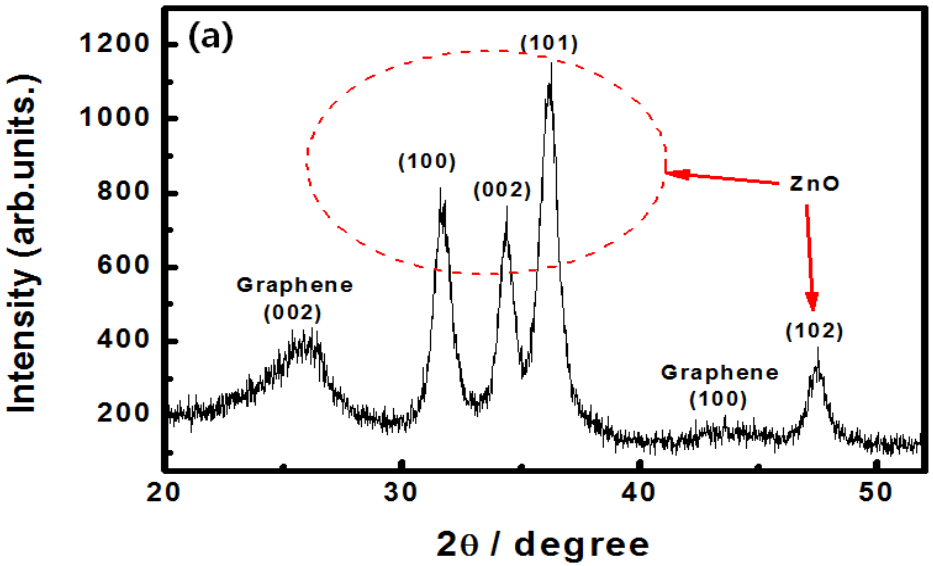


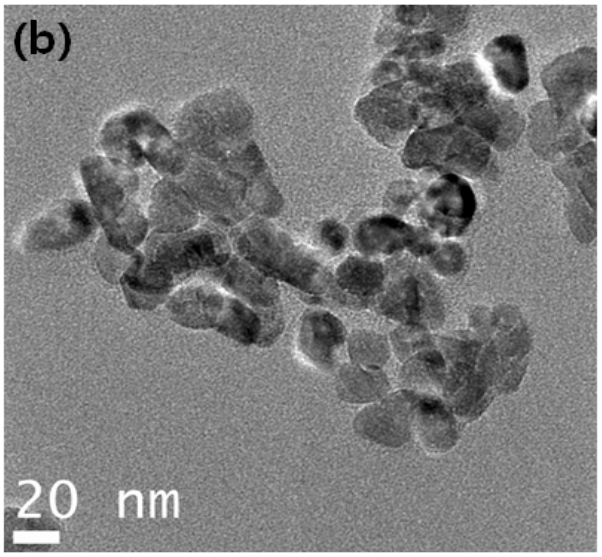


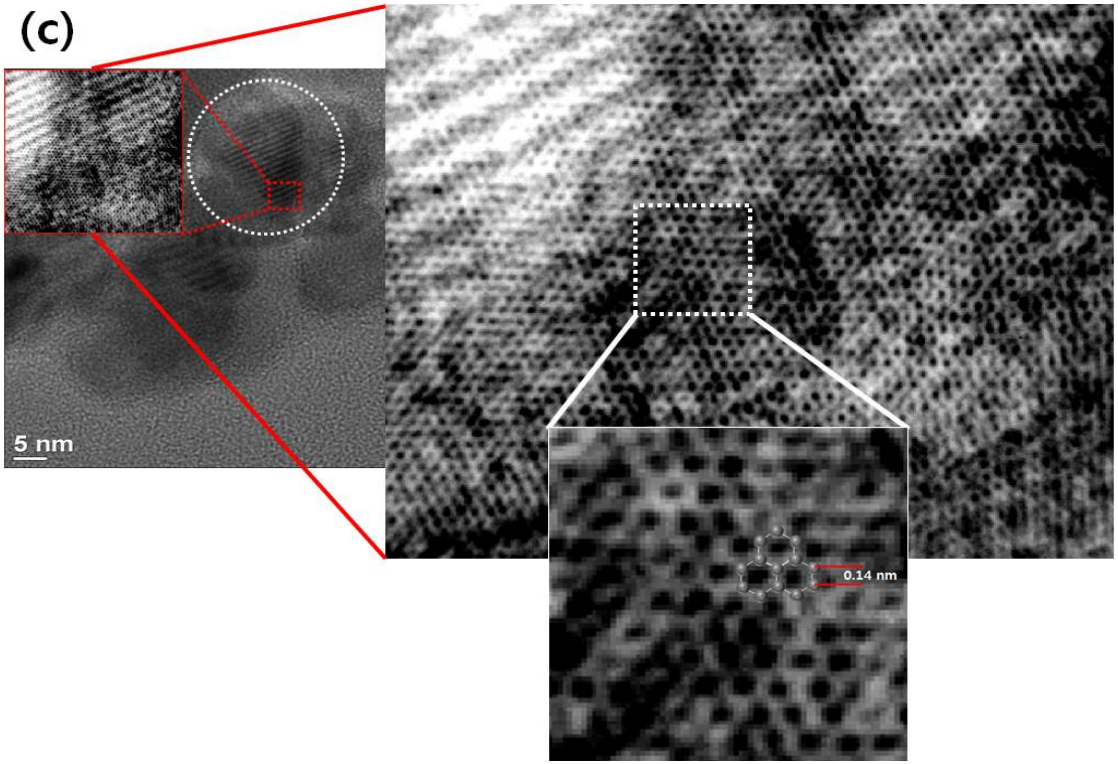


