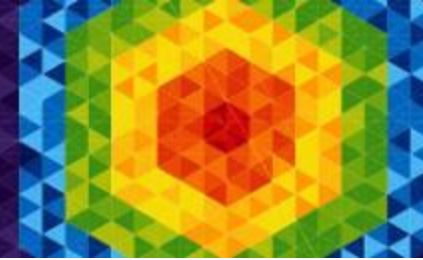


**2012 ASTRI INDUSTRY & UNIVERSITY
CONSULTATION FORUM**

LED Lighting Technology

Ryan Chung

Nov. 2012



Technology Highlights

Chip

- Substrate removal by CMP (Yield rate ↑)

Package

- Phosphor fabrication (Targeted bin rate ↑)
- Barrier-free packaging (Thermal resistance ↓)

Lamp

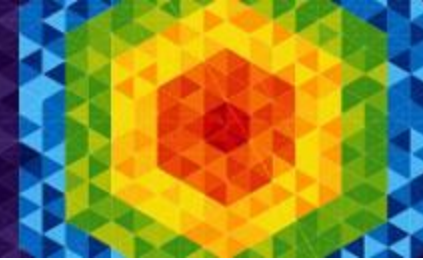
- Birdcage structure (Heat dissipation ↑)
- Omnidirectional light emission (~100% to Incandescent lamp)
- LED Outdoor Lighting (Public test since 2009)

Wireless

- Doppler's based motion sensing (Auto-calibration)

Control

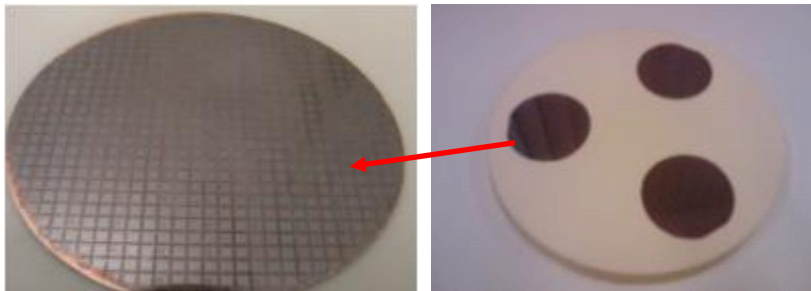
- VLC for real-time location positioning (Accurate tracking)
-



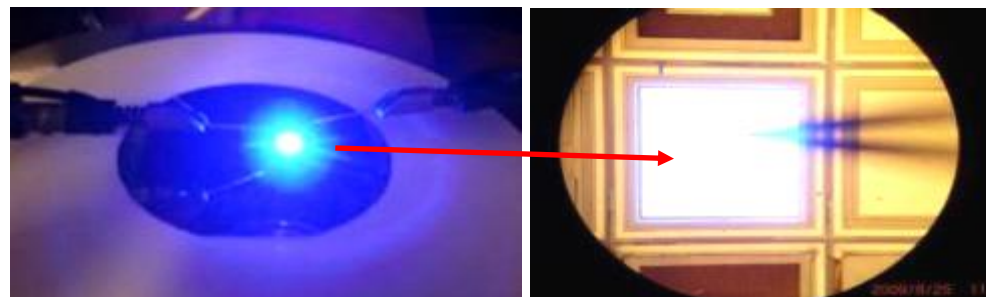
LED Sapphire Removal

Chemical-Mechanical Process

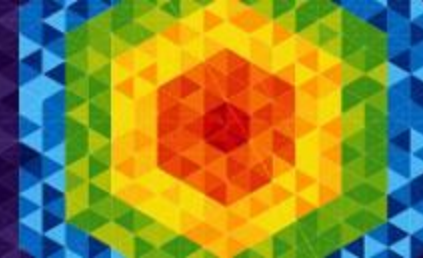
- For efficient heat dissipation
- High yield, **UNDER SPIN OFF**
- **8 [5] US and 9 [6] China patents pending [granted]**



