Phosphor crystals for tailored spectrum LEDs

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Abstract:

Phosphor converted LED (pc-LED) is experiencing a rapid growth for energy efficient solid state general lighting applications. By using a variety of available phosphors, it is possible to create a tailored the spectrum of the LEDs in the entire visible range. The full potential of pc-LEDs beyond general lighting is still yet to be fully explored. For example, artificial lighting mimicking natural sunlight in conjunction with next generation of displays with full spectrum backlighting will have beneficial effects on the cognitive psycho-physiological health of human beings. This talk will briefly present our motivation for the development of pc-LEDs using phosphor crystals instead of powders. The role of single crystal phosphors on the spectrum tunability, enhanced light extraction and enhanced environmental stability are some of the advantages over powder phosphor or ceramic substrates. High temperature melt and flux growth processes for phosphor crystals will be discussed. Classes of phosphor compounds include thiogallates $(SrCaBaMg)(AlGa)_2(SSe)_4:Eu^{2+}$, sulfides and selenides $(SrCaGa)SSe:Eu^{2+}$, tungstate, molybdates, vanadates and niobates $[(SrCaMgBaYGdLa)_x(VNbWMo)_yO_z:Eu^{3+}$, Ho^{3+}, Dy^{3+}, Pr^{3+}, Sm^{3+}, Tb^{3+}. Our studies have demonstrated that melt and flux grown phosphor crystals (Figure 1) exhibit many interesting features compared to solid state synthesized powders such as (a) higher excitation efficiency, (b) extension of charge transfer bands from UV to the blue regions, (c) reduced degradation with moisture exposure and (d) higher lumens output from pc-LEDs.

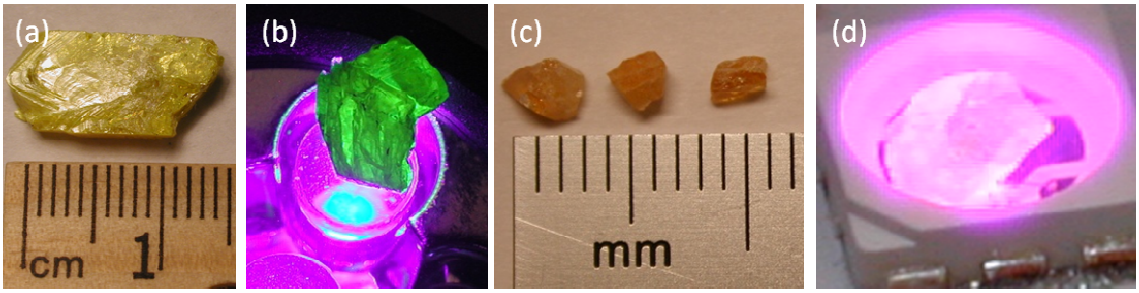

Figure 1. (a) $SrGa_2S_4:Eu^{2+}$ crystal, (b) green luminescent $SrGa_2S_4:Eu^{2+}$ crystal when excited by a 400 nm LED source, (c) $Ca_{0.76}WO_4$: $Eu^{3+}{}_{0.12}/Na^{+}{}_{0.12}$ crystals, (d) red luminescent $Ca_{0.76}WO_4$: $Eu^{3+}{}_{0.12}/Na^{+}{}_{0.12}$ crystals when exited by a 380 nm LED source.