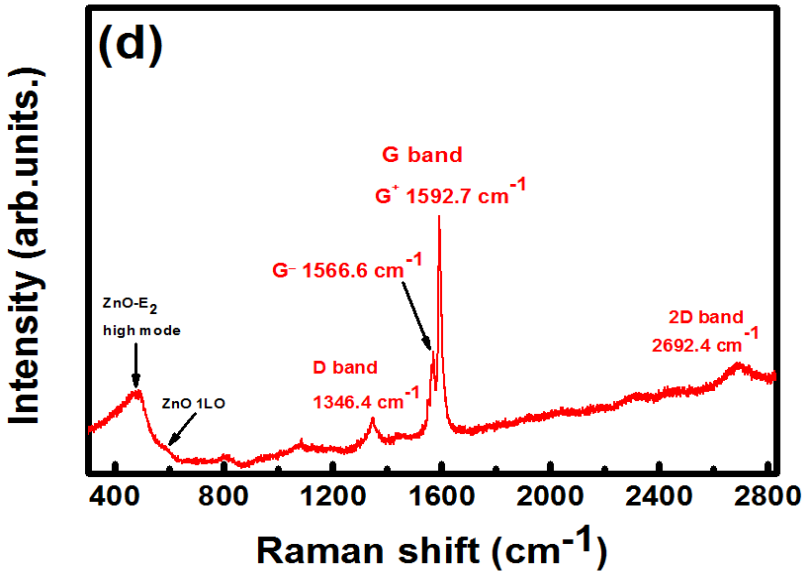
3. 본 기술의 개발 상태

XRD/TEM/FT-Raman



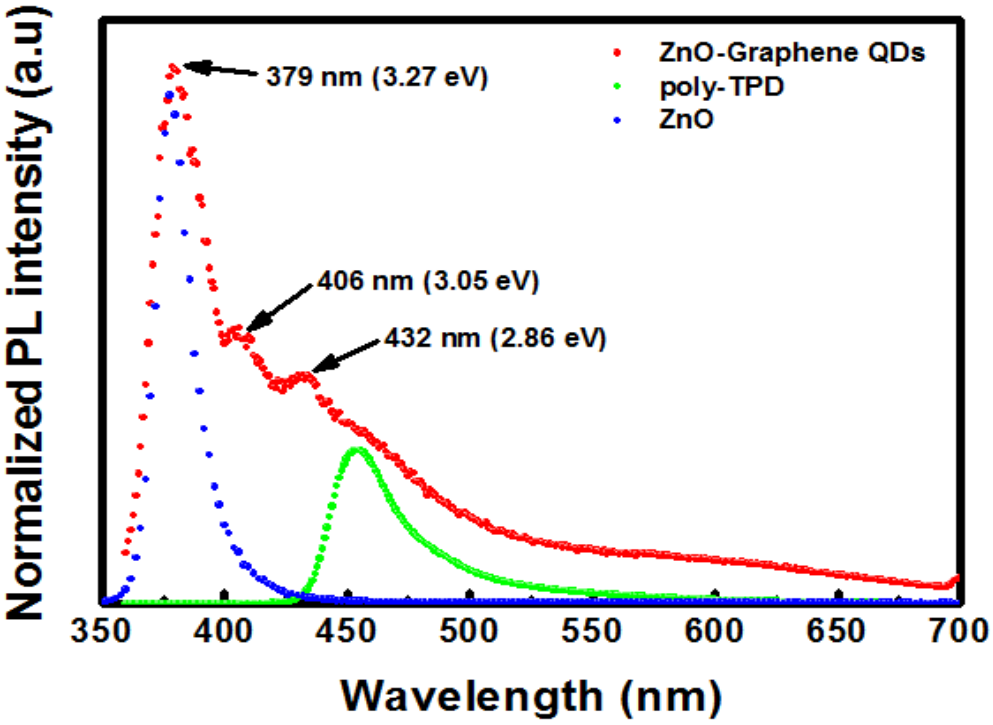