Multi-wafer process

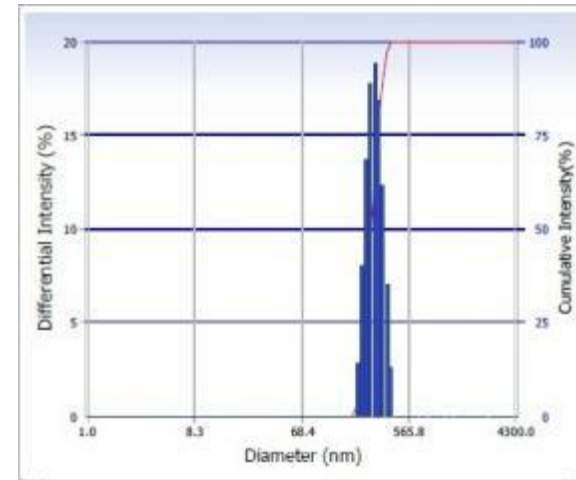


Function tested



High Performance Phosphor Fabrication

- Align with conventional dispensing process
- High **SINGLE BINNING** rate (~ 80%)
- Highest angular uniformity ($\leq \pm 50K$ in cool white)
- Luminous efficiency reach 95% of conventional **YAG**
- Compatible with ink-jet printing system
- 2 US patents pending



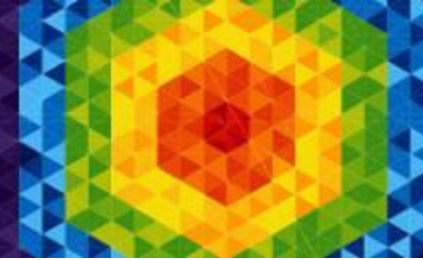
Distribution Results (Contin)

Intensity Distribution

Peak	Diameter (nm)	Std. Dev.
1	289.6	46.7



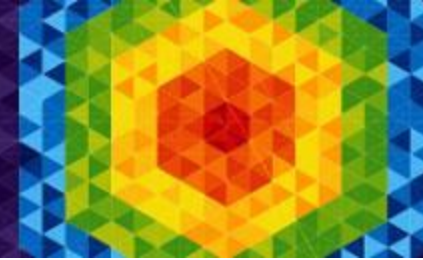
Phosphor Fabrication for high power LED




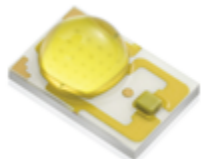

Single Binning Result

ASTRI's Phosphor Technology			Conventional Phosphor Technology		
Bin	Qty	Ratio	Bin	Qty	Ratio
E2	1058	79.07%	E3	4393	43.15%
F1	8	0.59%	E4	5190	50.98%
D4	4	0.30%	F2	140	1.38%
D3	28	2.10%	B5	18	0.18%
E3	237	17.71%	C4	112	1.10%
			C5	79	0.78%
			D3	63	0.62%
			G1	146	1.43%
			G2	23	0.23%

55% ↑

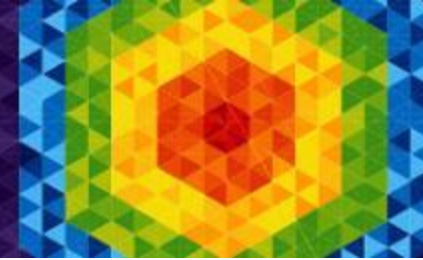


CCT Angular Variation Benchmarking

Angle Measured [0°, 90°]	ASTRI	Philips REBEL	Cree XP-G
			
Max CCT	4991 K	6119 K	6302 K
Min CCT	4902 K	4248 K	4480 K
Mean CCT	4949 K	5184 K	5314 K
CCT Variation	[+42 K, - 47 K]	[+934 K, -936 K]	[+987 K, -834 K]

