SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: MP1401

STSM title: Evaluation of gamma rays on EDF used in ring laser configuration

STSM start and end date: 11/06/2018 to 22/06/2018

Grantee name: Andrei STANCALIE

|  |
| --- |
| **PURPOSE OF THE STSM/** |
| (max.500 words)  Based on a national funded project, in 2017 the collaboration between the National Institute for Laser Plasma and Radiation Physics (Romania) and The University of Navarra (UPNA, Pamplona) started with a short working visit in the Laboratories of the University of Dr. Andrei Stancalie, with the kind support and invitation by Prof. Dr. Manuel López-Amo. The work, focused then, on the radiation effects on several erbium doped fibers (EDF) as investigated with different equipment in different set-up configurations. As our work showed promising results, we decided to push forward the investigation. Within the COST Action MP1401, I had the opportunity to benefit of a short time scientific mission in order to extend the preliminary investigations and the collaboration between the two partners. Prior to the STSM, two types of EDF were irradiated at INFLPR with different doses of gamma-ray. Our main purpose was to study the parameters of a fiber laser (ring laser configuration) in terms of laser stability output over time and laser power output, by using both irradiated and non-irradiated EDF fibers in a comparative manner. As a secondary task, we tried to obtain a random laser configuration by using a gamma irradiated optical fiber. The purpose of the STSM was for Andrei Stancalie together with the researchers from UPNA to develop the setups and study the parameter variations depending on the radiation dose. |

|  |
| --- |
| **DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS** |
| (max.500 words)  Two types of EDF, 5 meters long were irradiated in Romania with doses starting from 200 Gy up to 1kGy. The gamma-ray irradiation was run at a 60Co GC-5000 (BRIT, India) irradiator having a chamber volume of 5,000 cm3. The dose rate was 5.7 kGy/h (±1.8 %). The working plan that was carried had several steps. Before introducing the fibers in the fiber-ring configuration, they were carefully analysed with an optical spectrum analyser as well with a optical frequency domain reflectometer (LUNA, OBR 4600). Radiation induced effects were found to be linear with accumulated dose but different between the two types of optical fibers utilized. The first EDF fiber was M-12(980/125), which is a highly erbium doped fiber with a high conversion efficiency and designed for small package size C-band amplifiers. The second studied EDF was the type I-25(980/128), and also suitable for C amplifiers with an optimized core composition for high-channel-count DWDM systems´ EDFAs. For these fibers, the peak core absorption were between 16 to 20 dB/m at 1531nm and from 7.7 to 9.4 dB/m at 1531nm in that order. As a second part of the experiment, each EDF fiber 5 m long, was introduced into a laser ring configuration to serve as active medium within the cavity. The setup consisted of a 980nm EDFA pump, a WDM coupler, the irradiated EDF and a fiber Bragg grating sensor, 1550nm central wavelength connected to an optical spectrum analyser. The laser output stability was tested over time, from short periods of 30minutes up to 48 hours. The EDF fibers were then tested for RIA changes after the laser pumping as some improvement in the power output was noticed.  As the secondary target of the STSM, we tried to obtain and improve the performance of a random laser utilizing a Raman pump this time as well as irradiated EDF for active medium. For this purpose an additional dispersion compensating fiber (DCF) was added in the setup. The length was 1km and in order to test gamma influence over the configuration, one DCF same type was previously irradiated with 1kGy gamma radiation. The investigation focused on the differences between the results obtained with the irradiated and reference DCF. Two EDFA pump lasers, 980 nm, were utilized to obtain the gain in two EDF used simultaneously in the setup while a circulator was employed to close the circuit. The spectra was recorded by using an OSA with 0.01 nm resolution. |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DESCRIPTION OF THE MAIN RESULTS OBTAINED**  First, we noticed promising results regarding the RIA in the 5m EDF. From that point, we tried to correlate these results with the fiber ring laser parameters. The main goal was to find the best suitable parameters for optimal laser stability and output power. For that reason, the pump power was increased and data were collected from 100 mA to 500 mA (250mJ). A key role played the pump duration while lasing through the optical fibers (EDF). Our results indicated that, power output of the obtained laser increased with the time of the pumping up until a saturation level. Depending on radiation dose, the slope of the attained power may be different. Other parameters that may influence these changes are the type of the fiber and the power of the pump EDFA. Saturation effect and power variation in time of the fiber laser may be explained by photo bleaching effect inside the irradiated EDF.   |  |  | | --- | --- | |  |  | | Fig.1  Output spectra response of the attained laser using 5m of I25 irradiated with 350Gy (red) at the beginning of the experiment and after being pumped for 60 hours (black). | Fig.2  Output power variation over time when using 5m of an IEDF M12 (black) or I25 (blue) irradiated with 350Gy | |
| For the second subject of our investigation, related to obtaining a random laser by the use of irradiated optical fibers, the work is still undergoing. Several setups were tested, and one laser was obtained in good conditions by the use of a 50km long fiber roll with one Raman laser pump, 1445nm, and two EDFA pumps. The results show differences between the spectra obtained with the irradiated DCF and the reference fiber. Irradiated DCF seams to improve lasers stability. Still, by using only EDF fibers , from 5 m long to 20 m long, laser effect was hard to be attainted therefore further changes in the setup or pump lasers are to be taken into consideration. Further irradiation may be necessary as well, as laser output depends both on pump power and accumulated radiation dose.   |  |  | | --- | --- | |  |  | | Fig. 3  Random laser obtained by using 1.5W Raman pump, 300mA EDFA pump current and 500Gy irradiated EDF | Fig. 4  Random laser obtained by using 2.5W Raman pump. 500 mA EDFA pump current and 500Gy irradiated EDF |   Our study clearly indicates an improvement of the laser output proportional with the pump current. Still we noticed that at different values of the Raman pump correlated with some values of the EDFA pumps, we lose the laser signal output, this giving the option of using only some bands for pumping. There is still to be studied the radiation effect on the DCF utilized in the setup as we managed to prove that gamma radiation has potential of improving or even being part of obtaining a random laser. This was studied with respect to the reference DCF sample that gave us more modest results in the fiber laser output when utilized in the configuration. |

|  |
| --- |
| **FUTURE COLLABORATIONS (if applicable)**  (max.500 words) |
| As this work had two components, we carefully analyse the potential of each. Our preliminary results were presented in several events (COST MP1401 Winter school, Lausanne 2018, Photonics Europe Strasbourg 2018). As a follow up and by attaining new results, we target now a common publication (IEEE Journal of Lightwave Technology) as the updates will be as well presented at OFC-18 Conference, Lausanne, 2018. The collaboration between the two groups of the Institute of Laser Physics (Romania) and University of Navarra is a new and fresh one so follow up will be in the interests of both parts. The newly studied subject concerning the obtaining of a random laser is still to be further developed by the two groups in order to bring more detailed and precise results. This will be the main topic of our further collaboration. We hope this will lead to common publications, presentations within international meetings and the base of future common research projects proposals. |