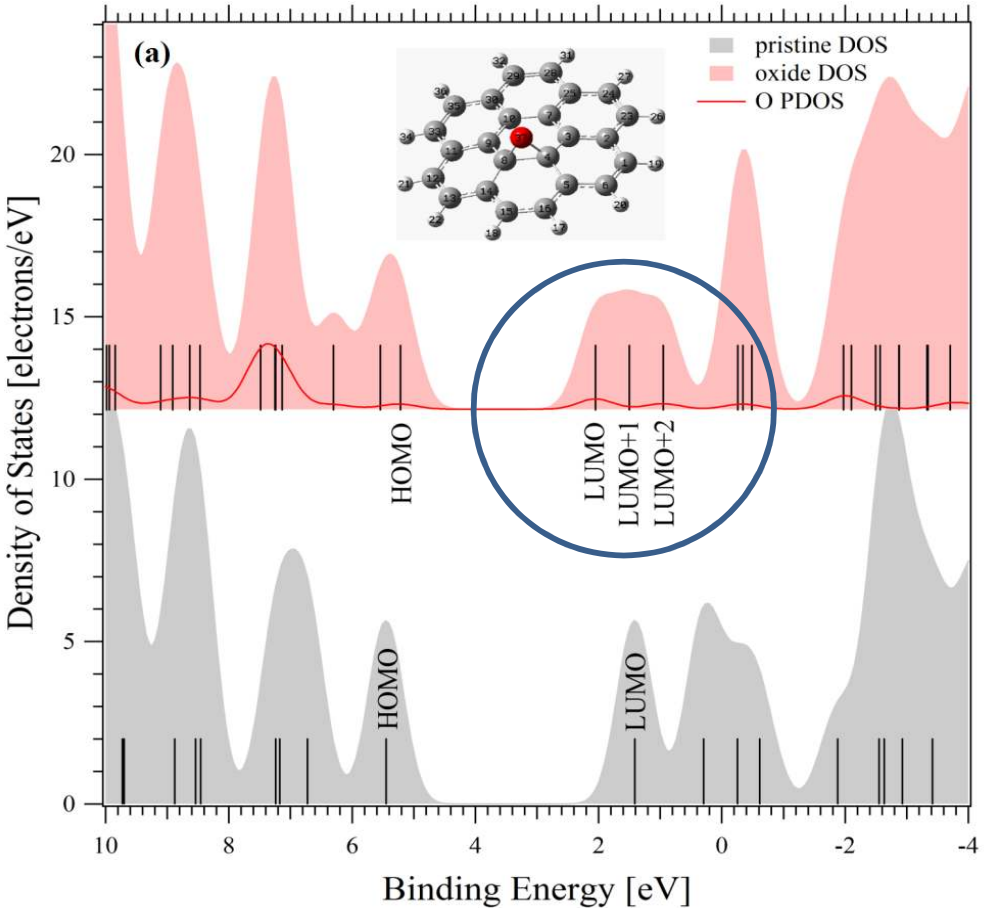




3. 본 기술의 개발 상태

Photoluminescene/Denisty Functional Theory (DFT)

