K. 6/115 amended

High performance phosphorescent platinum(II) emitters for OLED application

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Summary of the Impact

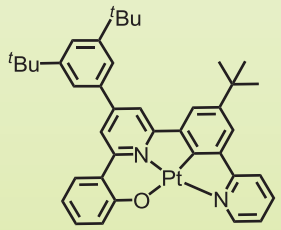
Expensive iridium based phosphorescent emitters are used in active matrix (AM) organic light emitting diode (OLED) production

Patents owned by UDC

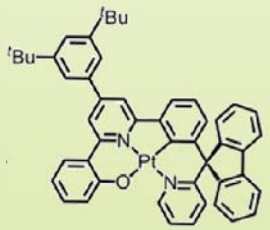
Prof. Che's work

AM-OLED could be manufactured with platinum(II) based emitters

These emitters can be prepared by one-pot reaction

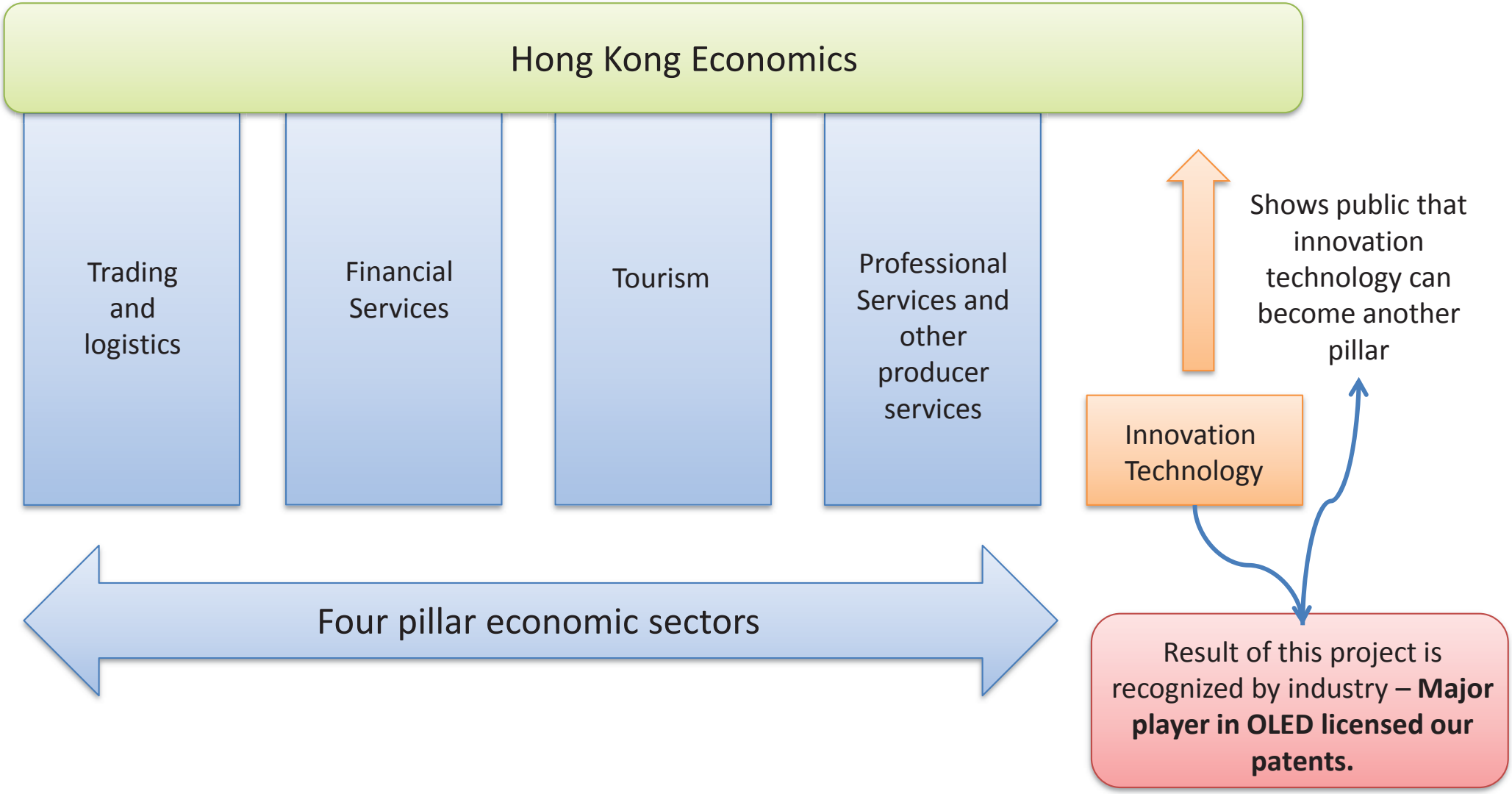


Efficiency: 94.1 cd/A
Lifetime: > 180,000hr
Efficiency roll-off: 13 %



Efficiency : 98.8 cd/A, 126 lm/W, 26.4%

Summary of the Impact



Underpinning Research

Phosphorescent platinum(II) complexes

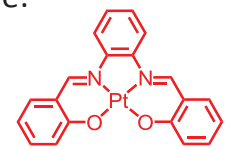
One ligand — One metal center — Platinum complexes

