APPLIED PHOTONICS

LASER SPECTROSCOPY SOLUTIONS

Modular LIBS System Test Report
Example Configuration 3

June 2022

Customer: XXXX
End User: XXXX

Telephone +44 (0)1756 708900 Facsimile +44 (0)1756 708909 Email mail@appliedphotonics.co.uk Web www.appliedphotonics.co.uk

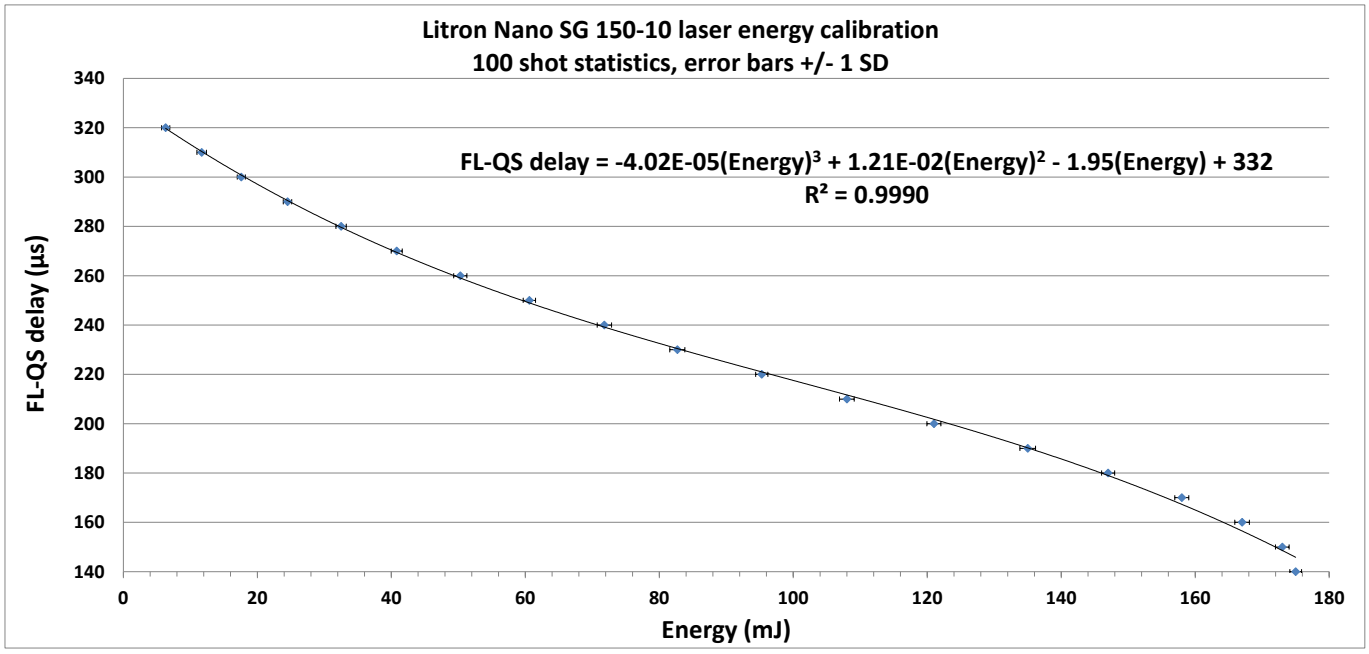
Applied Photonics Limited - Registered No. 3617150 - Registered Office: Unit 8, Carleton Business Park, Skipton, North Yorkshire BD23 2DE

