

## Luminescent Materials and their Application Areas

Chemical Composition	Application Areas
$\text{Al}_2\text{O}_3:\text{Cr}^{3+}$	Laser gain media (694 nm), NIR imaging, gemstones
$\text{Al}_2\text{O}_3:\text{Ti}^{3+}$	Laser gain media (650 – 1100 nm), gemstones
$(\text{Ba,Sr})_2\text{SiO}_4:\text{Eu}^{2+}$	LEDs (green)
$\text{Ba}_2\text{LiSi}_7\text{AlN}_{12}:\text{Eu}^{2+}$	LEDs (515 nm)
$\text{Ba}_2\text{Si}_5\text{N}_8:\text{Eu}^{2+}$	LEDs (580 nm)
$\text{Ba}_3(\text{PO}_4)_2:\text{Eu}^{2+}$	Storage screens
$\text{Ba}_5\text{GeO}_4\text{Br}_6:\text{Eu}^{2+}$	Storage screens
$\text{Ba}_5\text{SiO}_4\text{Br}_6:\text{Eu}^{2+}$	Storage screens
$\text{Ba}(\text{F,Br}):\text{Eu}^{2+}$	Storage screens
$\text{Ba}(\text{F,Cl}):\text{Eu}^{2+}$	X-ray intensifying screens
$\text{BaAl}_8\text{O}_{13}:\text{Eu}^{2+}$	Color 80 FLs (478 nm)
$\text{BaAl}_{12}\text{O}_{19}:\text{Eu}^{2+}$	Color 80 FLs (440 nm)
$\text{BaAl}_{12}\text{O}_{19}:\text{Mn}^{2+}$	PDPs (green pixel)
$\text{BaF}_2$	Crystals for high performance calorimeters
$\text{BaMgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$	FLs(color 80), PDPs (blue pixel), DB Xe discharge lamps
$\text{BaMgAl}_{10}\text{O}_{17}:\text{Eu}^{2+},\text{Mn}^{2+}$	FLs (color 90), PDPs (green pixel), DB Xe discharge lamps
$\text{BaSi}_2\text{O}_5:\text{Pb}^{2+}$	FLs for tanning (350 nm)
$\text{BaSi}_7\text{N}_{10}:\text{Eu}^{2+}$	LEDs (blue)
$\text{Bi}_4\text{Ge}_3\text{O}_{12}$	PET detectors, scintillator screens
$(\text{Ca,Mg})\text{SiO}_3:\text{Mn}^{2+}$	CRT screens (yellow)
$(\text{Ca,Sr})\text{AlSiN}_3:\text{Eu}^{2+}$	LEDs (red)
$(\text{Ca,Sr})_2\text{SiO}_4:\text{Eu}^{2+}$	LEDs (orange)
$\text{Ca}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+},\text{Nd}^{3+}$	Long afterglow screens (green)
$\text{Ca}_2\text{Si}_5\text{N}_8:\text{Eu}^{2+}$	LEDs (red)
$\text{Ca}_5(\text{PO}_4)_3(\text{F,Cl}):\text{Sb}^{3+}$	FLs („haloblu“)
$\text{Ca}_5(\text{PO}_4)_3(\text{F,Cl}):\text{Sb}^{3+},\text{Mn}^{2+}$	FLs (color 70, „halophosphate lamps“)
$\text{CaAl}_2\text{O}_4:\text{Eu}^{2+},\text{Nd}^{3+}$	Long afterglow screens (440 nm: blue)
$\text{CaAlSiN}_3:\text{Eu}^{2+}$	LEDs (650 nm: deep red)
$\text{CaCuSi}_4\text{O}_{10}$	LEDs (900 nm: NIR)
$\text{CaLi}_2\text{SiO}_4:\text{Pr}^{3+},\text{Na}^+$	Blue-to-UVC up-conversion
$\text{CaS}:\text{Ce}^{3+},\text{Na}^+$	LEDs (green)
$\text{CaS}:\text{Ce}^{3+},\text{Sm}^{3+}$	Storage screens