- Robust – 4 metal-ligand bonds
- No isomerization – 1 : 1 ligand to metal ratio
- Can be readily prepared by one-pot reaction

Materials with original patents owned by HKU scientists

High performance OLEDs

Example:

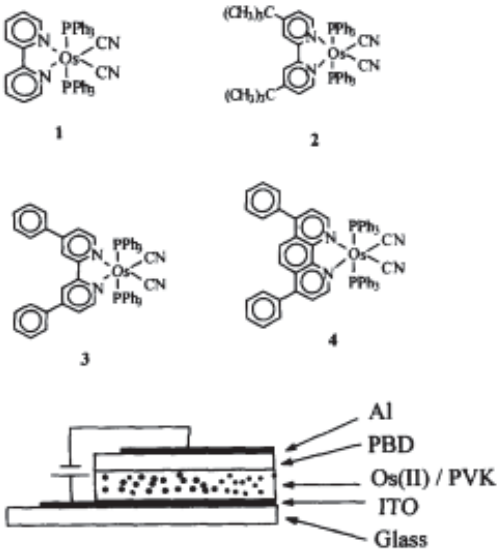


Up to 10 g PtSalophen can be prepared by a simple one-pot reaction in synthetic laboratory

Chem. Eur. J. **2010**, 233-247

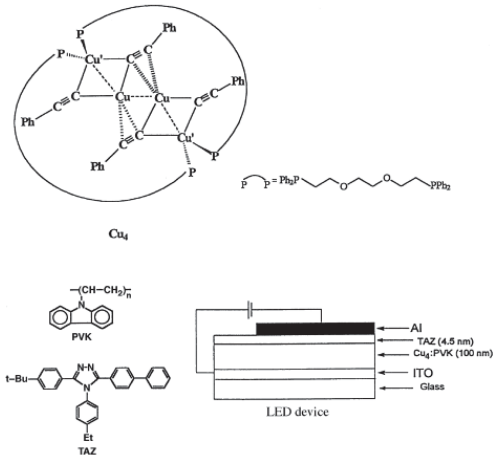
Underpinning Research

Phosphorescent material was firstly fabricated into OLED in 1998



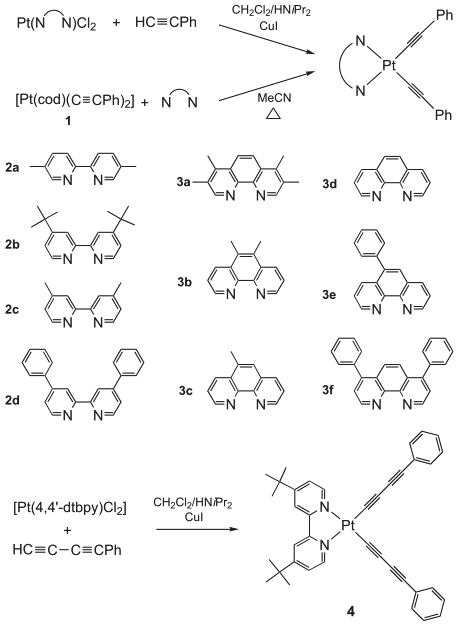
Synthetic Metals **1998**, 94, 245-248

Copper (I) complexes was firstly fabricated into OLED in 1999



New J. Chem. **1999**, 263-265

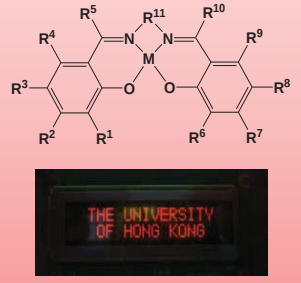
First series phosphorescent platinum(II) complexes for fabricating OLED were developed in 2001



