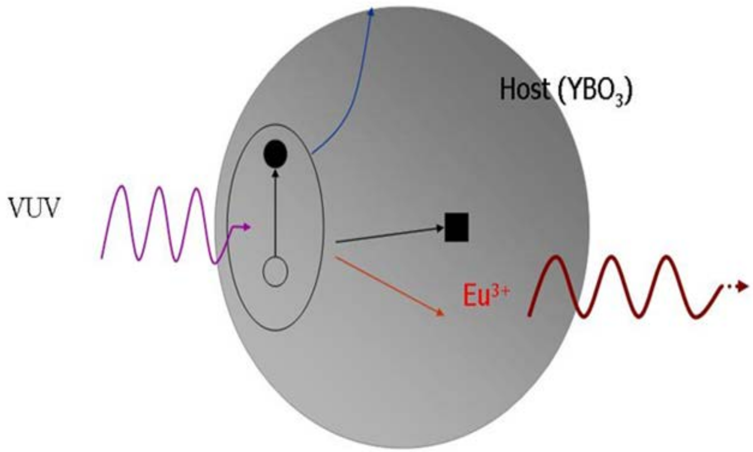
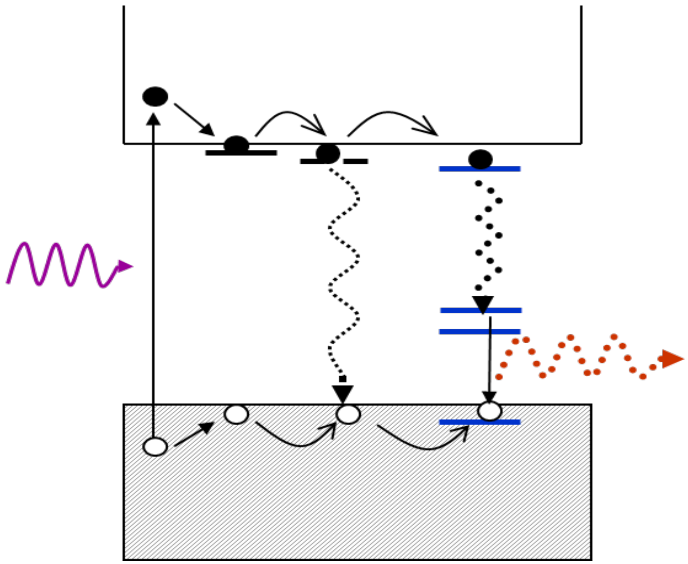
Diaz Research Group – electron migration and trapping in luminescent materials





Dr. Diaz's research involves the study of electron-hole (e-h) pair transport and trapping in doped luminescent materials under vacuum ultraviolet (VUV) excitation. Excitation by VUV radiation leads to the formation of an e-h pair in the host. In order for luminescence to occur this e-h pair must be trapped by the rare earth dopant. However, the electron may also be trapped by bulk killers (impurities or defects), or it may be lost to surface states. In this figure YBO_3 is the host and Eu^{3+} is the dopant. The purpose of our research is to quantify the fate of the e-h pair after absorption of a VUV photon takes place.

Above is another view of the process, which shows the electronic states involved. Once created, the e-h pair migrates through the lattice until it is trapped by killers or by a dopant. Dopant states are in blue, and loss to killers is indicated by the dashed line. The overall efficiency of host excitation once a photon is absorbed is given by $\eta_{host} = \eta_t*\eta_{qe}$, where η_t is the transfer efficiency and η_{qe} is the quantum efficiency of the dopant after the e-h pair is trapped. The transfer efficiency is then η_{host}/η_{qe}. These quantities are determined spectroscopically via absorbance and excitation measurements – essentially comparing the amount of light the material absorbs to the amount of light emitted by the dopant after absorption.

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$$\eta_t = \frac{\alpha N}{\alpha N + \beta} S_{loss}$$

activator concentration

rate constant to activator

rate to killers

Once transfer efficiency data are collected they are modeled using the equation on the left. The transfer efficiency is simply the ratio of the rate of transfer to dopants (also called "activators") divided by the combined rate of trapping by killers and activators. The multiplier S_{loss} is equal to 1 when no energy is lost to the surface, and approaches zero as more surface loss takes place. If transfer efficiency data are collected for a series of dopant concentrations, the α/β ratio and the value of S_{loss} can be determined. Theoretical curves are shown below on the left, while recent data on nanocrystalline $YBO_3:Eu^{3+}$ are shown on the right. With particle sizes > 500 nm no surface loss is observed, while at 25 nm more than 40% of absorbed energy is lost to the surface.