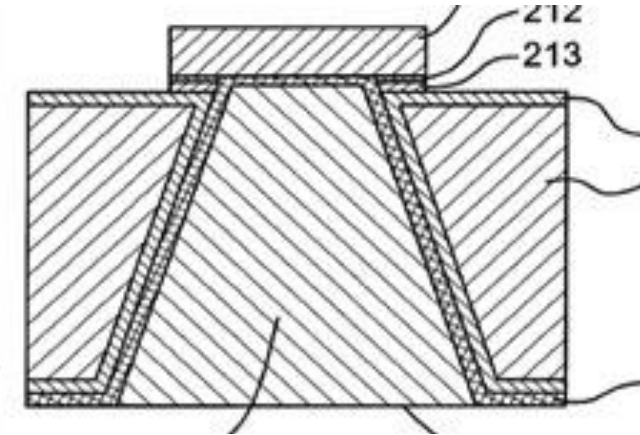
ASTRI Technology controls

Angular CCT variation in **± 50K in cool white !**

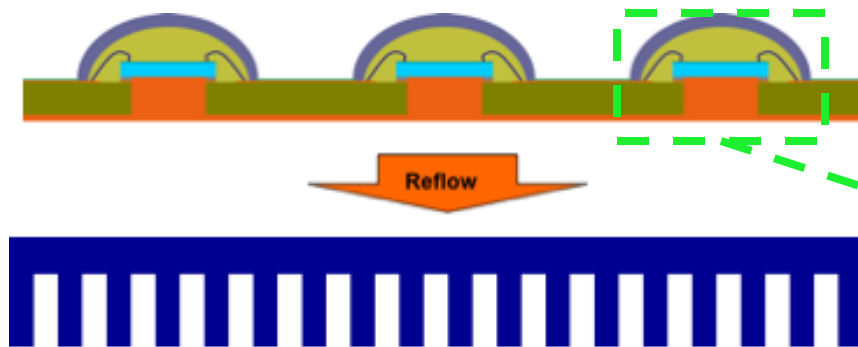


Barrier-free LED Packaging

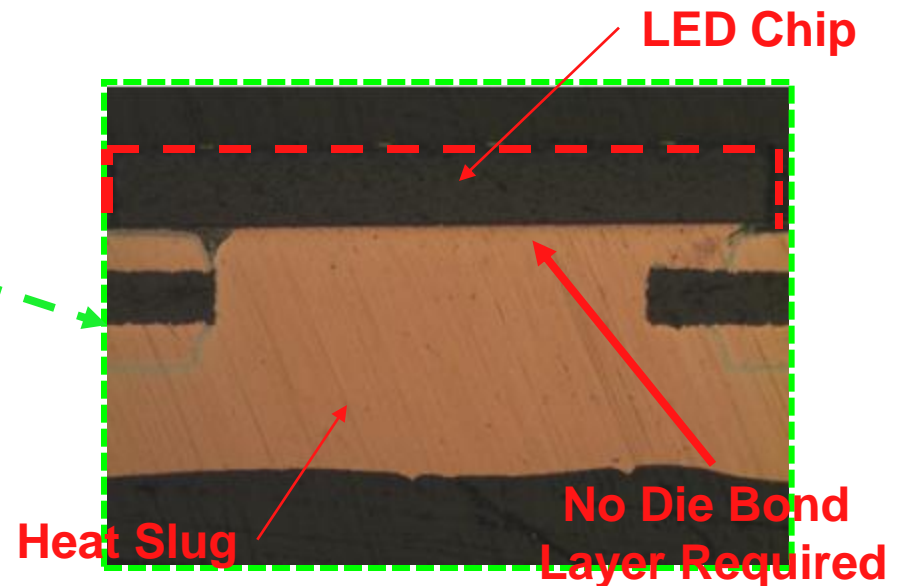
- **Zero interface** (die to heat slug) **structure**
- **¹COB flexibility & ²CoHS performance**
- **Align with conventional optics packaging process**
- **Patent protection (US824,8803)**
- **Also available for component solution**



Barrier-Free Structure
(US824,8803)



¹COB: Chip-on-Board;
²COHS: Chip-on-Heatsink





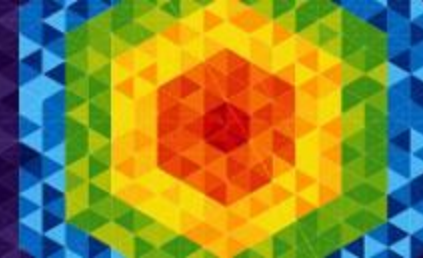
Barrier-free LED Packaging

Cost Analysis (Quotation from Cu-plating Company)