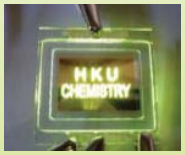
Chem. Eur. J. **2001**, 7, 4187

Underpinning Research

Red-emitting material
Efficiency: 15.49 cd/A
Lifetime > 77,000 hours



Green-emitting material
Efficiency: 62 cd/A



WOLED
Efficiency: 71 cd/A

Efficiency : 98.8 cd/A,
126 lm/W, 26.4%

2009 2010 2011 2012 2013 2014 2015 2016

Green to yellow emitting material
Efficiency: 28.6 cd/A

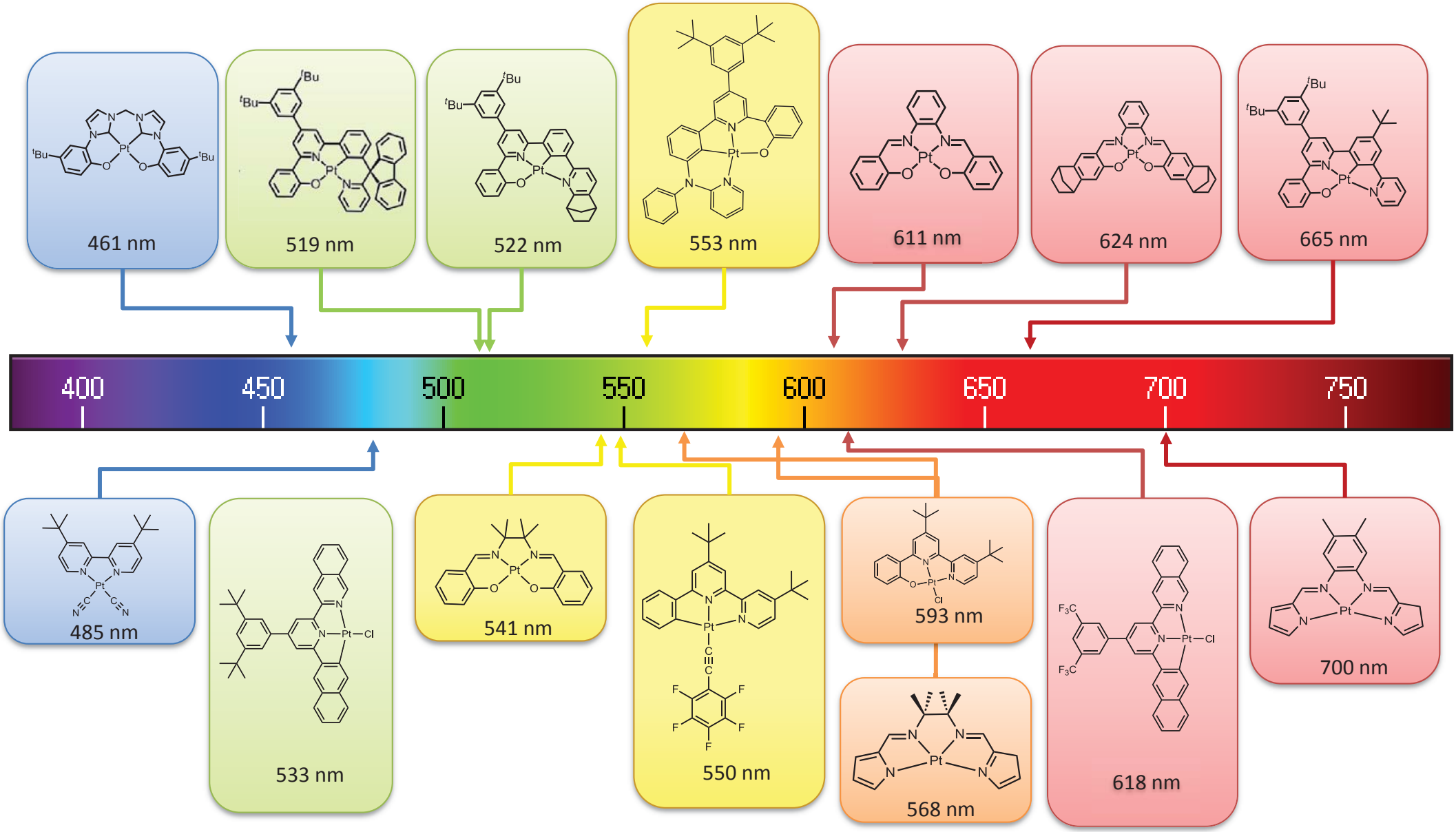
Blue-emitting material
Efficiency: 24 cd/A

