Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Electronic Supplementary Information

Synthesis of narrow-band red-emitting $K_2SiF_6:Mn^{4+}$ phosphors for a deep red monochromatic LED and ultrahigh color quality warm-white LEDs

Ji Hye Oh, Heejoon Kang, Yun Jae Eo, Hoo Keun Park, and Young Rag Do*

Department of Chemisty, Kookmin University, Seoul, 136-702, Republic of Korea

yrdo@kookmin.ac.kr

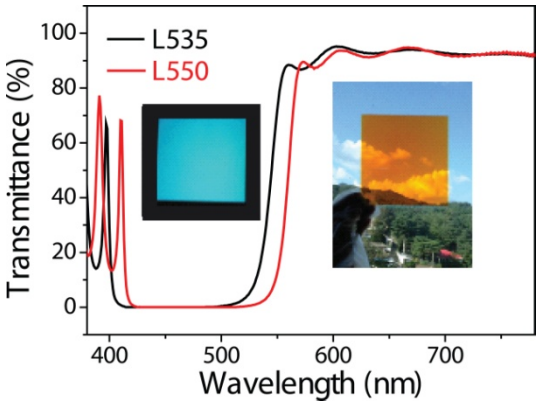

Fig. S1. The transmittance spectra of long-wavelength pass dichroic filters (LPDFs: L535 and L550, number denotes the cut-off wavelength of LPDFs), and photographs of the transmission and reflection of L535.

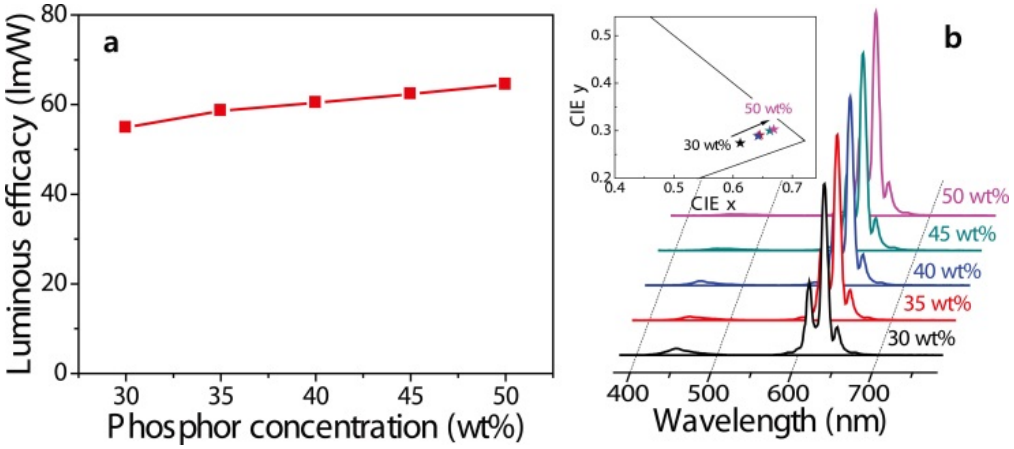

Fig. S2. (a) LEs and (b) EL spectra and 1931 CIE color coordinates of the $R_{N,B,M}$ pc-LED as a function of the $K_2SiF_6:Mn^{4+}$ phosphor concentrations.