Supplier	Substrate	USD
Company A	Al MCPCB	1.98
Company A	FR4	0.3
Company A	FR4 (+10hrs plating)	1.28
Company A	FR4 (+15hrs plating)	1.5
Company B	Flex PCB	1.08

Note:

- 1) Ignoring all tooling cost
- 2) Quotation is based on 10K/month
- 3) Size of substrate: 53.5mm x 53.5mm
- 4) Cu electroplating cost on 53.5mm x 53.5mm substrate is USD 0.08/hr



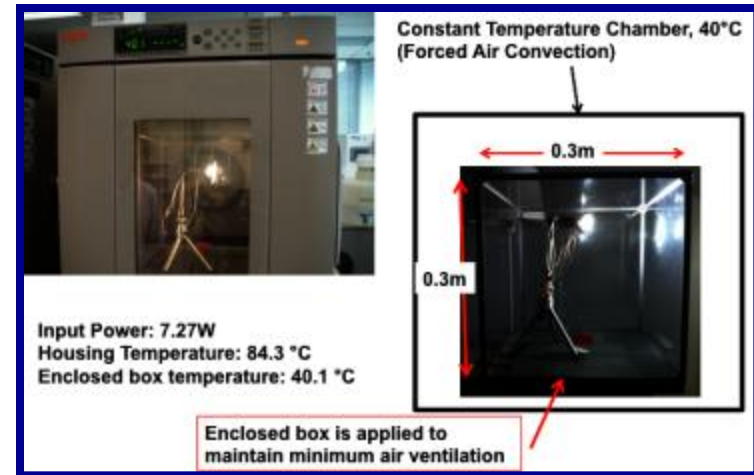
Birdcage Heat Dissipation

- Opened-space structure for **maximizing heat dissipation**
- Light weighted, fabricated by die-casting
- Strong patent protection: **US7701055**
& ZL200780043125.0
- **4 licensees (1 HK & 3 CN), mass production since 2007**



7W Birdcage MR16 (50W Rep. Lamp)

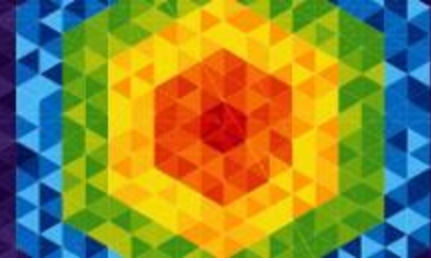
- **Lamp: 70 lm/W (LED:91 lm/W)**
- **500 lm @ 7.2W (3000K, Ra: 85)**
- **CBCP: 2100cd @ 25° (¹BA)**
- **² $\Delta T_{\text{Housing}} < 45^{\circ}\text{C}$; $\Delta T_{\text{LED}} \sim 56^{\circ}\text{C}$**



¹BA: Beam Angle

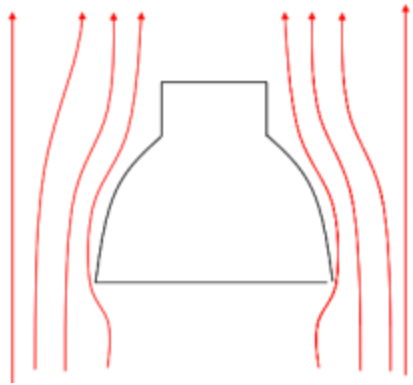
² Temperature rise reference to downstream ambient air, 40°C