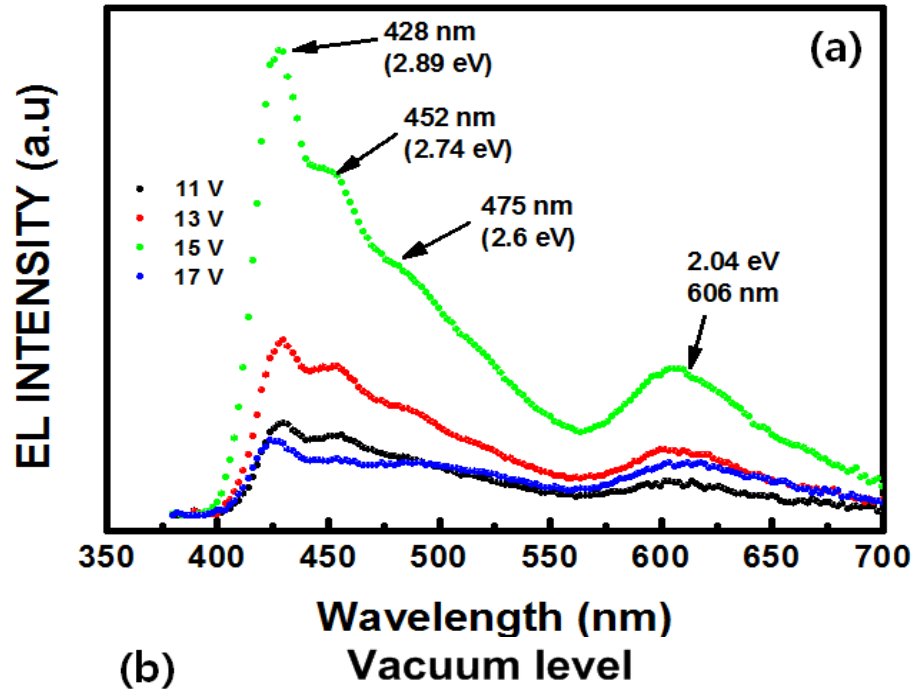


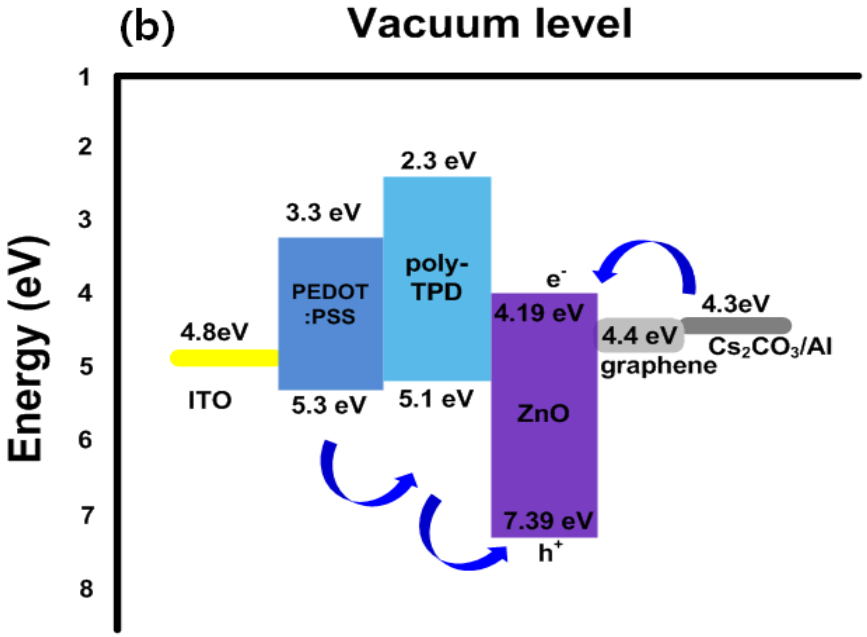


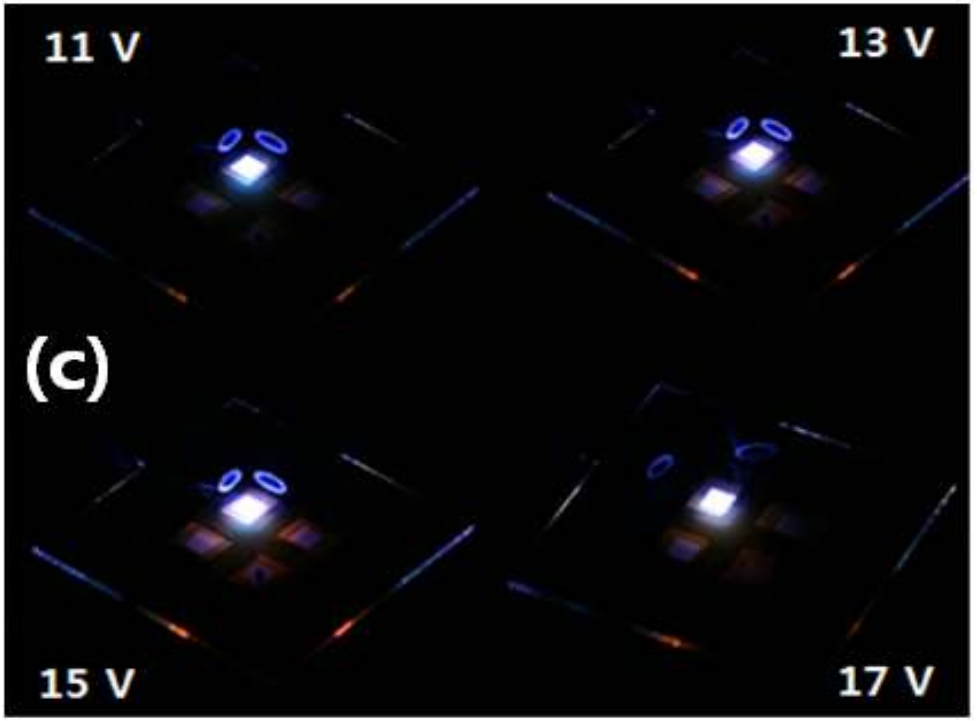
By the selection rule ($\Delta l = \pm 1$),
LUMO/LUMO+2(s-orbital) to O 2p