Yellow-emitting material
Efficiency: 84 cd/A

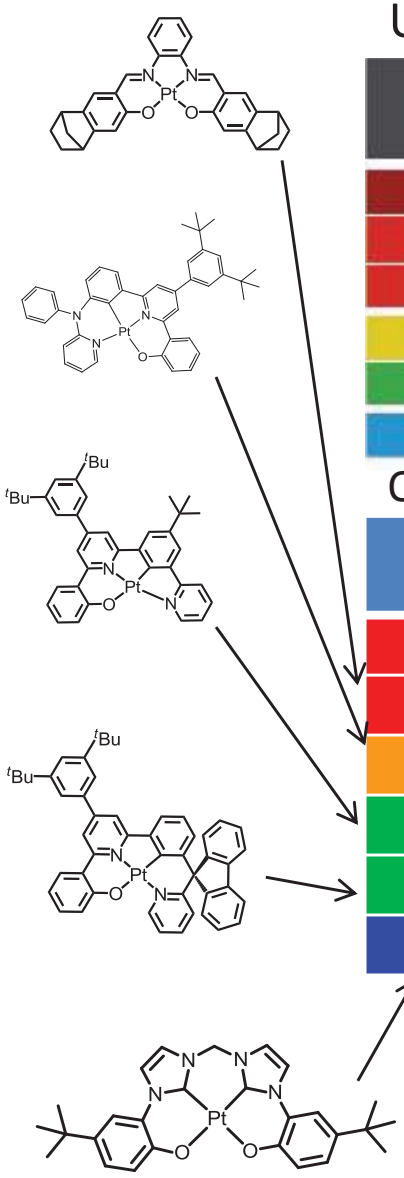
Blue emitting material
Efficiency > 25 cd/A
(unpublished result)

Red-emitting material
Efficiency: 15.6% (EQE)
(unpublished result)

Underpinning Research



Underpinning Research



UDC Data in 2012

PHOLED Performance (at 1000 cd/m²)	1931 CIE Color Coordinates	Luminous Efficiency (cd/A)	Operating Lifetime (hrs) LT 95%	LT 50%
DEEP RED	(0.69, 0.31)	17	14,000	250,000
RED	(0.66, 0.34)	29	23,000	600,000
RED	(0.64, 0.36)	30	50,000	900,000
YELLOW	(0.44, 0.54)	81	85,000	1,450,000
GREEN	(0.31, 0.63)	85	18,000	400,000
LIGHT BLUE	(0.18, 0.42)	50	700	20,000