System Information	**Laser Information**	
LIBS-8 (8-channel, 1064 nm) Serial No: XXXX, Manufactured: September 2020 AP-Nano Serial No: XXXX, Manufactured: September 2020	Litron Nano SG 150-10, LPU 350 Laser head Serial No: XXXX PSU Serial No: XXXX LUCI Serial No: XXXX Manufactured: August 2020	
Sample Chamber Information	**Spectrometer Information**	
XYZ-750 (Computer controlled sample chamber) Serial No: XXXX Manufactured: September 2020 SC-LQ2 (Liquids analysis sample chamber) Serial No: XXXX Manufactured: September 2020	SpectroModule-8 Serial No: XXXX Manufactured: September 2020 AvaSpec-ULS4096CL-RS-EVO S/N XXXX S/N XXXX S/N XXXX S/N XXXX S/N XXXX S/N XXXX S/N XXXX S/N XXXX	 178 – 255 nm 250 – 315 nm 308 – 363 nm 358 – 459 nm 452 – 535 nm 525 – 651 nm 642 – 857 nm 845 – 1024 nm
Software	**Fibre Information**	
LIBSoft 2020	**Internal** 1 off FG400AEA 6 off FG200UCC 1 off FG200UCC **External** 1 off FG400AEA 7 off FG200UCC	 400 µm, Length 0.5 m 200 µm, Length 0.5 m 200 µm, Length 0.6 m 400 µm, Length 2 m 200 µm, Length 2 m
Optional Extras		
IMG-HR High-resolution camera imaging kit	SpecLine AM Software V 2.1 Serial No: XXXX	
LIBS PC Dell Optiplex 7070 Small Form Factor Intel Core i5-9500 256GB Solid State Drive Service Tag: XXXX Express Service Tag: XXXX		

Laser Energy Calibration

The laser beam energy was measured using a calibrated laser energy meter (Coherent LabMax TOP Laser Power/Energy meter with J-50MB-YAG detector head). The laser pulse energy was measured at the output of the LIBS-8, with the transparent nozzle aperture removed and the detector head positioned close to the optics array so that the laser beam diameter is relatively large (so as not to damage the detector). The energy measurements are therefore representative of the laser pulse energy at the sample. The laser energy calibration was performed varying the Flashlamp-Q-Switch (FL-QS) delay (FL-QS Delay values: 140 µs - 320 µs) and measuring the average, minimum and maximum energy as well as standard deviation of 100 shots. The repetition rate was set to 10 Hz. Prior to the measurements and for laser warm up/stabilization purposes, the flashlamp was operating without lasing for 10 min. The laser coolant temperature during the laser energy calibration measurements ranged from 30 to 33 ºC. **For an optimum laser performance, the coolant temperature should reach a minimum of 25°C. This is achieved by firing the flashlamp with the Q-Switch disabled until this temperature is reached.**

FL-QS Delay (µs)	Laser Energy				
	Mean (mJ)	SD (mJ)	RSD (%)	Minimum (mJ)	Maximum (mJ)
140	175	0.87	0.5	173	177
150	173	1.02	0.6	171	176
160	167	1.09	0.7	166	170
170	158	1.05	0.7	155	161
180	147	0.97	0.7	145	150
190	135	1.16	0.9	132	138
200	121	1.04	0.9	119	125
210	108	1.10	1.0	106	111
220	95.3	0.92	1.0	93.5	98.1
230	82.7	1.12	1.4	80.5	85.8
240	71.8	1.07	1.5	69.6	74.7
250	60.6	0.92	1.5	58.7	64.1
260	50.3	0.99	2.0	48.0	53.3
270	40.8	0.83	2.0	39.0	42.9
280	32.5	0.77	2.4	30.9	34.9
290	24.5	0.64	2.6	22.9	26.5
300	17.6	0.60	3.4	15.8	19.3
310	11.7	0.70	6.0	10.0	14.0
320	6.32	0.61	10	4.76	8.34