$\text{CaS}:\text{Eu}^{2+}$	DCPEL, LEDs, EL displays (red pixel)
$\text{CaS}:\text{Eu}^{2+},\text{Sm}^{3+}$	Storage screens
$\text{CaS}:\text{Eu}^{2+},\text{Tm}^{3+}$	Long afterglow screens (red)
$\text{CaS}:\text{Mn}^{2+}$	DCPEL, EL displays (green pixel)
$\text{CaSc}_2\text{O}_4:\text{Eu}^{2+}$	LEDs (green)
$\text{CaSiO}_3:\text{Mn}^{2+},\text{Pb}^{2+}$	Storage screens (orange)
$\text{CaWO}_4$	X-ray intensifying screens
$\text{CaWO}_4:\text{Pb}^{2+}$	X-ray intensifying screens
$\text{CaZnGe}_2\text{O}_6:\text{Mn}^{2+}$	Long afterglow screens (red)
$\text{CdSe}$	QD LED LCD Displays (red)

CdWO <sub>4</sub>	Scintillator screens
Cd <sub>2</sub> B <sub>2</sub> O <sub>5</sub> :Mn <sup>2+</sup>	FLs (626 nm, mid 20 <sup>th</sup> century)
CeF <sub>3</sub>	Crystals for high performance calorimeters
CeMgAl <sub>11</sub> O <sub>19</sub> :Tb <sup>3+</sup>	Color 80 FLs (544 nm)
CsI	Crystals for high performance calorimeters
CsI:Na <sup>+</sup>	Scintillator screens
CsI:Tl <sup>+</sup>	CT detectors
Ga <sub>2</sub> O <sub>3</sub> :Eu	EL displays (red pixel)
Gd <sub>2</sub> O <sub>2</sub> S:Eu <sup>3+</sup>	X-Ray intensifying screens
Gd <sub>2</sub> O <sub>2</sub> S:Pr <sup>3+</sup> , Ce <sup>3+</sup>	X-Ray intensifying screens
Gd <sub>2</sub> O <sub>2</sub> S:Tb <sup>3+</sup>	Low-voltage CRTs, FEDs (green pixel)
Gd <sub>2</sub> SiO <sub>5</sub> :Ce <sup>3+</sup>	PET detectors, scintillator screens
Gd <sub>2</sub> SiO <sub>5</sub> :Tb <sup>3+</sup>	X-Ray intensifying screens
Gd <sub>3</sub> Ga <sub>5</sub> O <sub>12</sub> :Cr <sup>3+</sup>	LEDs (NIR)
Gd <sub>3</sub> Ga <sub>5</sub> O <sub>12</sub> :Ce <sup>3+</sup> , Cr <sup>3+</sup>	CT detectors
Gd <sub>3</sub> Ga <sub>5</sub> O <sub>12</sub> :Tb <sup>3+</sup>	X-Ray intensifying screens
Gd <sub>3</sub> Sc <sub>2</sub> Al <sub>3</sub> O <sub>12</sub> :Sm <sup>3+</sup>	Laser gain media (red)
GdAlO <sub>3</sub> :Cr <sup>3+</sup>	NIR medical imaging and therapy
GdMgB <sub>5</sub> O <sub>10</sub> :Ce <sup>3+</sup>	FLs (cosmetic, UV-A)
GdMgB <sub>5</sub> O <sub>10</sub> :Ce <sup>3+</sup> , Tb <sup>3+</sup>	Color 80 FLs (544 nm)
GdMgB <sub>5</sub> O <sub>10</sub> :Ce <sup>3+</sup> , Tb <sup>3+</sup> , Mn <sup>2+</sup>	Color 90 FLs (630 nm)
GdTaO <sub>4</sub> :Eu <sup>3+</sup>	X-Ray intensifying screens (red)
GdTaO <sub>4</sub> :Tb <sup>3+</sup>	X-Ray intensifying screens (green)
InBO <sub>3</sub> :Eu <sup>3+</sup>	Low-voltage CRTs (orange pixel)
