DEPARTMENT OF

PHYSICS & ASTRONOMY

SPEAKER SERIES

PRAIRIE UNIVERSITIES PHYSICS SEMINAR SERIES

Direct Measurements of Energy Levels in Next Generation Nitride Phosphors

Alexander Moewes

University of Saskatchewan

Thurs, March 21

1:40-2:55PM

D632

Everyone welcome!

Highly efficient narrow-band red emitting phosphors are the most desired and requested materials for developing illumination grade phosphor-converted light emitting diodes (pcLEDs). This research presents direct measurements of RE energy levels, critical to the color and efficiency of LED phosphors. Modern phosphors use the $5d_1$ to $4f_{n+1}$ transition of Eu^{2+}, which is an excited state since Eu^{2+} has no 5d electrons in the ground state. Unlike the relatively localized 4f states, the 5d states are very sensitive to the surrounding crystal and therefore key Eu^{2+} luminescence parameters like wavelength and efficiency can be tailored by the choice of host lattice. However, the problem is that the energetic position of the $5d_1$ was not possible to be measured directly. Dorenbos showed that thermal quenching (TQ) is caused by thermal excitation of the 5d electron to the CB, refuting other discussed mechanisms. The energy positions of the 5d have therefore been determined indirectly by measuring the thermal quenching curves. The difficulty here is that the thermal quenching depends strongly on the quality of the crystal matrix and therefore can only offer an estimation. For the first time, we experimentally directly determine the energetic separation of the Eu 5d state and the conduction band, which is the key indicator of quantum efficiency. This was achieved for the three next-generation pcLED phosphors $Li_2Ca_2[Mg_2Si_2N_6]:Eu^{2+}$, $Ba[Li_2(Al_2Si_2)\text{-}N_6]:Eu^{2+}$, and $Sr[LiAl_3N_4]:Eu^{2+}$ using resonant inelastic soft X-ray scattering. Furthermore we directly observe conduction to valence band and 4f to valence band transitions in X-ray excited optical luminescence spectra of $Sr[LiAl_3N_4]:Eu^{2+}$ and $Sr[Mg_3SiN_4]:Eu^{2+}$. These techniques are widely applicable and create a comprehensive, experimental picture of the important Eu^{2+} energy levels in these compounds, leading to a complete understanding of all pertinent electronic processes. This study forms the base needed for a detailed discussion of the structure − property relationships, such as specific atoms, coordination and density of states, underpinning phosphor color, efficiency and quenching.

University of Lethbridge

FIAT LUX