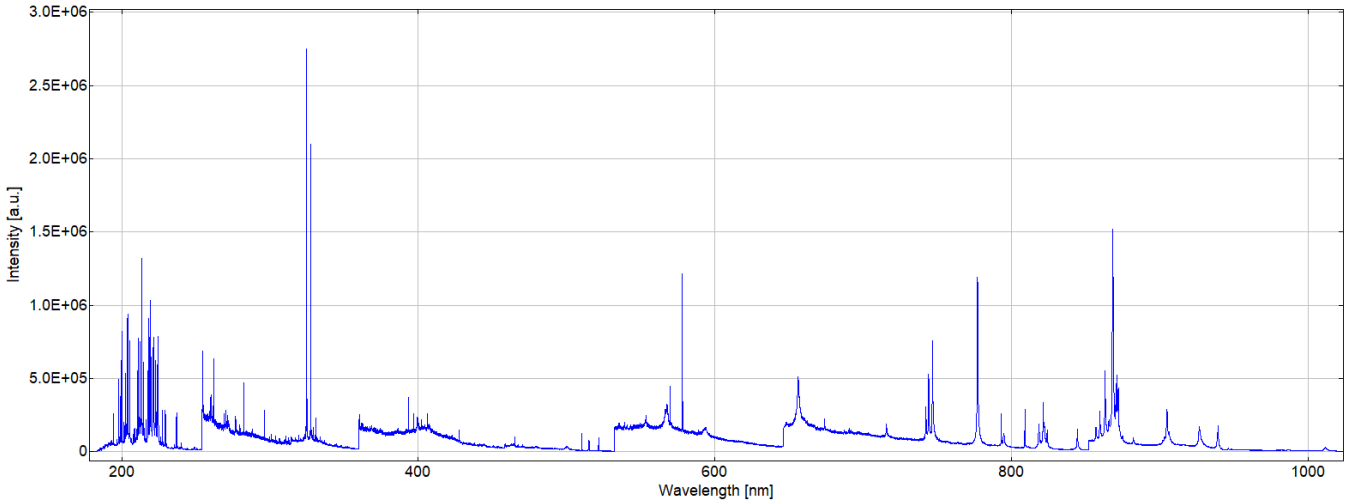


Test spectra

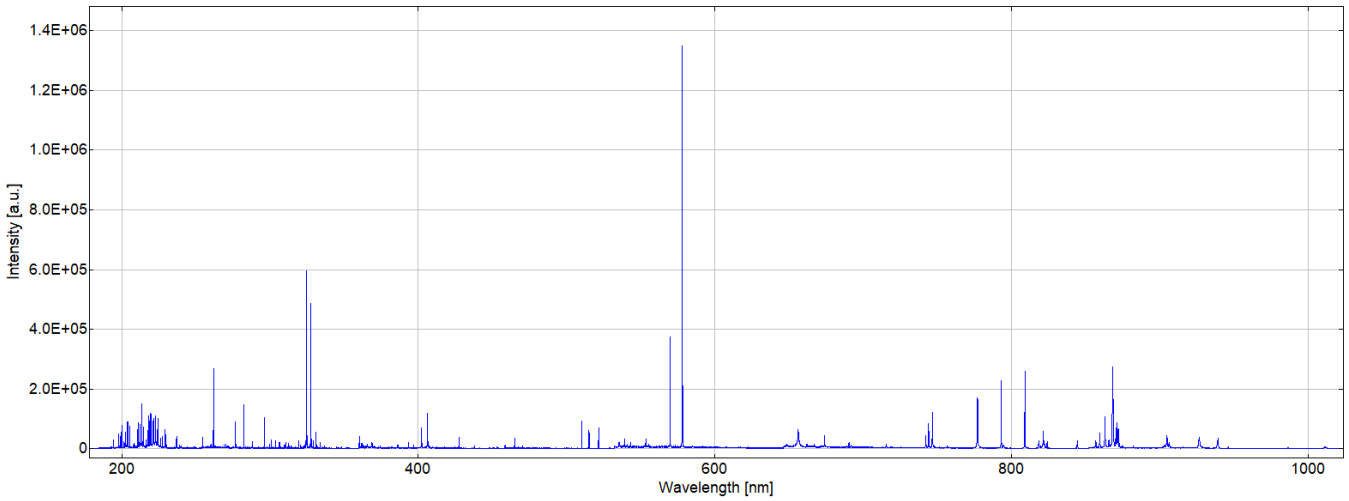
Spectra acquired using the following parameters:

- 50 conditioning / cleaning shots
- 50 shot accumulation
- 50 µs integration time
- Variable integration delay (stated in the spectrum)
- Laser energy at sample = approx. 50 mJ
- 10 Hz laser repetition rate
- Argon or Air purge gas as stated