InBO <sub>3</sub> :Tb <sup>3+</sup>	Low-voltage CRTs (green pixel)
K <sub>2</sub> SiF <sub>6</sub> :Mn <sup>4+</sup>	LEDs (631 nm)
KMgF <sub>3</sub> :Mn <sup>2+</sup>	CRTs (orange pixel)
KY <sub>3</sub> F <sub>10</sub> :Pr <sup>3+</sup>	Laser gain media
La <sub>2</sub> O <sub>2</sub> S:Tb <sup>3+</sup>	Low-voltage CRTs (green pixel)
La <sub>3</sub> Si <sub>6</sub> N <sub>11</sub> :Ce <sup>3+</sup>	LEDs (yellow)
LaB <sub>3</sub> O <sub>6</sub> :Gd <sup>3+</sup> , Bi <sup>3+</sup>	FLs for medical purposes (311 nm)
LaBO <sub>3</sub> :Sm <sup>3+</sup>	Security marking
LaF <sub>3</sub> :Ce <sup>3+</sup>	Scintillator screens
LaMgAl <sub>11</sub> O <sub>19</sub> :Ce <sup>3+</sup>	FLs for cosmetic or medical purposes (345 nm)
LaOBr:Tb <sup>3+</sup>	Low-voltage CRTs (green pixel)
LaOBr:Tm <sup>3+</sup>	X-ray intensifying screens (blue)
LaPO <sub>4</sub> :Ce <sup>3+</sup>	Cosmetic and medical FLs (320 nm)
LaPO <sub>4</sub> :Ce <sup>3+</sup> , Tb <sup>3+</sup>	Color 80 FLs (544 nm)
LiAlO <sub>2</sub> :Fe <sup>3+</sup>	FLs (plant growth)
LiEuMo <sub>2</sub> O <sub>8</sub> :Eu <sup>3+</sup>	LEDs (615 nm)
LiYF <sub>4</sub> :Pr <sup>3+</sup>	Laser gain media
Lu <sub>2</sub> SiO <sub>5</sub> :Ce <sup>3+</sup>	PET detectors, scintillator screens
Lu <sub>2</sub> Si <sub>2</sub> O <sub>7</sub> :Ce <sup>3+</sup>	PET detectors, scintillator screens
LuAlO <sub>3</sub> :Ce <sup>3+</sup>	PET detectors, scintillator screens
Lu <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> :Ce <sup>3+</sup>	LEDs, PET detectors, scintillator screens
Lu <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> :Er <sup>3+</sup>	Laser gain media, luminescent marker
Lu <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> :Eu <sup>3+</sup>	Luminescent marker

$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Gd}^{3+}$	UV-B lamps (314 nm)
$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Nd}^{3+}$	Laser gain media
$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Pr}^{3+}$	UV-B lamps (310 nm), PET, Blue-to-UVB up-conversion
$\text{LuPO}_4:\text{Ce}^{3+}$	PET detectors, Scintillator screens
$\text{MgSiO}_3:\text{Eu}^{2+},\text{Dy}^{3+},\text{Mn}^{2+}$	Long afterglow screens (red)
$\text{Mg}_2\text{SnO}_4:\text{Mn}^{2+}$	Long afterglow screens (cyan)
$\text{Mg}_{13}\text{As}_2\text{O}_{18}:\text{Mn}^{4+}$	HP Hg discharge lamps, FLs (655 nm: red decoration)