Birdcage Heat Dissipation



Typical MR16 Housing

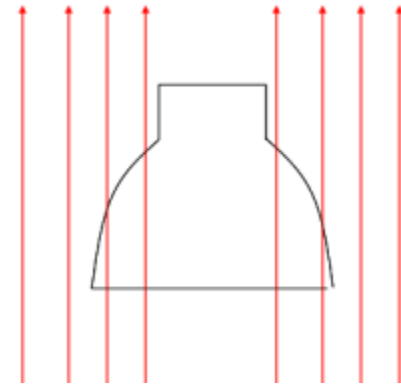
$$\Delta T = Q / (h * A)$$



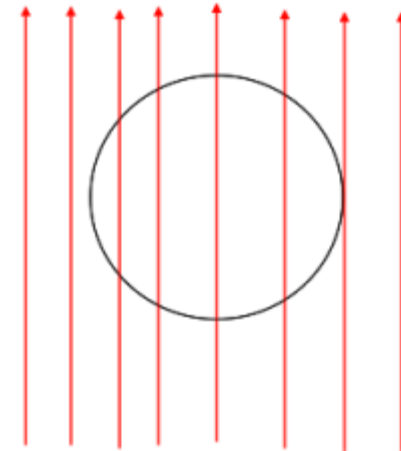
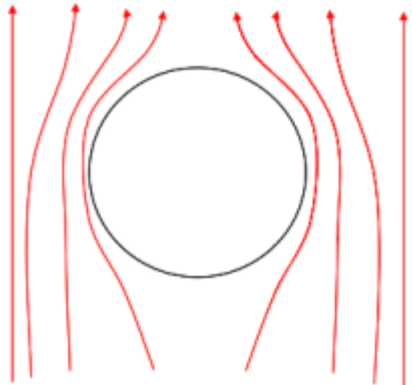
Light // Gravity

Birdcage MR16 Housing

$$\Delta T = Q / (h * A)$$



Light ⊥ Gravity



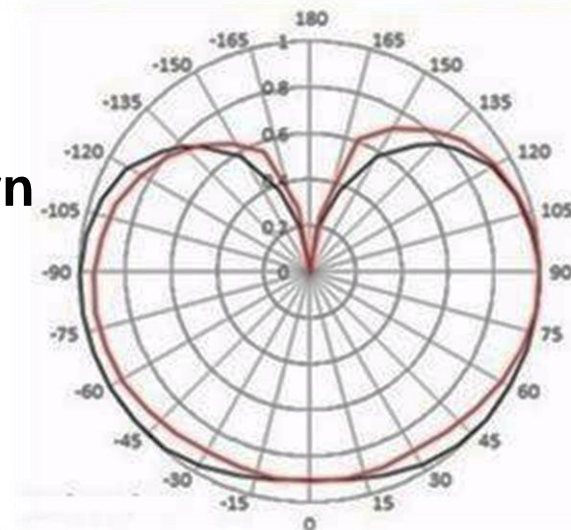


Omnidirectional Light Emission

- **Identical incandescent bulb** emission pattern
- **Omnidirectional** (>300°) light emission
- US & CN patents pending

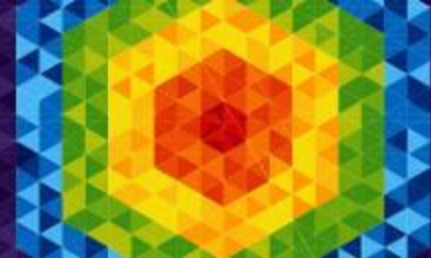
40W / 60W Replacement Bulbs

- **Beam angle: ~330°**
- 40W: 485lm @ 6.5W (¹CW) / 450lm @ 8W (²WW)
- 60W: 820lm @ 9.7W (CW)
- CRI: 70 (CW) / 80 (WW)



— **Omnidirectional Bulb**
 — **Incandescent Lamp**

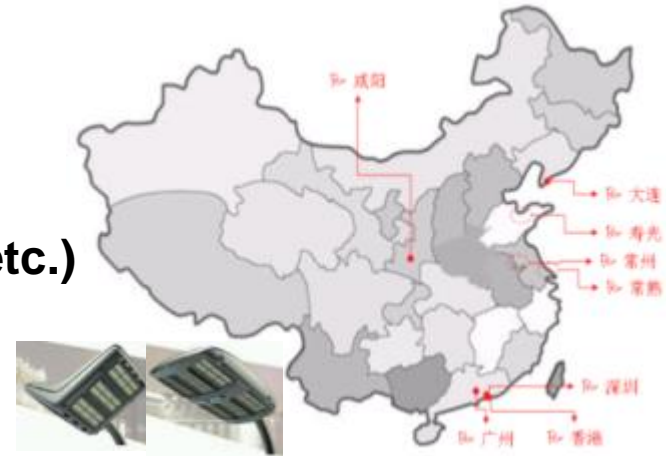




Outdoor Lighting

LED Streetlamp

- Multiple on-site installations & testing (TKO Hospital, HKUST library, HKUST south gate & etc.)
- **7 licensees installed in 8 cities**
- 7 patents pending (1 US & 6 CN)
- 2009 HKICT Best Lifestyle Silver Award