3. 본 기술의 개발 상태

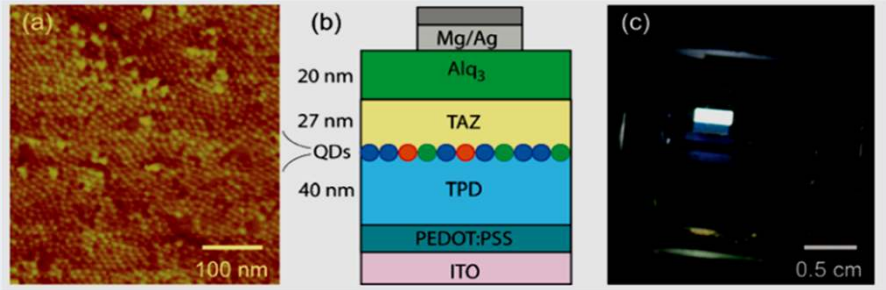
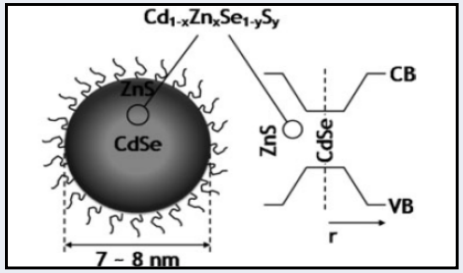
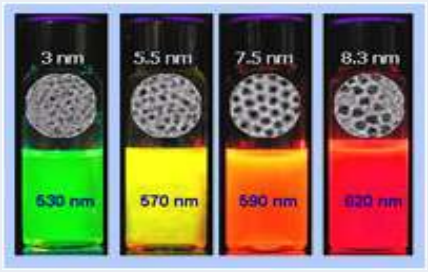
Electroluminescene/Band diagram