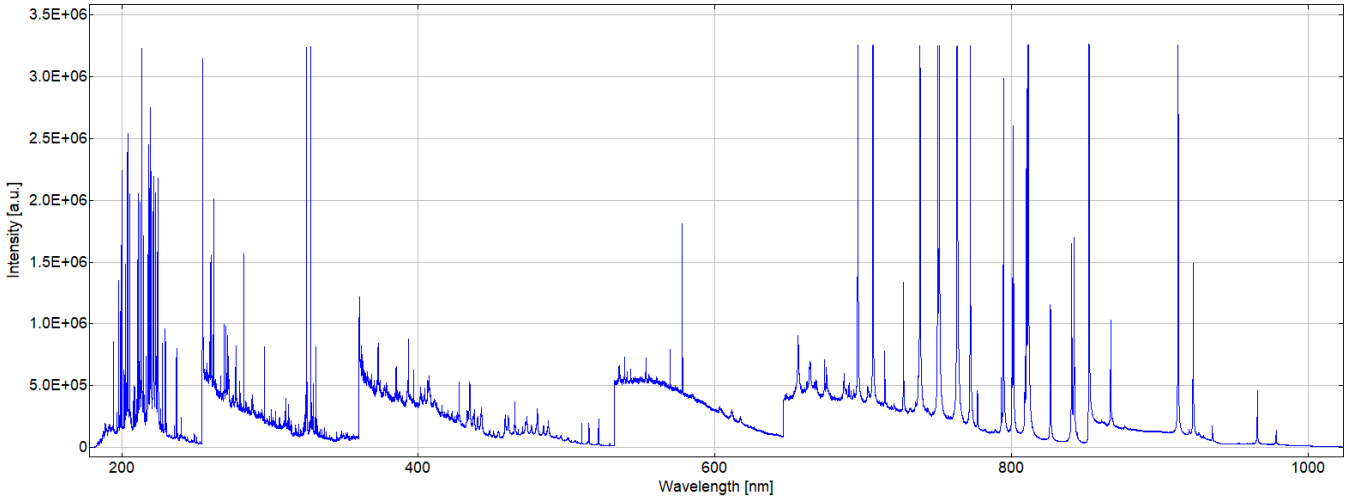
High purity copper (Air) 0.86µs integration delay (minimum integration delay)



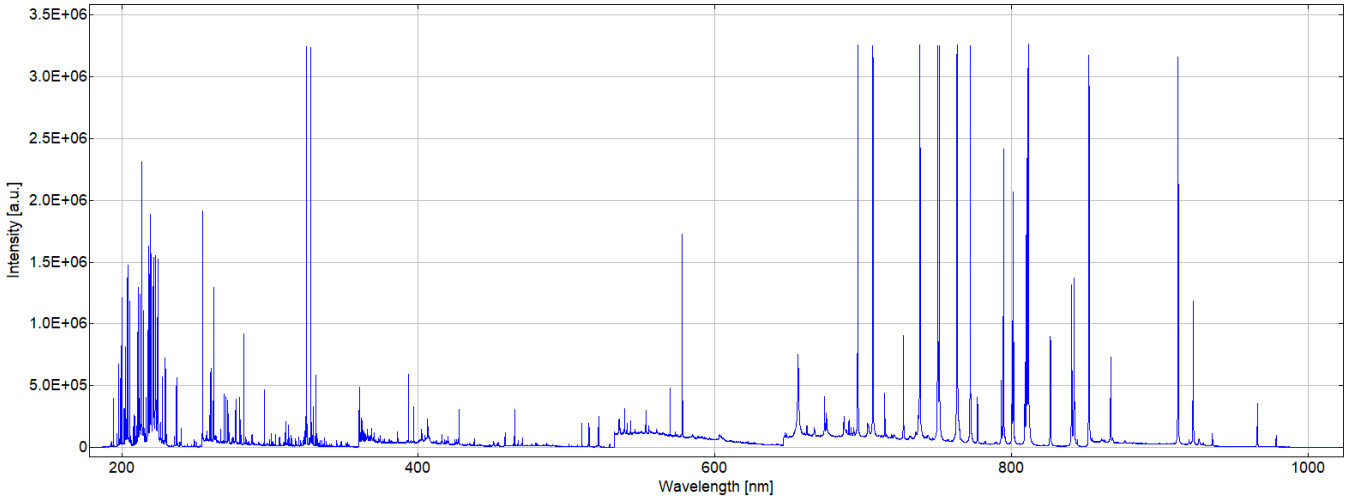
High purity copper (Air) 3 µs integration delay