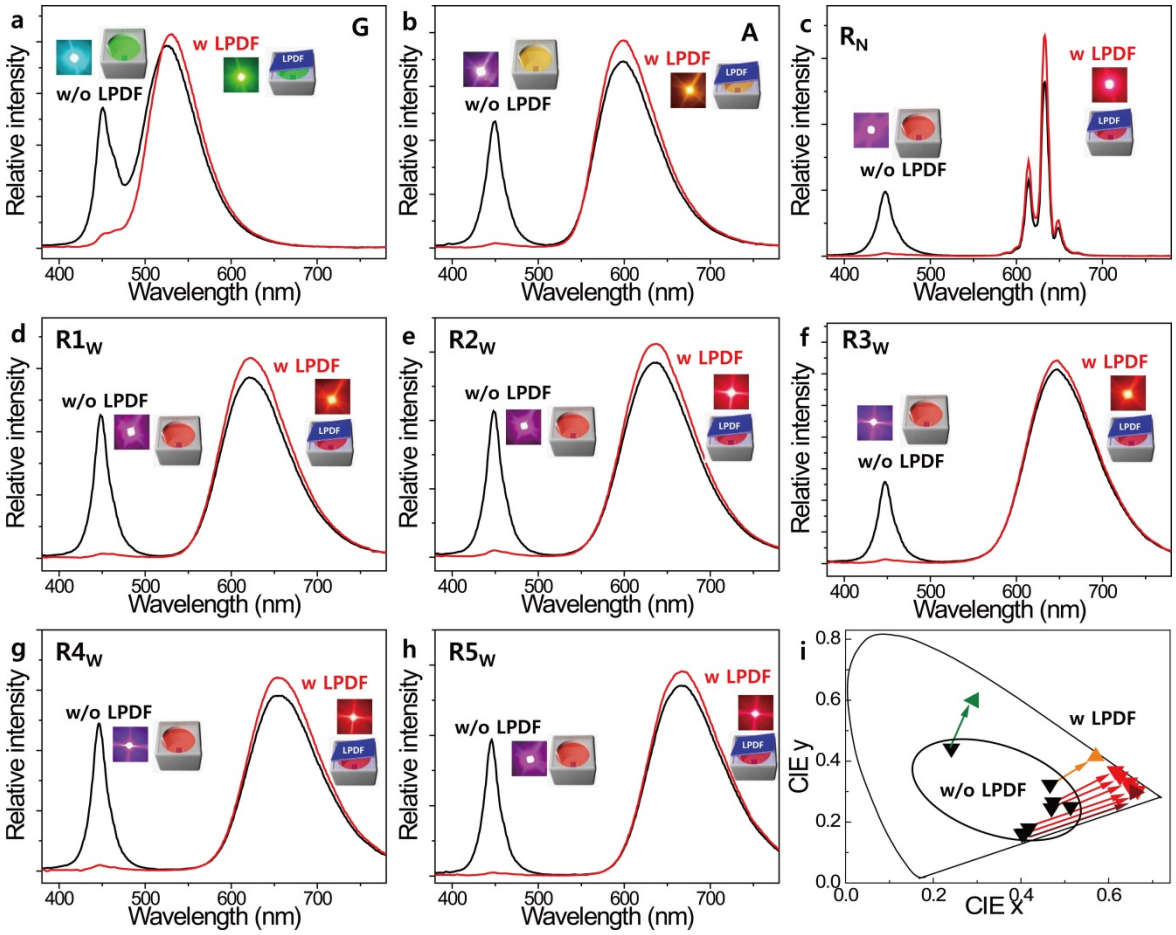

Fig. S3. Electroluminescent spectra of pc-LEDs with and without LPDF (inset: photographs of emission and schematic diagram) (a) green, (b) amber, (c) R_N, (d) $R1_W$, (e) $R2_W$, (f) $R3_W$, (g) $R4_W$ and (g) $R5_W$.