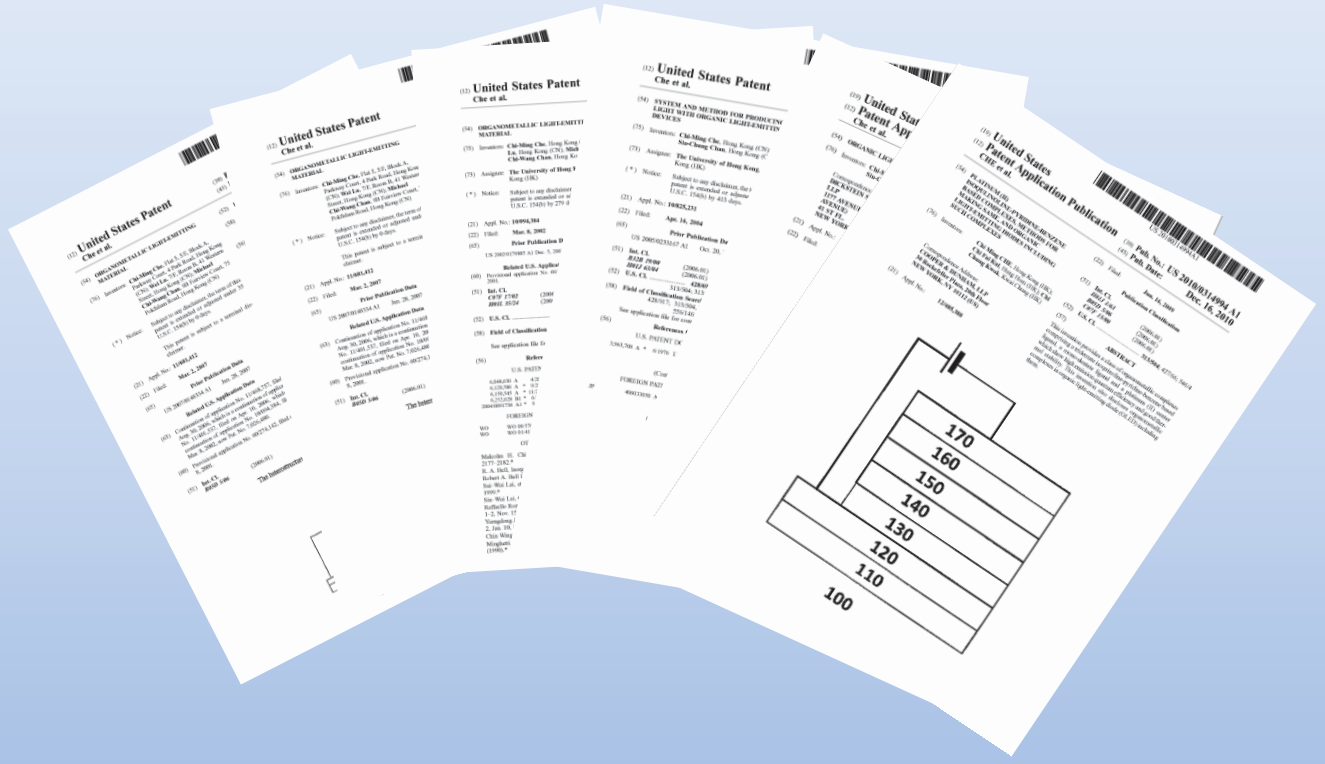
Our results

Colour (at 1000 cd/m²)	CIE	Luminous Efficiency (cd/A)	Lifetime LT 50 % (hrs)
CM-12	(0.58, 0.38)	9	77,000*
CM-45	(0.63, 0.36)	15	18,000*
CM-44	(0.41, 0.58)	89	-
CM-40	(0.35, 0.62)	82	> 180,000 hours***
CM-53	(0.31, 0.64)	99	-
CM-51	(0.19, 0.21)	24	-

* Lifetime result from *Collaborating Partner A* using their device configuration; initiation brightness: 500 cd/m².
** Lifetime result from *Collaborating Partner B*; initiation brightness: 1000 cd/m².
** Lifetime result from *Collaborating Partner C* using stable hole transporting and host materials which leading to a lower device efficiency; acceleration factor: 1.

Underpinning Research

All systems have been protected by HKU owned patents

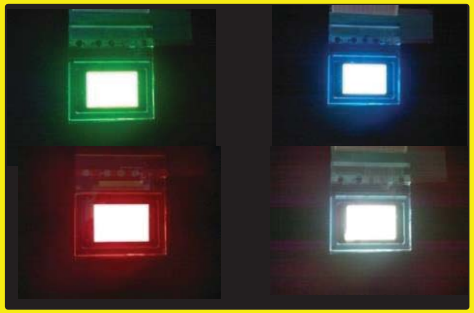


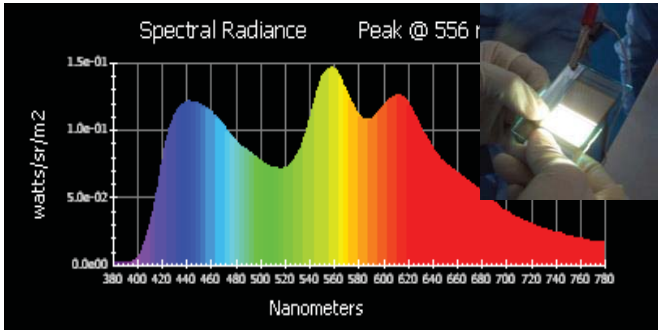
Most of them have been licensed to industry

Underpinning Research

Developed a high efficiency phosphorescent red-emitting material with original patent

Developed 1-inch full colour panel





Mark Thompson
S.R.Forrest

nature

"Highly efficient phosphorescent emission from organic electroluminescent devices" Nature , September 1998.