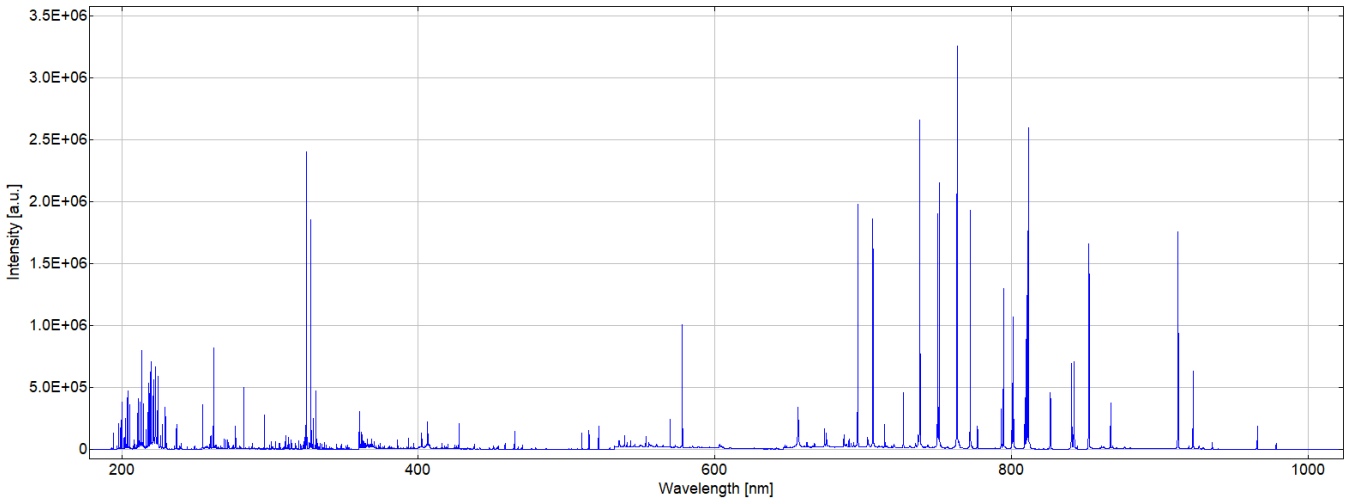
High purity copper (Argon) 0.86 µs integration delay (minimum integration delay)



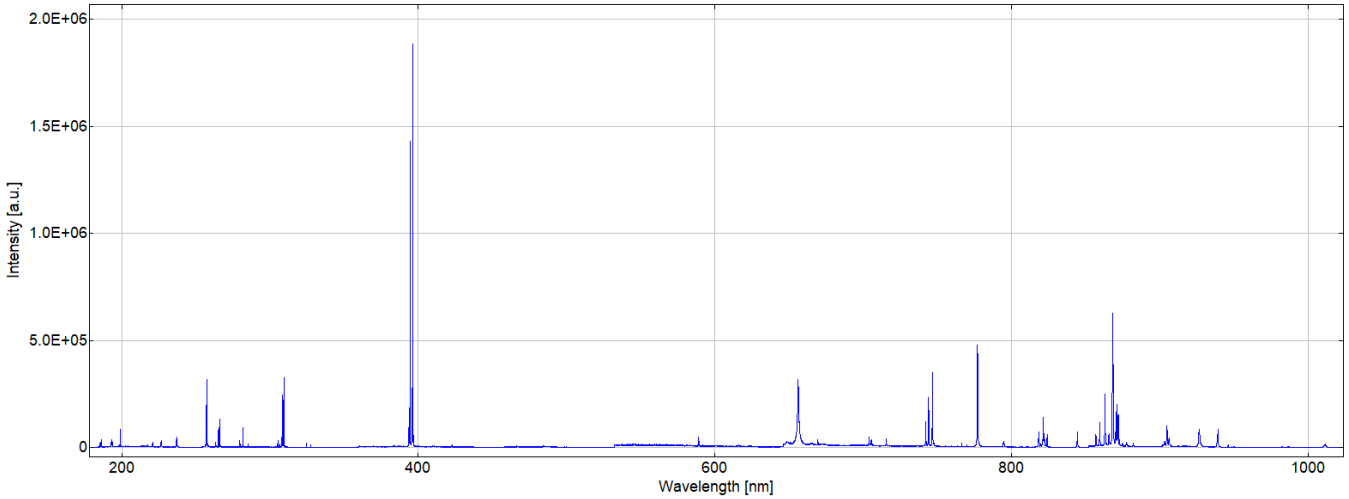
High purity copper (Argon) 3 µs integration delay



