N89 - 14915

319-36
ABS. ONLY
174758
3P

ET 146083

THE DETERMINATION OF ENERGY TRANSFER RATES IN THE Ho:Tm:Cr:YAG LASER MATERIAL

By

Edmond B. Koker
Assistant Professor
Department of Physical Sciences
Elizabeth City State University
Elizabeth City, NC 27909

Energy transfer processes occurring between atomic, ionic, or molecular systems are very widespread in nature. The applications of such processes range from radiation physics and chemistry to biology. In the field of laser physics, energy transfer processes have been used to extend the lasing range, increase the output efficiency, and influence the spectral and temporal characteristics of the output pulses of energy transfer dye lasers or solid-state laser materials. Thus in the development of solid-state lasers, it is important to investigate the basic energy transfer (ET) mechanisms and processes in order to gain detailed knowledge so that successful technical utilization can be achieved. The aim of the present research is to measure the ET rate from a given manifold associated with the chromium (Cr) sensitizer atom to a given manifold in the holmium (Ho) activator atom via the thulium (Tm) transfer atom, in the Ho:Tm:Cr:YAG laser material.

The energy level diagram for this material is illustrated in Figure 1. The specific mechanism of the process by which the excitation energy is transferred from sensitizer to activator is not quite clear at the present time. However, the following possibilities may account for what is believed to be occurring. Firstly, absorption of the incident 532 nm photon by the chromium atom excites it to the $^4T_2$ manifold. This is followed by relaxation of the lattice surrounding it resulting in a phonon transition to the ^2E manifold, from which some emission occurs. Secondly, some of the available electronic energy from the $^4T_2$ manifold is transferred to the $^4F_4 + {}^5S_2$ manifold of the activator, Ho, and the $^3F_3$ manifold of Tm resulting in emission from these levels. The third possibility is that the emission of a photon from the sensitizer is followed by reabsorption by the transfer ion, Tm, resulting in its excitation to lower-lying excited manifolds from which emission and/or transfer can occur to the $^5I_7$ manifold of holmium. Emission from $^5I_7$ to $^5I_8$ follows. The fourth possibility is for up-conversion to take place in the transfer ion; for example, from the Cr $^4T_2$ level to the Tm $^1G_4$ manifold. This level then emits to the $^3H_5$ manifold. Measurements of the lifetimes of these manifolds will shed some light on the exact mechanism.

The measurement is performed as a function of the upper and lower manifolds, the concentration of the activator and the temperature. The probability of transfer is concentration, and to some extent, temperature dependent. Transfer rates are inferred by exciting the sensitizer atom and measuring the rate of rise of the fluorescence from the activator atom. Typical emission spectra, shown in Figure 2, were generated using an Nd:YAG laser as the pump source. The 532 nm output from this laser was impinged on the doped crystal situated in a modified variable temperature dewar. The emission from the material was dispersed through a monochromator, at right angles to the pump source, and detected using a cooled photomultiplier tube (PMT). The PMT signal was processed by a gated integrator and boxcar averager, and fed to an IBM XT computer system. The rate of rise and decay of the fluorescence signal, shown in Figure 3, was monitored by scanning the gate of the boxcar across the signal from the manifold to which the monochromator was tuned.

All manifolds to which the excited manifold transfers energy were monitored, in addition to the ones to which it decays. By doing the latter, an independent check of the data would be obtained. This technique will be applied in the energy transfer rate elucidation of other component systems, such as Ho:Er:YAG, Ho:Tm:YAG,and Tm:Er:YAG in the near future.