Che and Ma

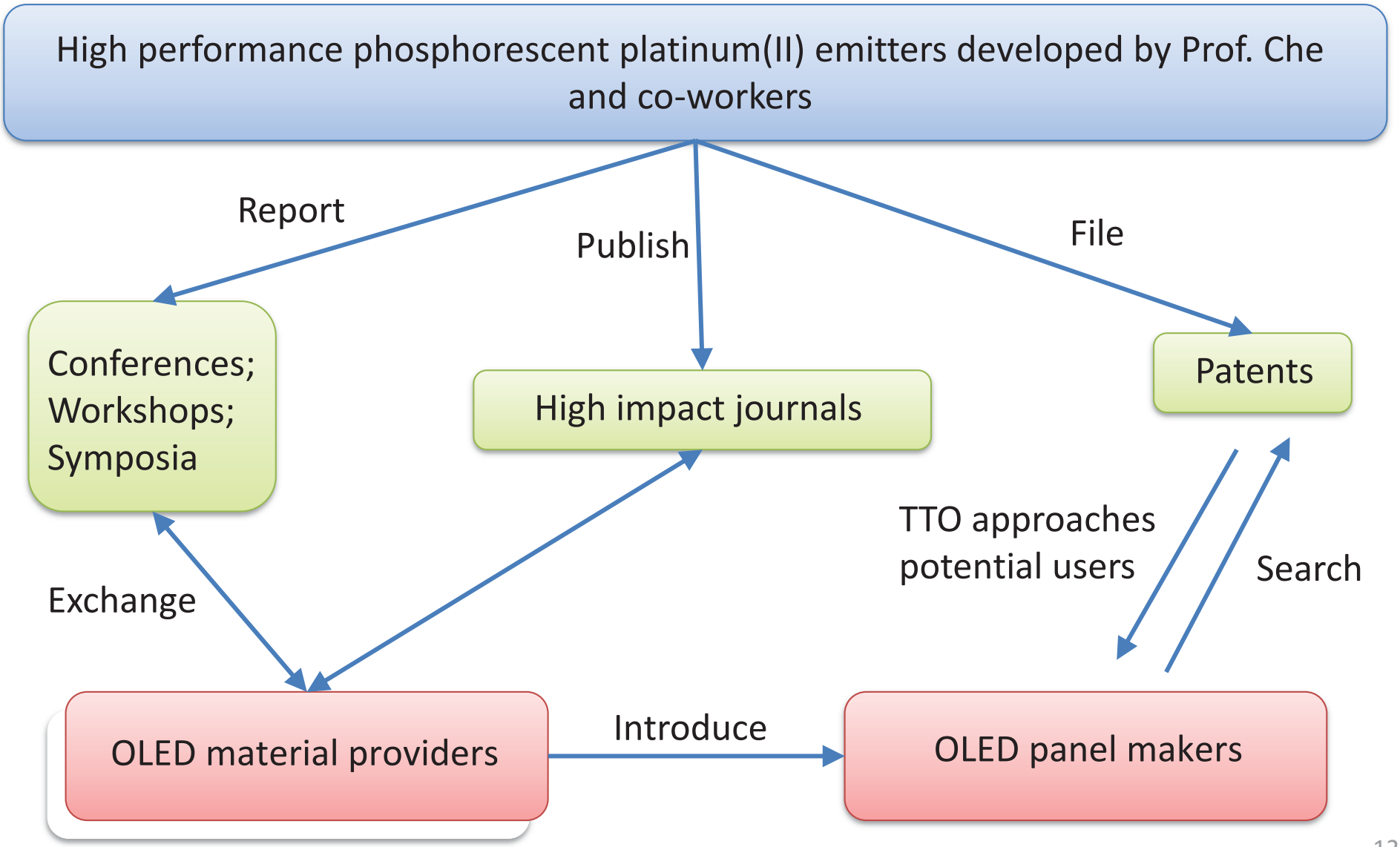
"Electroluminescence from triplet metal-ligand charge transfer excited state of transition metal complexes"

