MANUAL for LIBS with HDX spectrometer

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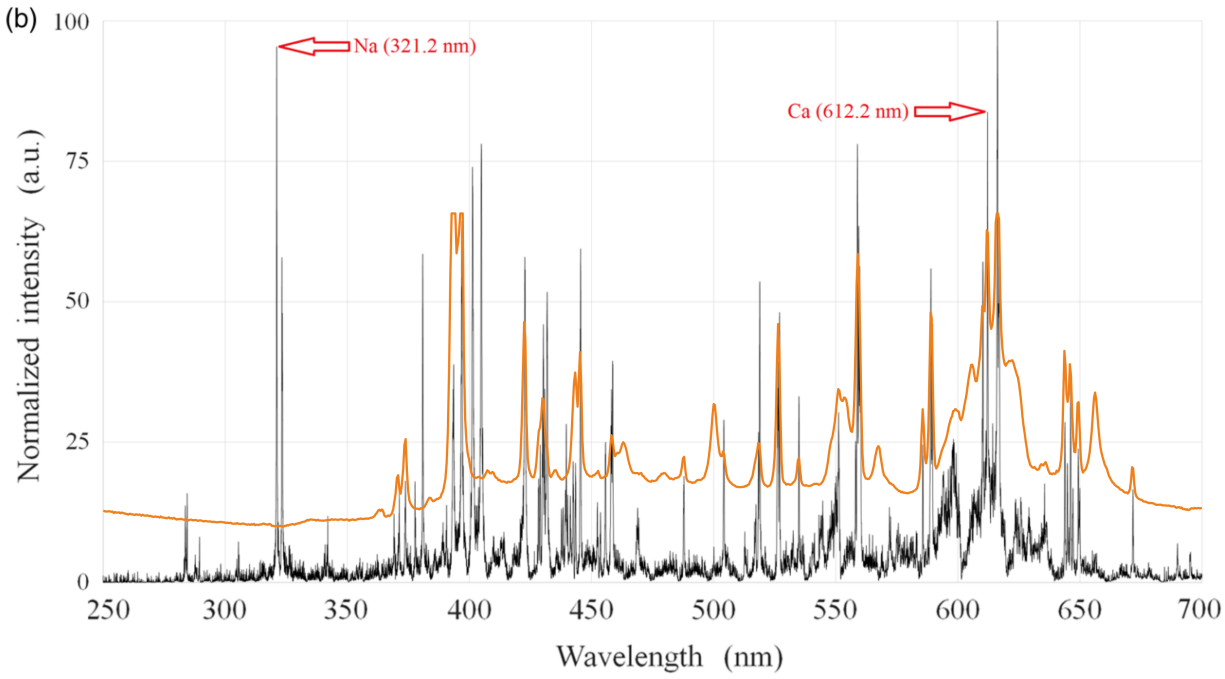

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1 Introduction

HDX spectrometer can be used together with Nd:YAG to collect Laser-Induced Breakdown Spectroscopy (LIBS) signal. LIBS is used at BLOG for tissue differentiation during laser ablation. This manual provides the correct settings how to obtain LIBS peaks and process the spectra.

2 Connections

Nd:YAG trigger cannot be directly connected to the spectrometer because the maximum acceptable voltage by the spectrometer is 3.3 V, while laser trigger outputs a 5 V pulse. That's why a function generator is needed in between to create the correct trigger pulse. A correct offset needs to be added to the trigger pulse in order to eliminate the Bremsstrahlung spectral baseline and only measure LIBS peaks.
Involved devices:

