Cross-Ionization in $Gd_3Sc_2Al_3O_{12}:Ce^{3+}$

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A cross-relaxation process has been observed in $Gd_3Sc_2Al_3O_{12}:Ce^{3+}$ between Gd^{3+} and Ce^{3+} ions that leads to the promotion of Ce^{3+} electrons into the host conduction bands. Energy transfer between the Gd^{3+} and Ce^{3+} ions is evident in the Ce^{3+} excitation spectrum, which shows sharp peaks coinciding with Gd^{3+} transition, in addition to the broad Ce^{3+} 5d bands. To demonstrate the presence of a "cross-ionization" process we conducted photoconductivity studies of the garnet $Gd_3Sc_2Al_3O_{12}:Ce^{3+}$. Photoconductivity is a direct way to detect electron transfer processes - in our case the promotion of an impurity electron into the host conduction band. For our studies a sample of the dimensions 5x5x1 mm^3 was cut and polished and mounted between two nickel meshes serving as transparent electrodes. These electrodes were electrically insulated from a copper sample holder by sapphire plates. The sample holder was then mounted onto the cold finger of a temperature variable cryostat.

Persistent photocurrents were excited by radiation from a 300 W Xe arc lamp filtered through a f/2 double monochromator (McPherson). The photocurrent as a function of excitation wavelength was measured with a Keithley 6517 electrometer. Under an applied voltage of 1000 V the observed current varied between 10^{-15} to 10^{-13} A, with a noise level of less than 10^{-15} A.

From our experiments, we establish a photoionization threshold for the Ce^{3+} ion of about 3.4 eV. Thus, the lowest 5d band (2.75 eV above the Ce^{3+} groundstate) is located within the host bandgap, while higher 5d bands are already resonant with the conduction band. This result is similar to those obtained in our group for a number of Ce^{3+} doped materials.

Novel in our experiment is the presence of narrow peaks in high resolution photoconductivity spectra at 4.0 eV and 4.5 eV, coinciding with f-f transition of Gd ions. We note that the undoped host material does not show these peaks in the photoconductivity spectrum. Thus, while excitation of the Gd^{3+} ions around 4.5 eV does not promote electrons directly into the conduction band (due to the large energy difference between the Gd^{3+} groundstate and the host conduction band), energy transfer to the Ce^{3+} ion leads to ionization due to the proximity of the Ce^{3+} groundstate to the host conduction band.

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