# Minutes kick-off meeting PWIE SP X2 25-05-2022

Present: Pawel Gasior (IPPLM), Wojciech Gromelski (IPPLM), Monika kubkowska(IPPLM), Gennady Sergeinko (FZJ), Salvatore Almaviva (ENEA), Hennie van der Meiden (DIFFER), Pavel Veis (CU), Alicia Marin Roldan (CU), Antti Hakola (VTT), Peeter Paris (UT), Indrek Jõgi (UT)

**Hennie**

Hennie motivated and summarized the goals of the SP X2 project.
Announcements: Magnum probably operation in August (problems Helium delivery), PSI-2 operational.

* Question to all: please consider if the resources at your institute/university are sufficient for doing both work for SP X2 and being involved in the JET LIBS enhancement project. Please inform Hennie if there is a conflict
* Comments Antti: concerning the JET LIBS enhancement project still a lot is unknown. Budget is not clear for construction and operation
* Salvatore gave a short update about the JET LIBS enhancement project:
* A QS laser MPL300 ps laser could be a good candidate (Gennady showed later also another interesting type of laser). The system for JET could be similar to the system used in FTU
* There will be separate meeting on laser type (and others) before the next JET LIBS enhancement meeting

It was for me very nice to meet my enthusiastic team again!

**Antti – VTT deliverables**

* Be-campaign was very successful for LIBS on produced Be-containing samples, but also on JET samples (real machine components), which contain also Be. First results show that LIBS matches very well with SIMS data especially in terms of D content (IBA results deviated more)
* Remark: the given thickness and doping of produced samples can deviate a lot, this is also the case concerning N or Neon content (sometimes nothing present). We should be aware of that.

**Indrek – UT deliverables**

* Comparison of ps vs ns LIBS will be done this year, but Indrek pleaded to use as much as possible the same samples with same content. Only then an accurate comparison is possible.
Also the best detection location in the plume will be investigated.
* 3 WEST C3 samples (originating from low errosion area) were studied with LIBS. All samples gave similar LIBS results, showing the reproducibility. CF-LIBS analysis?
* Be-campaign: Indrek showed some first results also Helium was well detectable. Te/ne was determined.
* Samples loaded with Helium were studied: H detected, highest intensity found at roughly 1 mm from the surface (at 2 mbar Ar pressure and short detection delay of 100 - 200 ns)).
* Analysis *in situ* LIBS (Magnum), intermediate W layer well detected, as well as D content. Relatively good correspondence with RBS/NRA data.

**Jelena – ISSP UL deliverables**

* Comparison of ps vs. ns LIBS: (CF)-LIBS (ps/ns or SP/DP) in reference and ITER-relevant coatings: absolute composition and D content (in depth)
* Comparison ps vs. ns LIBS / (CF)-LIBS on samples (if available) from different devices (tokamaks or W-7X)

Although there are some problems with the ps-laser, it should be feasible to complete the above mentioned tasks in 2022. State co-financing problems still not solved.

**Salvatore – ENEA deliverables**

The Be campaign done at VTT was very interesting. Following a short summary concerning some impressions of this campaign, to be further investigated and checked by a thoroughly looking at the data.

WPPWIE-SPX2 Be samples

1) D was always detected, both on Be coatings and on real JET samples, both at low (2 mbar Ar) and at high pressure (100 mbar of Ar) at concentration of few percent.

This suggest in my opinion that T will be detected in the same way on JET samples after the D-T campaign.

2) He was detected only at low pressure of Ar. We performed a set of measurements at increasing Ar pressure (up to 40 mbar) and the signal start to disappear.

A possible explanation is that the He line at about 587 nm (the line we monitored) broaden very fast by increasing the Ar pressure for the Stark broadening, the peak height is reduced and it is finally merged with the background (to be confirmed by data analysis)

3) O as impurity is always detected, both at low and a high pressure of Ar, through its emission lines at about 777 nm. It is to be confirmed if O follow the intensity behaviour of H as in this case its presence could be ascribed to environmental water vapour and water molecules that stick on the samples surface. Also simply O molecules could stick on the superficial layer.

