YAG:Nd luminescence: a new pressure sensor for diamond anvil cell

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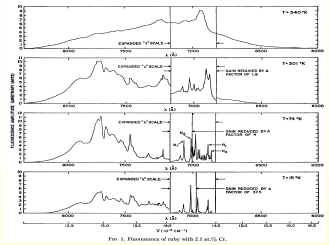
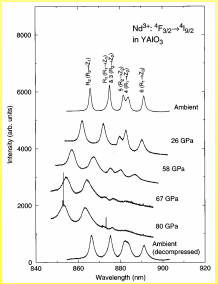
Problem:
Ruby luminescence is well-known and most elaborated pressure sensor for diamond anvil cells (DAC).
Ruby emits red light around 700 nm, thus spectra investigated in this wavelength range may be affected by the ruby emission, that consists not only of the R-lines but also some other features.

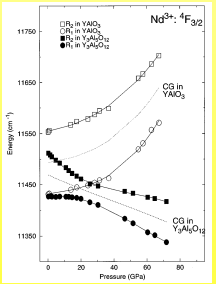


R. C. Powell, *Phys. Rev.* **155**, 296-308 (1967)

Proposed solution:
To find a new pressure sensor with similar performance, but with luminescence well separated from the ruby emission region. The pressure-sensitive emission should be easily recorded with available luminescence detectors and excited with popular lasers (for example, Ar^+ laser).

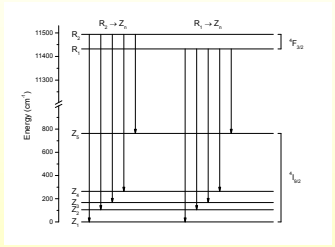
Previous works:
Luminescence shift with pressure was studied by H. Hua, Y. K. Vohra. The observed Nd^{3+} luminescence lines are associated with the $^4F_{3/2} \rightarrow {}^4I_{9/2}$ transitions. Due to some experimental constrains authors did not investigate the two most interesting lines of Nd^{3+}, placed near 950 nm associated with transitions ending at the highest component of the $^4I_{9/2}$ electronic level of Nd^{3+}.

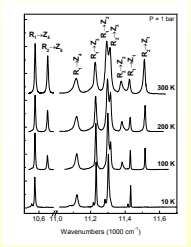


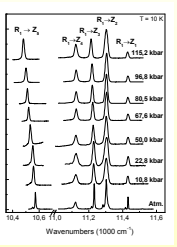


H. Hua, Y. K. Vohra, *Appl. Phys. Lett.*, **71**, 2602 (1997)

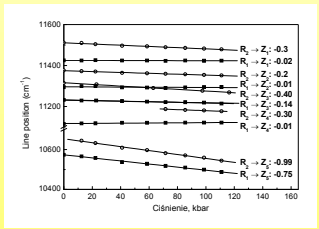
Our results:
We studied luminescence of a commercial YAG:Nd (0,9 at. %) laser rod under the pressure up to 120 kbar and temperature range 10 – 300 K.



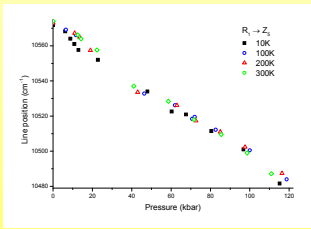




In the region of 950 nm there are two luminescence lines with noticeably high pressure coefficients.



It was found that the values of these coefficients do not depend on temperature between liquid helium temperature and 300 K within the experimental error.



Summary:

Parameters	Ruby	YAG:Nd^{3+}
FWHM (10K)	R_1: 4,5	$R_1 \rightarrow Z_5$: 6,6
	R_2: --	$R_2 \rightarrow Z_5$: --
$\Delta E/\Delta P$, cm^{-1}/kbar	R_1: -0,76	$R_1 \rightarrow Z_5$: -0,75
	R_2: -0,76	$R_2 \rightarrow Z_5$: -0,99
$\Delta E/\Delta T$, cm^{-1}/K	R_1: -0,14	$R_1 \rightarrow Z_5$: 0,0073
	R_2: -0,14	$R_2 \rightarrow Z_5$: 0,0093
Availability	+	+

1. Due to it's availability and high pressure coefficients of $R_1 \rightarrow Z_5$ and $R_1 \rightarrow Z_5$ transitions of Nd^{3+} crystal, YAG:Nd^{3+} can be readily used as an accurate pressure gauge for DAC between liquid helium and room temperatures.

2. At the same time there is no luminescence from Nd^{3+} in the region around 700 nm, which makes YAG:Nd crystal a good replacement for ruby in case of luminescence measurements in DAC in this spectral region.

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