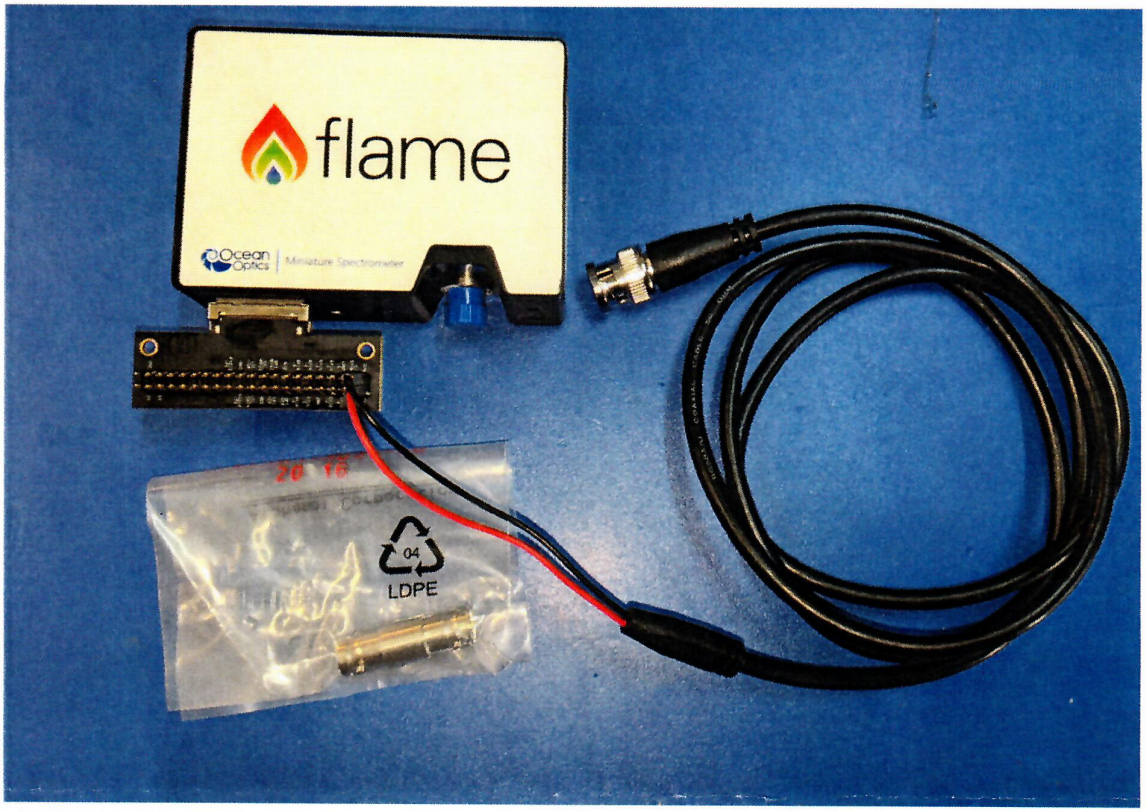
Spectrometer	Ocean Insight HDX
Laser	Nd:YAG
Function generator	UNI-T
Oscilloscope	Keysight

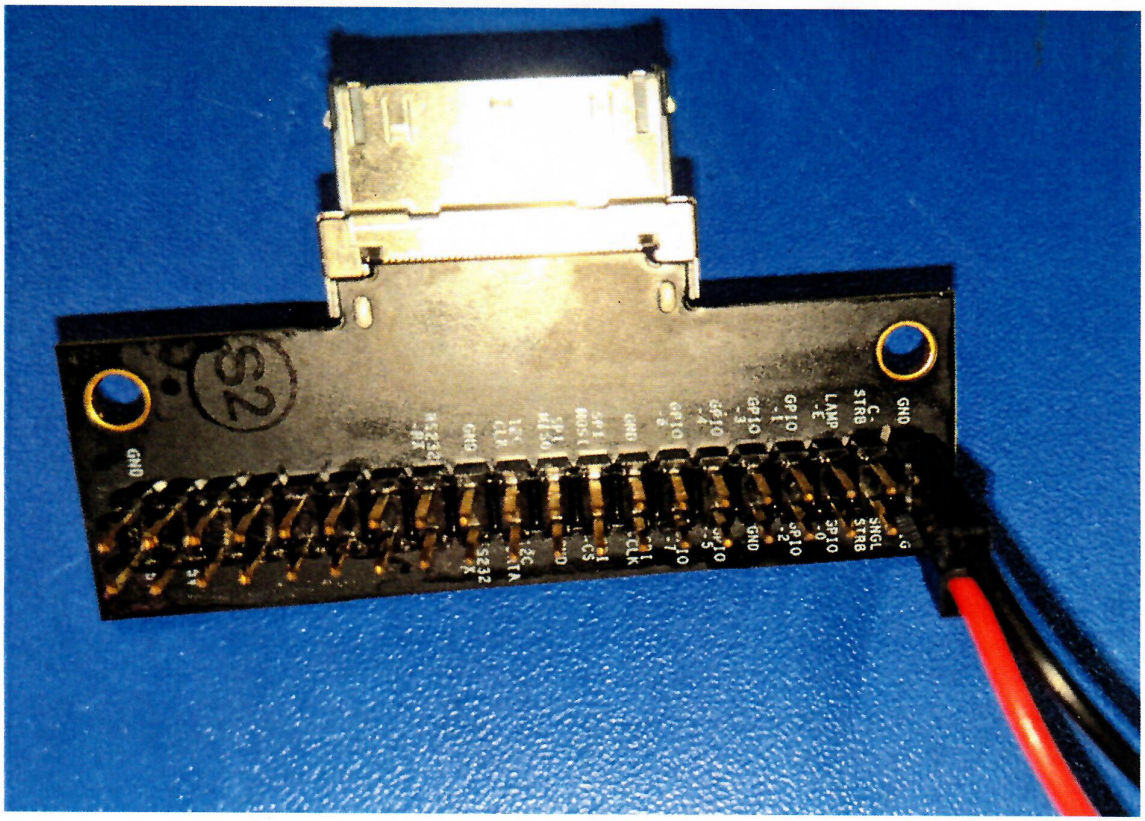
How to connect the devices (Figure 1):