Minor elements on JET samples

4) Nickel was (probably) detected through some emission lines in the UV-VIS region at low pressure.

5) W and Mo were not clearly detected as minor elements in the JET samples but W is clearly observed in the Be coatings both at low and at high pressure as main component of the substrate.

6) N was not detected.

Be as minor element.

7) During this campaign we also analysed some samples of Cu+Be (+ others) alloy with Be content in traces (few percent?). They were provided by CU (Pavel, Alicia). It should be very easy to check for Be lines, considering that on the previous Be bulk samples from JET and WPPWIE the Be emission lines were very strong and easy to identify. So it should be very easy to check if we were able to detect Be as minor element (in traces) in this samples.

Thickness

8) My impression is that we weren't able to see any spectral changes in JET thick samples (estimated thickness of the superficial re-deposited layer given By SIMS > 50 um) by drilling the sample with about 1000 - 1500 laser shots on the same point.

9) We instead clearly observed the previous elements in the thin JET sample (estimated thickness of the superficial layer <= 1 um) the LIBS data seems to be in good agreement with the SIMS data. Indeed only in the first 1-2 shots is possible to see the elements in traces in the sample

10) we "drilled" the 20 um Be coating of the reference romanian samples with 5-6 laser shots (--> average ablation rate about 3.3 - 4 m per shot).

In this case the transition of the spectral signal from the surface to the substrate (made of W) appeared evident bot at low and a high Ar pressure.

Laser for the LIBS on JET project discussion and summary

Given the improved ablation properties of picosecond lasers compared to ns, we are focusing our attention on the research of compact ps lasers to suitable for the LIBS device for JET.

Candidates available on the market are shown in the following:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Laser** | **Pulse duration** | **Pulse energy**  | **Dimensions (mm)** | **Weight /laser head)** |  **cooling** |
| <https://www.qslasers.com/picosecond-high-energy-passively-q-switched/> | **≥ 300 ps** | **≤ 50 mJ** | **400 x 175 x 132** | **(waiting for the company reply)** | **Air or water (depending on the repetition rate)** |
| <https://www.qslasers.com/mpl1310/> | **< 350 ps** | **2 mJ** | **113 x 162.5 x 45** | **(waiting for the company reply)** | **Air** |
| <https://www.qslasers.com/mpl1510/> | **< 450 ps** | **2 mJ** | **113 x 162.5 x 45** | **(waiting for the company reply)** | **Air** |
| <https://passatltd.com/sub-nanosecond-dpss-laser-mini/> | **300 ps** | **≤ 80 J** | **221 x 76 x 54** | ? | **Air** |
| [https://www.ipgphotonics.com/en/226/FileAttachment/YLPP+Series+Datasheet.pdf](https://www.ipgphotonics.com/en/226/FileAttachment/YLPP%2BSeries%2BDatasheet.pdf)  | **1-5 ps** | **≤ 200 J** | **271 x 82 x 124** | **4 kg** | **Water** |
| <https://www.ipgphotonics.com/en/products/lasers/pico-femtosecond-fiber-lasers/1-03-1-06-micron/ylpp-r-series> | **1-5 ps**  | **≤ 25 J** | **370 x 65 x 70** | **≈ 2.5 kg** | **Water** |
| [https://www.ipgphotonics.com/en/products/lasers/pico-femtosecond-fiber-lasers/1-03-1-06-micron/ylpp-0-15x5-ns-50-w#[specifications-52]](https://www.ipgphotonics.com/en/products/lasers/pico-femtosecond-fiber-lasers/1-03-1-06-micron/ylpp-0-15x5-ns-50-w)  | **0.15 – 5 ns** | **≤ 1 mJ** | **320 × 160 × 58**  | **10 kg** | **Thermoconductive Bottom cooling** |
| https://www.thorlabs.com/newgrouppage9.cfm?objectgroup\_id=14322 | **500 ps** | **40 – 50 J**  | **136.3 x 88.9 x 47..1** | **0.8 kg** | **Air** |