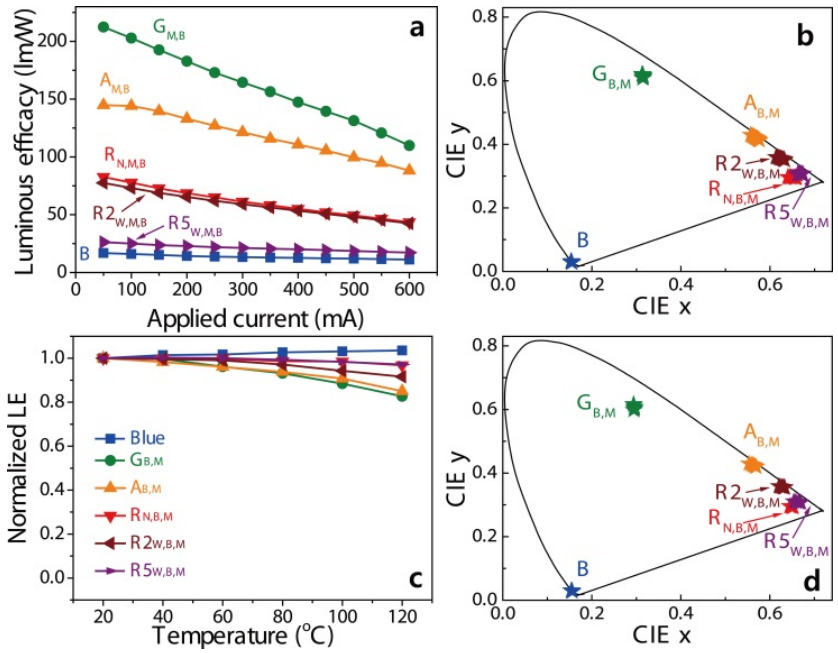

Fig. S4. The current dependence of the blue LED and $G_{B,M}$, $A_{B,M}$, $R_{N,B,M}$, $R2_{W,B,M}$, and $R5_{W,B,M}$ pc-LEDs: (a) relative LE and (b) 1931 CIE color coordinates. The temperature dependence of the blue LED and $G_{B,M}$, $A_{B,M}$, $R_{N,B,M}$, $R2_{W,B,M}$, and $R5_{W,B,M}$ pc-LEDs: (c) normalized LE and (d) 1931 CIE color coordinates.

Table S1. The optical properties of six combinations of multi-package white LEDs.

$R_{B,M}A_{B,M}G_{B,M}B$	CCT (K)	Color coordinates		LE (lm/W)	LER (lm/W)	CRI (R_a)	R_9	CQS (Q_a)
		CIE x	CIE y					
$R_{N,B,M}$	6584	0.312	0.323	95	299	87	96	88
	5000	0.345	0.351	101	312	89	90	91
	3448	0.408	0.391	109	328	92	95	93
	3012	0.434	0.400	107	328	92	94	93
	2756	0.456	0.410	107	331	94	93	93
	2092	0.512	0.408	95	318	94	71	90
$R1_{W,B,M}$	6500	0.314	0.321	85	289	83	35	81
	4905	0.348	0.354	93	312	83	30	83
	3473	0.412	0.404	105	333	82	11	83
	3021	0.438	0.409	105	329	82	8	82
	2786	0.459	0.420	104	330	80	1	82
	2066	0.526	0.423	86	316	68	-32	75
$R2_{W,B,M}$	6500	0.314	0.321	87	291	84	49	82
	4976	0.346	0.353	93	305	84	40	84
	3510	0.408	0.397	100	316	85	32	85
	3087	0.432	0.404	101	312	85	27	84
	2794	0.454	0.412	98	309	84	23	84
	2058	0.522	0.417	82	293	74	-10	79
$R3_{W,B,M}$	6500	0.313	0.332	90	287	84	58	85
	4952	0.347	0.355	94	289	87	67	87
	3437	0.407	0.388	93	292	89	57	88
	2941	0.439	0.401	89	288	89	49	87
	2653	0.463	0.411	87	287	88	40	87
	2000	0.524	0.410	73	264	79	14	80
$R4_{W,B,M}$	6542	0.312	0.328	91	273	84	67	85
	4952	0.347	0.355	92	278	87	71	88
	3437	0.410	0.394	91	275	89	61	88
	3021	0.434	0.400	87	265	89	56	88
	2660	0.461	0.407	83	254	88	48	87
	2029	0.521	0.411	69	217	81	24	82
$R5_{W,B,M}$	6584	0.312	0.330	90	273	83	59	84
	5053	0.344	0.357	90	275	85	64	87
	3497	0.406	0.393	86	275	88	55	87
	3040	0.433	0.400	82	268	88	52	86
	2653	0.462	0.408	77	261	86	42	85
	2025	0.525	0.415	64	240	78	19	81