Spectrometer (HDX)	Special trigger cable breakout board-BNC to CH1 from the FG
Laser	Q-Switch OUT to by BNC to FSK/TRIG port at the back side of the FG
Function generator (FG)	CH1 both to HDX and oscilloscope to check the trigger pulse

Flame – External Trigger

Pin #1 – GND (black) Pin #2 - Trigger in (red)





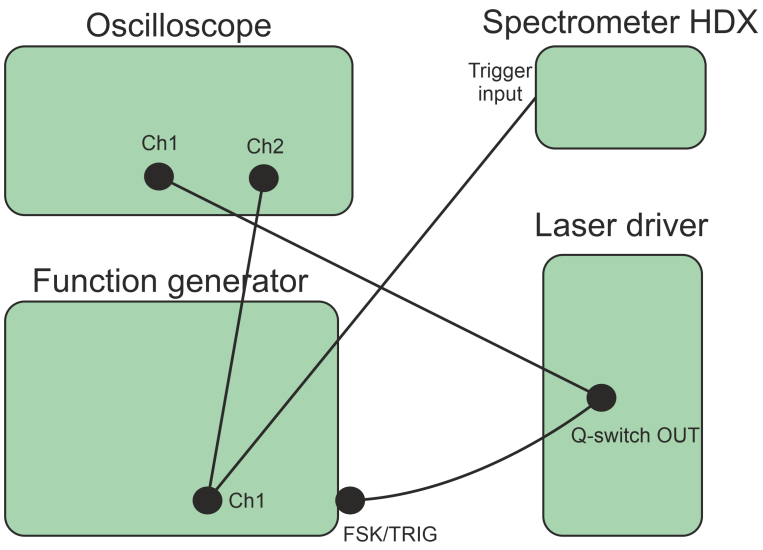


Figure 1: Schematic representation of the LIBS setup

3 Settings

NdYAG

Frequency	5 Hz
Voltage	645 V
Pulse width	170 us

Ocean View or Python

Integration time	6 ms (min value)
Trigger	Rising edge

Function generator

Menu	Burst
Type	Pulse Ncyc, Cycles 1
Phase	0 deg
TrSrc	External
Carrier freq	slightly higher than laser frequency, e.g. 5.000300 Hz
Amplitude	1.5 Vpp
Offset	750 mV
Phase	-357.2
Duty	0.1 %
Rise	24 ns

IMPORTANT
Amplitude and offset settings are correct, already consulted with a HDX technician. If amplitude and offset are not set correctly, the trigger pulse can damage the HDX. **HDX needs a pulse 0-3.3 V**. Higher voltage as well as negative voltage can damage the electronics, as it happened already in December 2021.
Intensity of the Bremsstrahlung and the peaks can be adjusted by changing the phase. It's OK have a bit of Bremsstrahlung modulation together with the peaks. The Bremsstrahlung gets removed by post-processing. I wasn't able to completely eliminate the baseline.

4 Collecting and processing data

All relevant code can be found on Gitlab or BLOG server in
\\dbe-storage.dbe.unibas.ch\groups\blog\10_Projects\Sandra\Code\Spectrometer.
For collecting data from HDX, you can use Ocean View or a customized Python script *SpectroSaveData.py*. Bremsstrahlung baseline can be removed later in Matlab using function *baseline.m*. Example is shown in Figure 2. *baseline.m* uses a Savitzky-Golay filter to find the baseline, the parameters can be adjusted. This function can be rewritten to Python to remove the baseline in real-time while ablating.
The first results for LIBS can be found in Figure 3. A peak at 400 nm can be used for thresholding method to distinguish hard bone from other tissues. Alternatively, I trained a machine learning SVM classification algorithm to differentiate between tissues, trained with 95 % accuracy, I did not try testing it. Data was processed using *LIBS.m*.