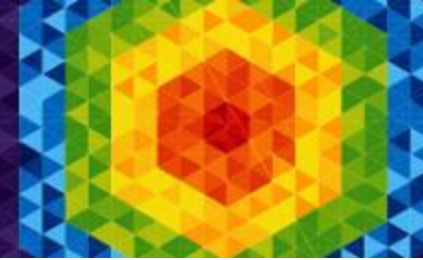
LED Corridor Lamp

- Twice the efficiency of CFL lamp
- Life tests in HKSTP & Tsz Ching Estate





Doppler's Effect based Motion Sensing



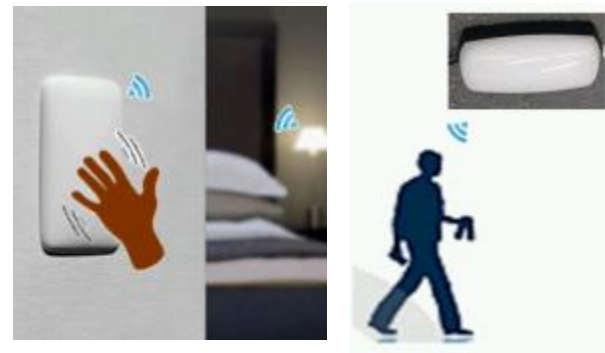
- **ONE** wireless module **TWO** functions (motion sensing & signal transmission) → (cost & size: ↓50%)
- **Speedy auto calibration (< 3sec.)**
- **Low power consumption (~0.1W)**
- **Anti-false triggering algorithm**
- **2 US patents pending**

	Company H	ASTRI
Operation Power	4W	1.6W
Detection Range	11m	11m
Calibration	-	Remotely Manual
Calibration Time	-	< 30 sec
False Alarm Prevention	-	Software
BOM		↓46%
Module Size	45 x 75 mm ²	20 x 40 mm²