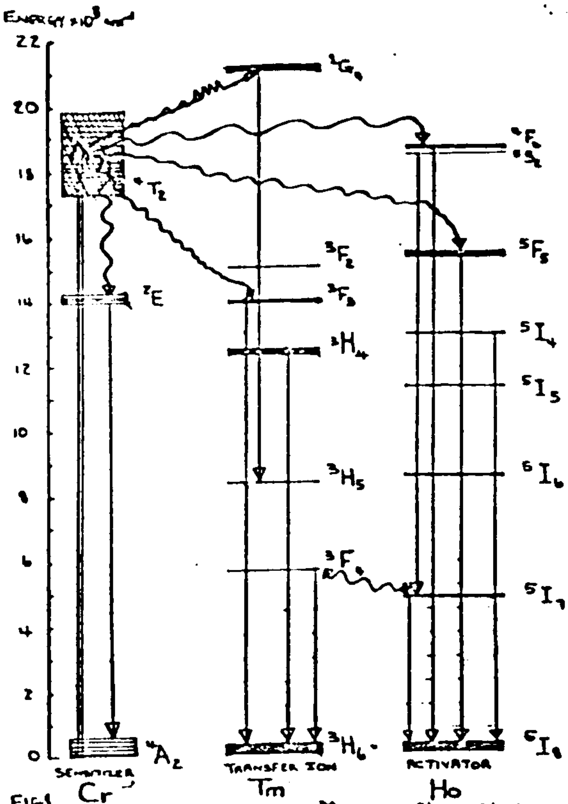

FIG1
ENERGY LEVELS OF Cr^{3+}, Tm^{3+} AND Ho^{3+} IN YAG

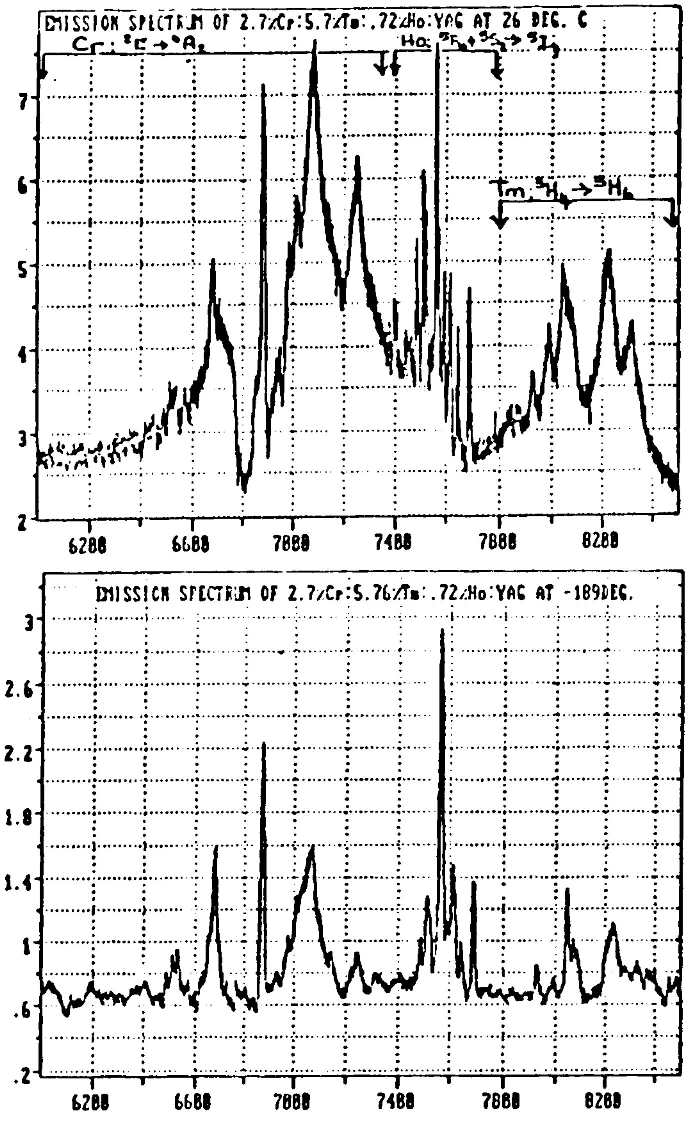

FIG. 2

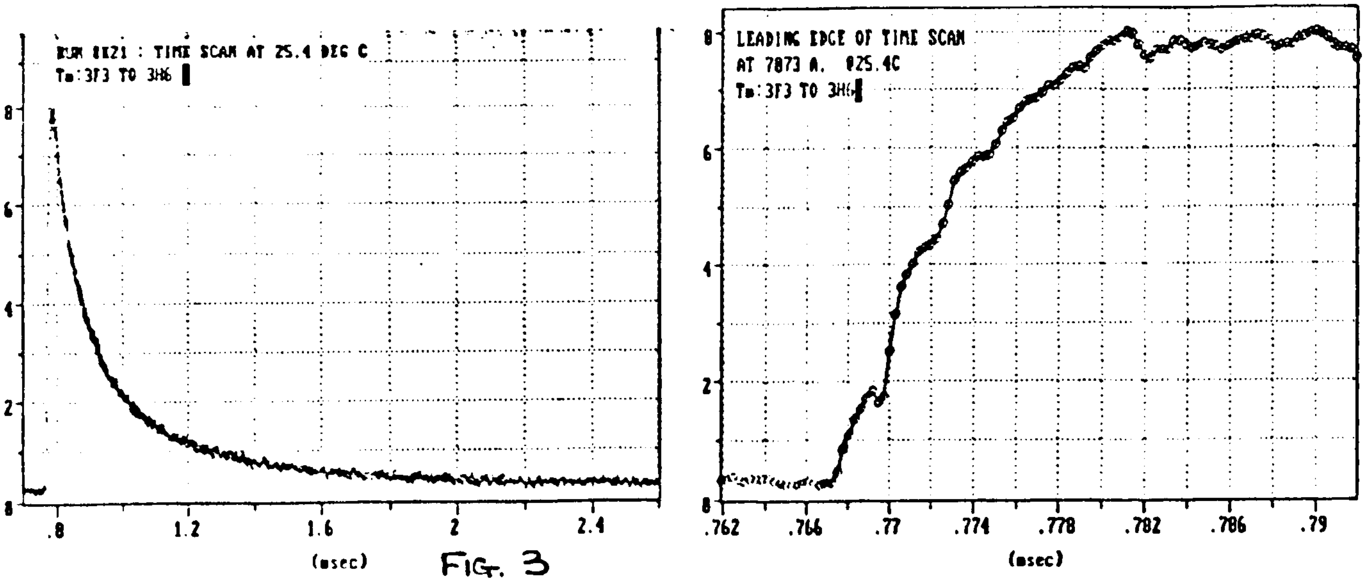

FIG. 3