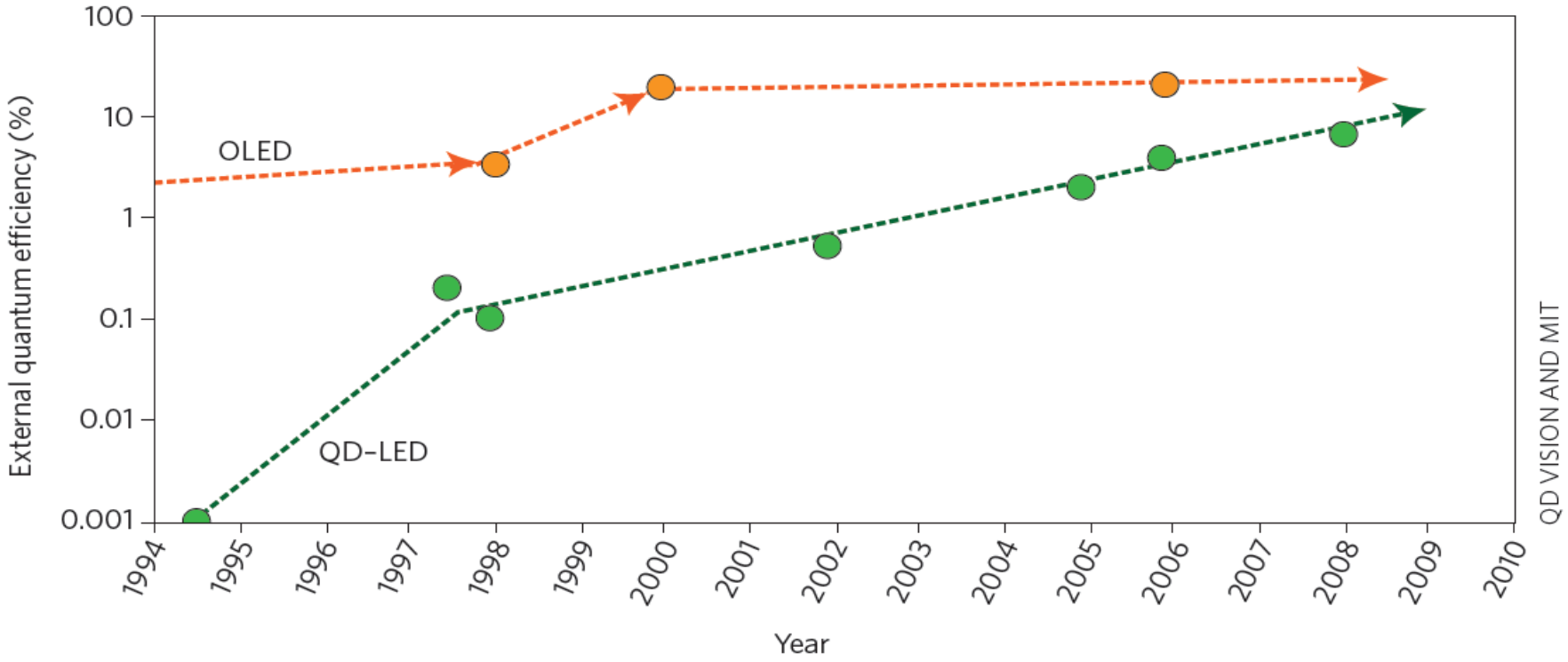




4. 본 기술의 특징 및 차별점

	선행기술	기술요약	본발명과의 비교
논문	Bawendi, and Vladimir Bulovic, 2007 Nanoletters 7, 2196	R, G, B QDs를 혼합한 white Q-LED	ZnO-Graphene(B) p-TPD(B),PEDOT-PSS(Y)가 혼합된 white LED
			
특허/논문	S. Kim *et al., J. Am. Chem. Soc.*, 125, 11466 (2003) Adv. Mater. 2009, 21, 1–5	QD size 및 composition을 조절한 R,G,B를 혼합	산화물 QD의 VB 에너지 조절에 의한 R,G,B조절
		CdSe/ZnS, Si/SiO_2, InP/ZnS, $Cd_{1-x}Zn_xSe_{1-y}S_y$	

5. 관련제품의 시장현황 및 규모



Evolution of the efficiency of QD-LEDs (green circles) over their history, and comparison with OLEDs (orange circles).

nature photonics | VOL 3 | JUNE 2009 315-316