Doppler Sensor Benchmarking



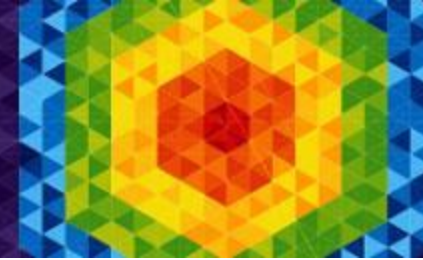
External Design



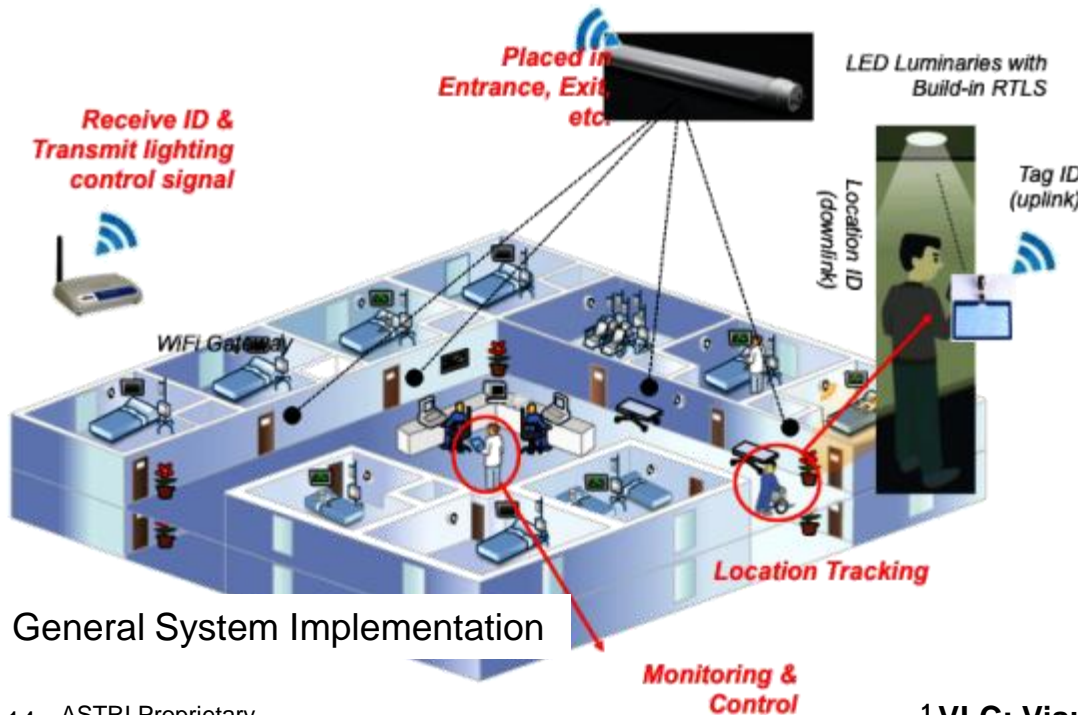
Wall Switch

Embedded Design

¹VLC for Real-time Location Positioning



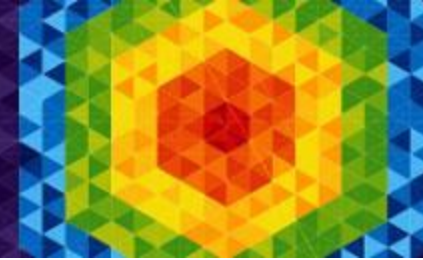
- Use LED lamps as signal communication device
- **Dual** construction – wifi / LAN general network & Zigbee (VLC transmitter) network in restricted area
- Aim for simple & fast data transmission



Performance

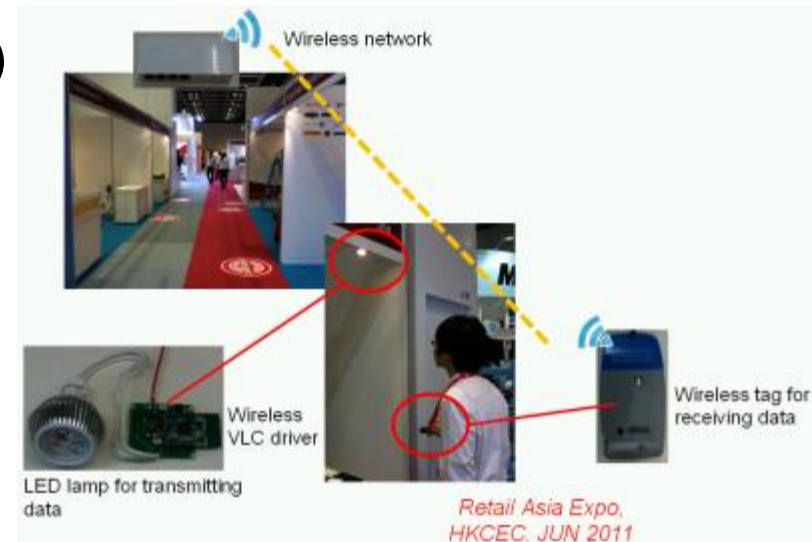
- Low light intensity variation (< 3 LUX)
- Better tag sensitivity (↑40%)
- Long battery life (> 1 year)
- Accurate tracking

VLC for Real-time Location Positioning



HK Retail Asia Expo 2011 in HKCC (Demonstration)

- Collect participants' visiting habit and provide them accurate information
- **ASTRI's VLC technology** (Wifi + Zigbee based VLC Transmitter coupled network) as backbone
- Integrated with commercial LED spot lamps & **name tag** for positioning
- No. of Booth: 180 (1 booth, 1 transmitter)
- Tag used: 1000 pcs run at the same time





End of Presentation

Thank you. Questions are welcome.

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