Title: Visiting Professor Research Subject. Crystal growth and spectroscopic properties of laser single crystals/ceramics

Abstract: I have continued fruitful cooperation with Pr.Yoshikawa and Pr;Goto Labs between November 13 and December 16, 2012, mainly on (Nd^{3+}/Yb^{3+})-doped transparent sesquioxide and spinel ceramics or crystals for laser application. I also have been invited at the Material Science Week 2012, November 28 – 30, 2012.

This is a great privilege to cooperate with IMR Laboratories since a long time. I have proposed to apply our fruitful relationships between LPCML (nowadays ILM at the UCBLyon1) and IMR (Tohoku University) with the natural continuation of the laser materials research program on rare earth (Nd^{3+}/Yb^{3+})-doped transparent sesquioxide and spinel ceramics/crystals as laser materials with high melting points. I want to express my acknowledgements to Prof. Niinomi, Head of IMR, Prof. Nojiri, Head of ICC-IMR, Prof. Konno, TEM Lab, Prof. Goto, SPS ceramics Lab and Prof. Yoshikawa, Advanced Crystal Engineering Lab.

The project ELyT lab : M12–LASMAT has started in march 2012, including Yoshikawa and Goto's teams. Lu_2O_3 have been selected among sesquioxides for the following reasons: this is an un-active lattice in optics like Sc_2O_3, Y_2O_3, the easy substitution of Lu^{3+} by other rare earth cations as dopants, the highest thermal conductivity (12.5 W/m/K) and a lower phonon energy (391cm-1) comparing with YAG (700cm-1). We first focus our attention on Lu_2O_3 ceramics, then we will study Lu_2O_3 crystals grown by µ-PD using a special crucible. Indeed, Lu_2O_3 has high melting point up to 2490 °C, which makes it extremely difficult to be grown by conventional crystal growth methods. Such difficulties make people seek other ways to get Lu_2O_3 as a ceramic laser material.

The research activity on advanced laser materials is indeed increasing with the availability of transparent sintered polycrystalline ceramics which present some advantages compared to single crystals (sizes, mechanical strength, overall production cost, low cost) [1]. After the pioneer works of Dr. A. Ikesue [2] at the World Lab. Co.Ltd and Dr. H. Yagi at the Konoshima Company [3] on ceramics fabricated by conventional methods, an original and promising research is under progress, with the synthesis of Nd^{3+}: Lu_2O_3 ceramics by non-conventional Spark Plasma Sintering (SPS) technique by Prof.T. Goto's team [4]. The spectroscopic properties are analyzed at LPCML (UCBLyon1) and will be compared with the rare earth-doped crystals grown by Prof.A. Yoshilawa's team. Regarding the spatial distribution of rare earth dopants we have already published results with A. Yoshikawa's team on rare earth segregation phenomenon in YAG laser ceramics especially from TEM associated with EDX probe in cooperation with Dr. T. Epicier at INSA-Lyon lab [5-8]. We program the same evaluation with Lu_2O_3 ceramic.

Another interest of Nd^{3+}: Lu_2O_3 single crystal is the recent report on laser output in 2011 [9] which points out a specific dual Nd^{3+} wavelengths lasing at 1076.4 and 1080.5 nm (see Fig.1) very promising for applications in coherent terahertz (THz) generation by difference frequency and ultrahigh repetition rate pulse by optical beating.

Fabrication, thermal conductivity and structural

characterization by TEM will be done at IMR whereas spectroscopic and laser properties will be analyzed and optimized at ILM. Our first analysis of absorption spectra, emission spectra and life times of Nd^{3+} $^4F_{3/2}$ level under selective wavelengths made at LPCML(Lyon) have been submitted and discussed with the members of this cooperation.

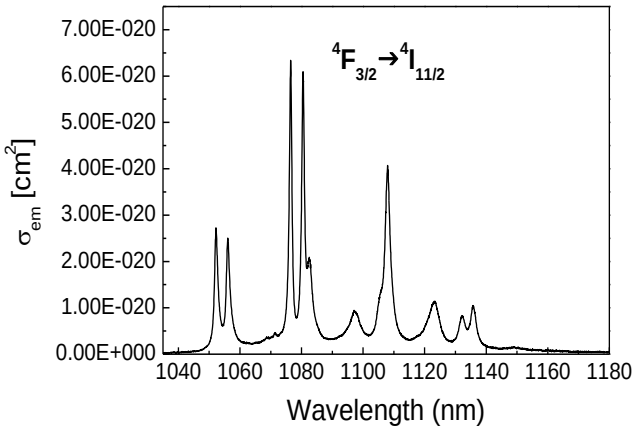

Fig.1 IR Emission spectra of 1%Nd-doped Lu_2O_3 ceramic showing the two 1076.4 and 1080.5 nm laser lines of the main C_2 crystallographic site.

It was also the opportunity to attend ICC-IMR- ELyT workshop on materials science on November 27 and to have been invited at the Material Science Week 2012 (MSW2012), Summit of Material Science, November 28– 30, 2012. The high interest of such Material Science Week is to have access to the large program of IMR on materials. My Invited talk was given for the Introduction session (I 2) and was related with ”Laser materials: from single crystals to polycrystalline ceramics and distribution of rare earth dopants” which is directly connected with my IMR cooperation [5-8]. The goal of this lecture was to present the evolution of laser materials from doped- single crystals to doped-ceramics. Another important cooperation between IMR (Prof. T Konno, Prof. K. Sato), INSA-Lyon (Dr. T. Epicier) and us in UCBLyon1 involves detection of Yb dopants at the atomic level in a YAG optical ceramic by STEM-HAADF, has been presented by T. Epicier (P 94).

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