$\text{Mg}_8\text{Ge}_2\text{O}_{11}\text{F}_2:\text{Mn}^{4+}$	HP Hg discharge lamps, FLs (660 nm: red decoration)
$\text{MgF}_2:\text{Mn}^{2+}$	Radar screens (orange)
$\text{MgS}:\text{Eu}^{2+}$	CRT screens (orange), Dosimeters
$\text{MgWO}_4$	X-ray intens. screens, CRTs, FLs (480 nm, mid 20 <sup>th</sup> century)
$\text{NaI}:\text{Tl}^+$	PET detectors, Scintillator screens
$\text{NaYF}_4:\text{Yb}^{3+},\text{Er}^{3+}$	Up-Converter crystals (green)
$\text{NaYF}_4:\text{Yb}^{3+},\text{Tm}^{3+}$	Up-Converter crystals (blue)
$\text{RbBr}:\text{Tl}^+$	Storage screens
$\text{ScBO}_3:\text{Tb}^{3+}$	CRTs (green pixel)
$\text{Sr}_2\text{Al}_6\text{O}_{11}:\text{Eu}^{2+}$	Color 90 FLs (492 nm)
$\text{Sr}_2\text{MgSi}_2\text{O}_7:\text{Eu}^{2+},\text{Nd}^{3+}$	Long afterglow screens (blue)
$\text{Sr}_2\text{MgSi}_2\text{O}_7:\text{Pb}^{2+}$	FLs (cosmetic, UV-A)
$\text{Sr}_2\text{P}_2\text{O}_7:\text{Eu}^{2+}$	FLs (Photocopy lamps, violet)
$\text{Sr}_2\text{SiO}_4:\text{Eu}^{2+},\text{Dy}^{3+}$	Long afterglow screens (orange)
$\text{Sr}_2\text{Si}_5\text{N}_8:\text{Eu}^{2+}$	LEDs (620 nm)
$\text{Sr}_2\text{Si}_5\text{N}_8:\text{Eu}^{2+},\text{Yb}^{2+}$	Long afterglow screens (red)
$(\text{Sr},\text{Mg})(\text{PO}_4)_3:\text{Sn}^{2+}$	HP Hg discharge lamps (orange-red)
$(\text{Sr},\text{Zn})(\text{PO}_4)_3:\text{Sn}^{2+}$	HP Hg discharge lamps (orange-red)
$\text{Sr}_3\text{Gd}_2\text{Si}_6\text{O}_{18}:\text{Pb}^{2+},\text{Mn}^{2+}$	FLs (green)
$\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+},\text{Dy}^{3+}$	Color 90 FLs (490 nm), long AG screens (cyan)
$\text{Sr}_5(\text{PO}_4)_3\text{Cl}:\text{Eu}^{2+}$	Color 80 FLs (445 nm)
$\text{SrAl}_2\text{O}_4:\text{Eu}^{2+},\text{Dy}^{3+}$	Long afterglow screens (520 nm)
$\text{SrAl}_{12}\text{O}_{19}:\text{Ce}^{3+},\text{Na}^+$	Cosmetic FLs (300 nm)
$\text{SrAl}_{12}\text{O}_{19}:\text{Sm}^{3+}$	Security marking, NIR imaging
$\text{SrB}_4\text{O}_7:\text{Eu}^{2+}$	Blacklight lamps, Cosmetic FLs (368 nm)
$\text{SrB}_4\text{O}_7:\text{Sm}^{2+}$	Security marking
$\text{SrGa}_2\text{O}_4:\text{Pr}^{3+}$	EL displays (red pixel)
$\text{SrGa}_2\text{O}_4:\text{Tm}^{3+}$	EL displays (blue pixel)
$\text{SrGa}_2\text{S}_4:\text{Ce}^{3+},\text{Na}^+$	Flying-spot scanner tubes (blue)
$\text{SrGa}_2\text{S}_4:\text{Eu}^{2+}$	ACTFEL, LEDs, EL displays (green pixel)
$\text{SrGa}_2\text{S}_4:\text{Pb}^{2+}$	Flying-spot scanner tubes (orange)