After discussion with the sale office the IPG photonics devices include an optical fiber connection between the laser head and the power supply (weight about 30 kg) that cannot be longer than 4 m. This preclude the possibility to move the power supply out of the JET VV and leave inside only the laser head. Thus, currently, the most eligible candidates seems to be lasers from qslasers and Thorlabs, provided that they don’t have similar constraints. This will be asked to the producers.

**Pavel – CU deliverables**

* Comparison ps vs. ns LIBS regarding absolute composition and D content in reference and ITER-relevant coatings which can include impurities (FZJ, CU, UT, ISSPUL, CEA) *🡪 planned measurements on non Be-containing samples using Vacuum UV-NIR LIBS and resonant LIBS (RLIBS) with tunable ns OPO laser*
* (CF-) LIBS (ps, ns SP or DP) on samples (if available) from different devices (tokamaks or W-7X) (collab. SP B) (ISSP UL, CU, UT, VTT, FZJ, ENEA) 🡪 *3x JET samples*
* (CF-)LIBS on Be containing coatings with different type of fuel content (VTT, UT, CU) 🡪 *8x Be-containing samples*
* CF-LIBS on produced reference samples before and after He loading (FZJ, CU, UT, ENEA) 🡪 *He observed at low pressures*

**Pawel – IPPLM deliverables**

Pawel showed the progress on machine learning application in LIBS. The accuracy in composition determination of CF-LIBS is very dependent on *T*e and other parameters. Also other issues were mentioned. The application of machine learning, which is based on **pattern recognition**, could be very beneficial: it requires a certain amount of calibrated data as input for accurate operation. Good progress! Here a summary of the discussion.

* Tools for generation of synthetic data,
* Tools for spectral data pre-treatment and visualisation,
* ML Models efficiently operating on simulated data after dimensionality reduction,
* Good overview of the performance of these modelsin terms of their capability for prediction,
* Very nice experimental results from the recent LIBS Be campaign!

2022 plans:

* Massive investigation of pre-processing techniques mostly based on the LIBS Be campaign,
* Modifications of synthetic data and model re-calibration,
* Application of dimensionality reduction of the pre-processed experimental data, finding
 correlations between tchem and dimensionally reduced synthetic data,
* Training and cross-validation of conversion systems
* Validation of the systems – results obtained on JET samples are perfectly tailored for this!

**Gennady– FZJ deliverables**

* The dynamical retention experiment in PSI-2 devices is under preparation. Ns-laser (Innolas) has been repaired and reinstall on PSI-2 laser lab but need modification of solenoid control valve for cooling water.
* Optical setup for ns-LIBS in air was installed in the beam line of PSI-2 LIBS system.
* New ps-LIBS setup is under preparation. New high repetition ps-laser YLPP-25-3-50-R (1030nm, 50kHz-2MHz, pulse duration 2 ps, pulse energy < 35μJ) from IPG photonics being tested at FZJ. The laser beam will focused on target surface in spot of about 50 μm diameter and will continuously move over the target surface by fast scanning optics to create larger ablation area. The all spectra produced during complete scan of the ablated area are accumulated that allow to reach higher sensitivity in comparison with standard single pulse LIBS. Repetitive complete scans of the ablation area will allow to perform the depth profiling. 2D-scanner for IPG laser is under installation and will be ready at June for LIBS measurements in air
* Double-Pulse Laser ablation molecular isotopic spectroscopy (LAMIS) of W-7X divertor fingers was performed for the measurement of C13 distribution in the vicinity of the gas injection.

**Arnaud Bultel – CORIA/CEA deliverables**

* Please write here the most important progress Arnaud

**In general**

Remarks?