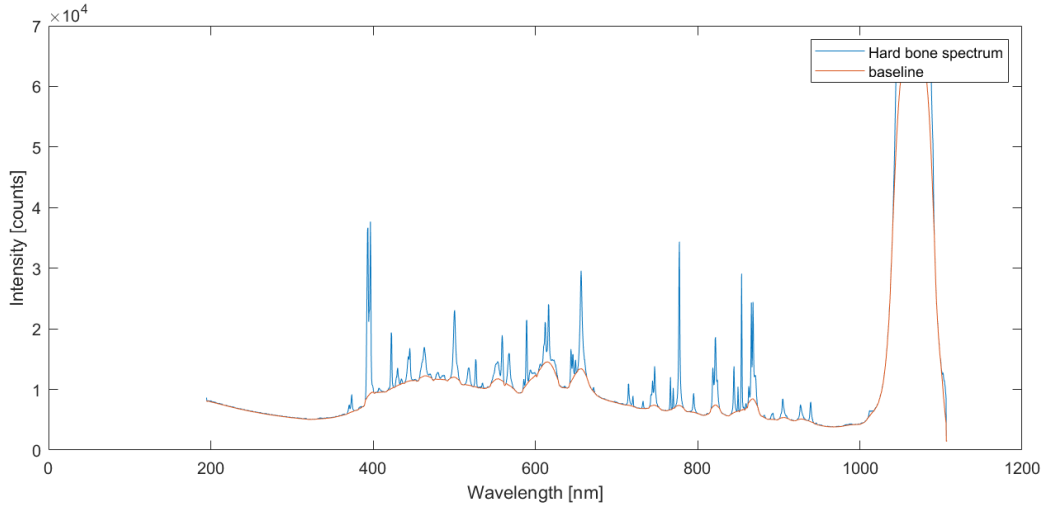


Figure 2: LIBS spectrum of hard bone sample with a baseline found in Matlab

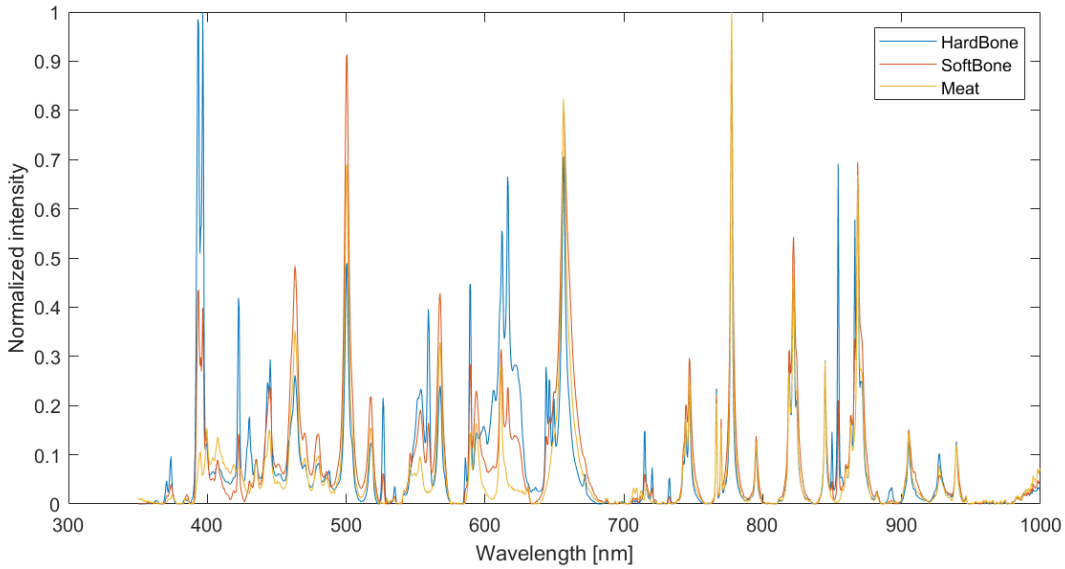


Figure 3: LIBS spectrum of hard bone sample, soft bone and meat after baseline was removed in Matlab. Water was dried from the surface.

5 Testing and troubleshooting

In case of any issues, contact @Sandora for support. Before you do that, please try turning the devices on and off again. Python programs can be interrupted with CTRL+C. Consult the manuals for the range of acceptable settings for different devices.

5.1 Spectrometer

Testing:

- Try if it receives any spectrum in Ocean View
- Try if it reacts to the Nd:YAG trigger

Troubleshooting:

- Whenever you change the trigger mode, either in Python or Ocean View, you will most likely have to restart the spectrometer (disconnect the power).
- Whenever the HDX gets stuck waiting for the trigger, disconnect the power