Synthetic Metals 94 (May ,1998) 245 - 248

1998	2002	2003	2004	2005	2006	2007	2008	2010	2011
	Lecloux, US 7,166,368		Kim, US 7,241,884						
	Che, US 7,026,480	Itoh, WO 2004/039781	Chi, US 7,002,013						
	Che, US 6,653,654	Sowinski, US 6,824,895	Nii, WO 2004/108857	DOBBS WO 2005075601	Okubo, Jp 2007-207968	Itoh, US 20080036373	Satou, US 20090026936		
			Lennartz, US 20070111025	Kitamura, US 20060068222	Matsushima, Jp 2007277170	Satou, US 20080054799	Kinoshita, US 20090079340		
			Sotoyama, WO 2006/025124	Ogasawara, US 20060099450	Igarashi US 20060255721	Iwakuma, US 20090030202	Hashimoto, US 20090115324		
			Itoh, WO 2005/042444	Ise, US 20060073359	Sano US 20060210831	Burce, WO 2009/040551	Kinoshita, US 2009/0153045		
			Nakayama, WO 2004/096755	Che US 10/835,481	Sano US 20060204787	Che, US 10/835, 481	Murakami US 20090072726		
			Che, US 7,361,415		Igarashi US 20060172146	Che, US 60/944,423	Takamutsu, WO 2008117889		

Developed a patentable phosphorescent blue-emitting material

Engagement


High performance phosphorescent platinum(II) emitters developed by Prof. Che and co-workers
Report
Publish
File
Conferences; Workshops; Symposia
High impact journals
Patents
TTO approaches potential users
Search
Exchange
OLED material providers
Introduce
OLED panel makers

Impacts Achieved

Research Grants

Period	Funding Body	Project Title	Amount
2014-2016	ITF	Blue-light emitting material for practical OLED application	HK$ 1,384,600
2011-2013	ITF	Research and Development of Phosphorescent Organic Light Emitting Diode (OLED) Materials and Prototype Devices for Lighting Applications	HK$ 13,664,990
2008-2010	ITF	Research & Development of New Materials for Printable Electrons	HK$ 11,070,000
2006-2007	ITF	New OLED Materials Technologies for Displays, Illumination and Backlighting	HK$ 5,500,000
2001-2004	ITF	Research and Development of New Materials for Organic Light Emitting Devices	HK$ 5,196,000
2010-2012	GRF	Phosphorescent Metal Complexes with d^8 and d^{10} Electronic Configurations. Photochemistry, and Self-Assembled Nanostructure	HK$ 1,217,076
2007-2010	GRF	Molecular Design and Application Studies of Photoluminescent Platinum(II) Complexes	HK$ 923,000
2013	973	Triplet Excited States – Basic Fundamental and Applications	RMB$ 34,000,000
2012-2016	TBRS	Challenges in Organic Photo-Voltaics and Light-Emitting Diodes- A Concerted Multi-Disciplinary and Multi-Institutional Effort	HK$ 57,407,000
2010-2017	AoE	Area of Excellence: Institute of Molecular Functional Materials	HK$ 92,000,000

Impacts Achieved

Selected Publications

Year	Title	Detail
2014	Structurally robust phosphorescent [Pt(ONCN)] emitters for high performance organic light-emitting devices with power efficiency up to 126 lmW^{-1} and external quantum efficiency over 20%	*Chemical Science* **2014**, 5, 4819
2013	High Efficiency White Organic Light-Emitting Devices Incorporating Yellow Phosphorescent Platinum(II) Complex and Composite Blue Host	*Advanced Functional Materials* **2013**, 23, 5168-5176
2013	Light-emitting platinum(II) complexes supported by tetradentate dianionic bis(N-heterocyclic carbene) ligands: towards robust blue electrophosphors	*Chemical Science* **2013**, 4, 2630
2013	Robust phosphorescent platinum(II) complexes with tetradentate O^N^C^N ligands: high efficiency OLEDs with excellent efficiency stability	*Chemical Communications* **2013**, 49, 1497
2007	Efficient white organic light-emitting devices based on phosphorescent platinum(II)/fluorescent dual-emitting layer	*Advanced Materials* **2007**, 19, 3599
2003	Structural, Photophysical and Electrophosphorescent Properties of Platinum(II) Complexes Supported by Tetradentate N_2O_2 Chelates	*Chemistry - A European Journal* **2003**, 9, 1263