SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: MP1401
STSM title: Chalcogenide Glasses for Integrated Infrared Sensors and Lasers
STSM start and end date: 11/11/2018 to 01/12/2018
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PURPOSE OF THE STSM:

Chalcogenide glasses are notoriously appealing materials for MIR optics and photonics, owing to their exceptionally broad transmission range, which covers a large section of the light spectrum, from visible, through near-IR, to the mid-IR. Rare earth-doped chalcogenides have gained interest in recent years for being promising materials for NIR and MIR applications, both for signal generation and for sensing [1-11].
Chalcogenide thin films are particularly interesting for the purpose of fabricating optically active devices in the infrared range, and especially for integrated devices [2-4] and confined structures such as optical waveguides and fibres [5-7].
This mission was carried out in the framework of the study of PVD-fabricated erbium-doped GeGaSbS (2S2G-S:Er3+) thin films. The main purpose of the STSM was to obtain the optical and spectroscopic properties of films deposited by RF-sputtering and PLD, in particular the fluorescence spectra in the near- and mid-infrared, and the fluorescence lifetimes of the main transitions.
As the samples were previously annealed, the new data were needed for comparison with older measurements, in order to estimate the effects of the heat treatment on the films.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

The experiments consisted in spectroscopic measurements, performed by exciting the samples with a diode laser in an unguided-light configuration. Excitation was achieved by focusing the laser onto the sample surface at an angle. Modulated laser diodes centered at 980 nm and 808 nm were used to excite the main emission transitions of erbium ions.
The emitted fluorescence was then collected by a lens aligned to the samples surface normal, and focused onto the intake slit of a monochromator, and the residual scattered laser signal was filtered out by a long-pass filter. The signal was then collected by a detector at the monochromator output, and finally processed by a lock-in amplifier and recorded.
An InGaAs detector was used for near-IR fluorescence, while a liquid nitrogen-cooled InSb detector was employed for longer wavelengths.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

The fluorescence spectra of the erbium-doped chalcogenide films were collected. The 1.5 µm emission band corresponding to the $^4I_{13/2} \rightarrow ^4I_{15/2}$ transition was observed clearly when exciting with a laser diode at 980 nm to the $^4I_{11/2}$ level. By exciting the system to the $^4I_{9/2}$ level, at 808 nm, the 1.5 µm emission was also observed,

along with the 980 nm emission corresponding to the $^4I_{11/2} \rightarrow {}^4I_{15/2}$ transition, and the 2.7 µm emission corresponding to the $^4I_{11/2} \rightarrow {}^4I_{13/2}$ transition were also detected. While it is possible to also observe the $^4I_{9/2} \rightarrow {}^4I_{11/2}$ transition at 4.5 µm in bulk glass samples, the signal from the thin films is too low to detect that emission.
The fluorescence bands obtained were compared to those obtained in previous measurements, to assess the effect of annealing on the samples spectroscopy. The band shapes show changes after the annealing process, and the effect is more pronounced in the PLD samples than the sputtered ones.
The $^4I_{13/2} \rightarrow {}^4I_{15/2}$ transition lifetime was recorded for all samples by fitting the time-resolved signal with a single exponential decay function. These fluorescence lifetimes were then compared to those estimated before annealing: the comparison yielded that the annealing process increased the lifetimes, more significantly for PLD samples.
The 2.7 µm emission lifetime was also estimated for a set of samples, by collecting the time-resolved fluorescence measurement at 980 nm and calculating the value for the $^4I_{11/2} \rightarrow {}^4I_{13/2}$ transition by virtue of the known branching ratios from the $^4I_{11/2}$ level.
A first draft of the full paper containing the detailed results and treatment of these measurements, and intended for peer-reviewed publishing, is underway and will be available shortly.

FUTURE COLLABORATIONS (if applicable)

Further collaboration between the University of Pardubice, ISCR, FOTON and CIMAP are envisioned in the future, in the framework of the fabrication and characterisation of rare earth-doped quaternary chalchogenide thin films and optical devices for infrared sensing and light generation.

References

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