$\text{SrLiAl}_3\text{N}_4:\text{Eu}^{2+}$	LEDs (650 nm)
$\text{SrLi}_2\text{SiO}_4:\text{Pr}^{3+},\text{Na}^+$	Blue-to-UVC up-conversion
$\text{SrMgSi}_3\text{N}_4:\text{Eu}^{2+}$	LEDs (615 nm)
$\text{SrS}:\text{Ce}^{3+}$	DCPEL, EL displays (green pixel)
$\text{SrS}:\text{Eu}^{2+}$	LEDs, EL displays (red pixel)
$\text{SrS}:\text{Eu}^{2+},\text{Sm}^{3+}$	Storage screens
$\text{SrSc}_2\text{O}_4:\text{Eu}$	Long afterglow screens (686 nm)
$\text{Tb}_3\text{Al}_5\text{O}_{12}:\text{Ce}^{3+}$	LEDs (yellow)
$\text{Y}_2\text{O}_3:\text{Eu}^{3+}$	Color 80 FLs (611 nm), FEDs, PDPs (red pixel)

$(Y,Gd)_2O_3:Eu^{3+},Pr^{3+}$	CT Detectors, CL lamps, PDPs (red pixel)
$Y_2O_2S:Eu^{3+}$	CRTs, FEDs (red pixel: 627 nm)
$Y_2O_2S:Yb^{3+},Er^{3+}$	Up-Converter (green)
$Y_2SiO_5:Ce^{3+}$	Low-voltage CRTs (blue pixel), storage screens
$Y_2SiO_5:Ce^{3+},Sm^{3+}$	Storage screens
$Y_2SiO_5:Ce^{3+},Tb^{3+}$	HP Hg discharge lamps
$Y_2SiO_5:Tb^{3+}$	Low-voltage CRTs (green pixel)
$Y_2Si_2O_7:Ce^{3+}$	Flying spot scanner, Beam index tubes
$Y_2W_3O_{12}:Eu^{3+}$	Low-voltage CRTs (red pixel)
$Y_3Al_5O_{12}:Ce^{3+}$	LEDs, color 90 FLs, HP Hg and DB Xe discharge lamps
$(Y,Gd)_3Al_5O_{12}:Ce^{3+}$	LEDs (yellow)
$Y_3(Al,Ga)_5O_{12}:Ce^{3+}$	LEDs, Low-voltage CRTs (green pixel)
$Y_3Al_5O_{12}:Er^{3+}$	Laser gain media (IR: 1.56 $\mu m$ ), Luminescent marker
$Y_3Al_5O_{12}:Eu^{3+}$	Luminescent marker
$Y_3(Al,Ga)_5O_{12}:Tb^{3+}$	FEDs (green pixel)
$Y_3Al_5O_{12}:Ho^{3+}$	Laser gain media (NIR)
$Y_3Al_5O_{12}:Nd^{3+}$	Laser gain media (NIR)
$Y_3(Al,Ga)_5O_{12}:Nd^{3+}$	Laser gain media (NIR)
$Y_3Al_5O_{12}:Pr^{3+}$	UV-B Lamps (320 nm)
$Y_3Al_5O_{12}:Tb^{3+}$	Low-voltage CRTs (green pixel)
$Y_3(Al,Ga)_5O_{12}:Tb^{3+}$	Low-voltage CRTs (green pixel)
$Y_3Al_5O_{12}:Yb^{3+}$	Laser gain media (NIR)
$Y_3(Al,Ga)_5O_{12}:Yb^{3+}$	Laser gain media (NIR)
$(Y,Gd)BO_3:Eu^{3+}$	PDPs (red pixel), DB Xe discharge lamps
$(Y,Gd)BO_3:Tb^{3+}$	PDPs (green pixel), DB Xe discharge lamps
$YAlO_3:Ce^{3+}$	PET detectors, scintillator screens (blue)
$YPO_4:Bi^{3+}$	DB Xe discharge lamps (disinfection, UV-C)
$YPO_4:Ce^{3+}$	FLs (cosmetic, UV-A)
$YPO_4:Nd^{3+}$	DB Xe discharge lamps (photolysis, VUV)
$YTaO_4:Nb^{5+}$	X-Ray intensifying screens
$YTaO_4:Tm^{3+}$	X-Ray intensifying screens
$YVO_4$	PDPs (blue pixel)
$YVO_4:Eu^{3+}$	HP Hg discharge lamps, CRTs (red pixel: 615 nm)
$YVO_4:Nd^{3+}$	Laser gain media (NIR)
