Functional Materials 10, No.1 (2003) © 2003 — Institute for Single Crystals

# High pressure photoluminescence characterization of inhomogeneous broadening of the $^2E \rightarrow {}^4A_2$ transition in $Cr^{3+}$ ion in LLGG crystals

*A. Kornylo, M.Grinberg, T. Lukasiewicz*, J. Kisielewski*, M. Swirkowicz**

Institute of Experimental Physics, University of Gdansk, 57 Wita Stwosza, 80-952 Gdansk, Poland
*Institute of Electronic Materials Technology, 133 Wolczynska, 01-919 Warsaw, Poland

Lanthanum-lutetium-gallium garnets $La_{2.32}Lu_{2.59}Cr_{0.02}Ga_{3.07}O_{12}$ and $La_{2.7}Lu_{2.29}Cr_{0.01}Ga_3O_{12}$ have been grown by Czochralski method. We have measured the photoluminescence in pressure range from ambient to 220 kbar within temperature range of 20 K to 280 K. As the pressure increases, a significant shift of the broad band related to the $^4T_2 \rightarrow {}^4A_2$ transition in $Cr^{3+}$ ions toward higher energy (shorter wavelength) is observed. At pressures exceeding 90 kbar, the broad band is replaced by sharp lines near 14100 $cm^{-1}$ related to the $^2E \rightarrow {}^4A_2$ transition. Low-temperature, high-pressure photoluminescence measurements in the $La_{2.32}Lu_{2.59}Cr_{0.02}Ga_{3.07}O_{12}$ system allowed to identify four different $R_1$ lines related to four $Cr^{3+}$ sites (α, β, γ and δ).

Методом Чохральского выращены лантано-лютециево-галлиевые гранаты $La_{2.32}Lu_{2.59}Cr_{0.02}Ga_{3.07}O_{12}$ и $La_{2.7}Lu_{2.29}Cr_{0.01}Ga_3O_{12}$. Измерялась фотолюминесценция в диапазоне давлений от атмосферного до 220 кбар при температурах от 20 К до 280 К. При повышении давления наблюдается значительный сдвиг широкой полосы, отнесенной к переходу $^4T_2 \rightarrow {}^4A_2$ в ионах $Cr^{3+}$, в сторону высоких энергий (коротких волн). При давлениях свыше 90 кбар эта широкая полоса сменяется узкими линиями в области 14100 $см^{-1}$, отнесенными к переходу $^2E \rightarrow {}^4A_2$. Измерения фотолюминесценции в системе $La_{2.32}Lu_{2.59}Cr_{0.02}Ga_{3.07}O_{12}$ при низких температурах и высоких давлениях позволили различить четыре различных $R_1$-линии, соответствующие четырем позициям $Cr^{3+}$ (α, β, γ и δ).

Mixed garnets with lanthanum and gallium are described by general formula $\{La_3\}[R_2](Ga_3)O_{12}$ where {}, [] and () correspond to the sites of dodecahedral, octahedral and tetrahedral coordination, respectively [1]. R represents Sc, Lu, Yb, Tm, and Er. Lanthanum-lutetium-gallium garnet (LLGG) crystals of the $\{La_{3-y}Lu_y\}[Lu_2](Ga_3)O_{12}$ composition doped with Nd were first grown by Kokta and Grasso [2]. The crystals were examined as potential laser diode-pumped solid state laser material [3]. It was found that to obtain a single-phase garnet, the minimum $y$ value should be 0.3. In practice, the composition of the examined crystals varied from $Nd_{0.13}La_{2.14}Lu_{2.53}Ga_{3.20}O_{12}$ to $Nd_{0.04}La_{2.32}Lu_{2.57}Ga_{3.07}O_{12}$ [3]. Chromium in its trivalent state, $Cr^{3+}$, usually occupies the $Lu^{3+}$ sites. The ground state of the octahedrally coordinated $Cr^{3+}$ ions is always $^4A_2$. The LLGG is characterized by a large lattice parameter [2], therefore, $Cr^{3+}$ ions incorporated in LLGG form the weak-field centres where the first excited state is the $^4T_2$ electronic manifold. In such a case, luminescence is characterized by a broad band