$Y(V,P)O_4:Eu^{3+}$	HP Hg discharge lamps, PDPs (red pixel: 615 nm)
$Zn_2SiO_4:Mn^{2+}$	Color 80 FLs (525 nm), CRTs, FEDs, PDPs (green pixel)
$(Zn,Be)_2SiO_4:Mn^{2+}$	FLs (mid 20 <sup>th</sup> century)
$Zn_2(Si,Ge)O_4:Mn^{2+}$	EL Displays (green pixel)
$Zn_3(PO_4)_2:Mn^{2+}$	CRTs (red pixel)
$ZnGa_2O_4:Mn^{2+}$	EL Displays (cyan)
$ZnO:Zn^0$	CRTs, EL (green pixel)
$ZnS:Ag^+$	CRTs, FEDs (blue pixel: 450 nm)
$(Zn,Cd)S:Ag^+$	CRTs (green pixel)
$(Zn,Cd)S:Ag^+$	CRTs (red pixel)
$ZnS:Cu^+,Al^{3+},Au^+$	ACPEL, CRTs (green pixel)
$ZnS:Cu^+,Co^{3+}$	Long afterglow screens (green)
$ZnS:Mn^{2+}$	ACPEL, EL Displays (yellow pixel)

(Zn,Cd)S:Mn <sup>2+</sup>	ACPEL, EL Displays (yellow pixel)
ZnS:Tb <sup>3+</sup>	ACTFEL screens (green)
ZnWO <sub>4</sub>	Scintillator screens

### Abbreviations (Lamps, Lighting, and Luminescence)

ACPEL	Alternating Current Powder Electro Luminescence
ACTFEL	Alternating Current Thin Film Electro Luminescence
AG	Afterglow
AMOLED	Active Matrix Organic Light Emitting Diode
CFL	Compact Fluorescent Lamp
CL	Cathode Luminescence
CR	Cross-Relaxation
CRT	Cathode-Ray Tube
CT	Computed Tomography
DB	Dielectric Barrier
DCPEL	During Current Powder Electro Luminescence
DCTFEL	During Current Thin Film Electro Luminescence
EL	Electro Luminescence
ET	Energy Transfer
ETU	Energy Transfer Up-Conversion
EUV	Extreme Ultra-Violet (10 - 100 nm)
FED	Field Emission Display
FIR	Far Infra-Red (50 - 1000 μm)
FL	Fluorescent Lamp
HP	High-Pressure
IR-A	Infra-Red A (700 – 1400 nm)
IR-B	Infra-Red B (1400 – 3000 nm)
IR-C	Infra-Red A (3000 nm – 1000 μm)
LCD	Liquid Crystal Display
LD	Laser Diode
LED	Light Emitting Diode
LP	Low-Pressure
MIR	Mid Infra-Red (3 - 50 μm)
MP	Medium-Pressure
NIR	Near Infra-Red (0.7 - 3 μm)
NUV	Near Ultraviolet (380 – 420 nm)
OLED	Organic Light Emitting Diode
OPV	Organic Photovoltaics
PALCD	Plasma Addressed Liquid Crystal Display
PCLED	Phosphor Converted Light Emitting Diode
PDP	Plasma Display Panel
PET	Positron Emission Tomography
PL	Photoluminescence
PV	Photovoltaics
QD	Quantum Dot
QLED	Quantum Dot comprising Light Emitting Diode
SHG	Second Harmonic Generation

SPECT	Single Photon Emission Computed Tomography
UC	Up-Conversion
UHP	Ultra High Pressure
UPS	Ultraviolet Photoluminescence Spectroscopy
UV	Ultraviolet
UV-A	Ultraviolet A (320 – 400 nm)
UV-B	Ultraviolet B (280 – 320 nm)
UV-C	Ultraviolet C (200 – 280 nm)
VUV	Vacuum Ultraviolet (100 – 200 nm)
XPS	X-ray Photoluminescence Spectroscopy