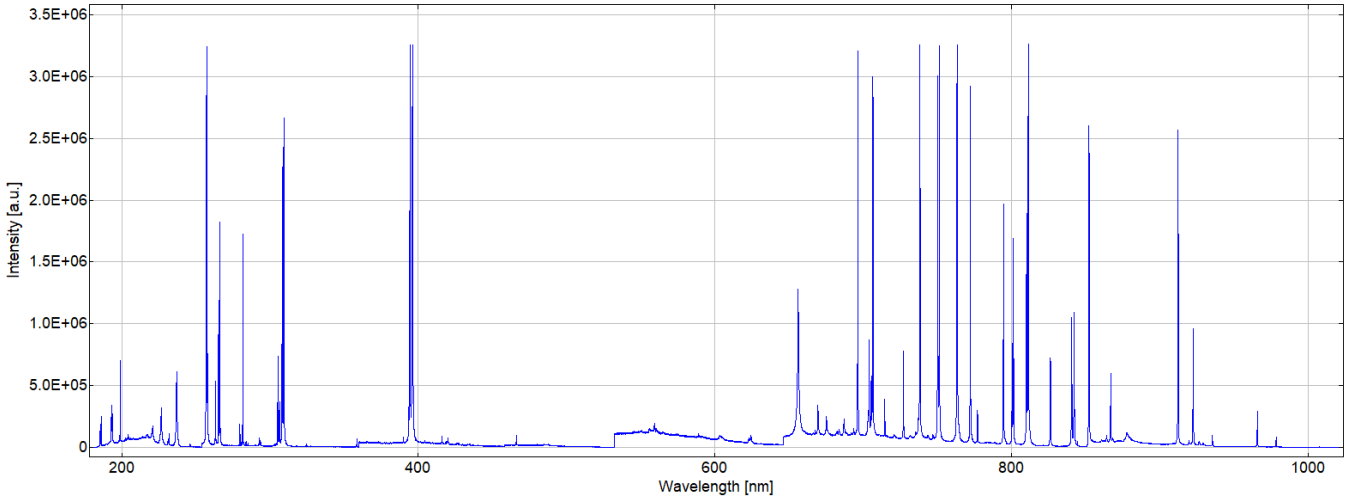
High purity copper (Argon) 10 µs integration delay



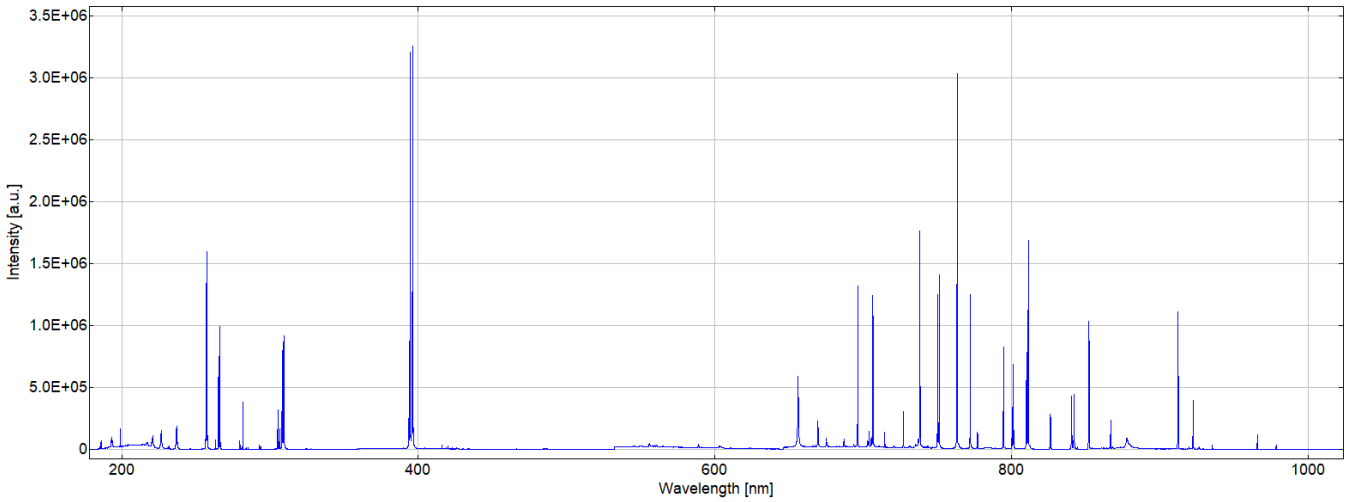
High purity aluminium (Air) 3 µs integration delay



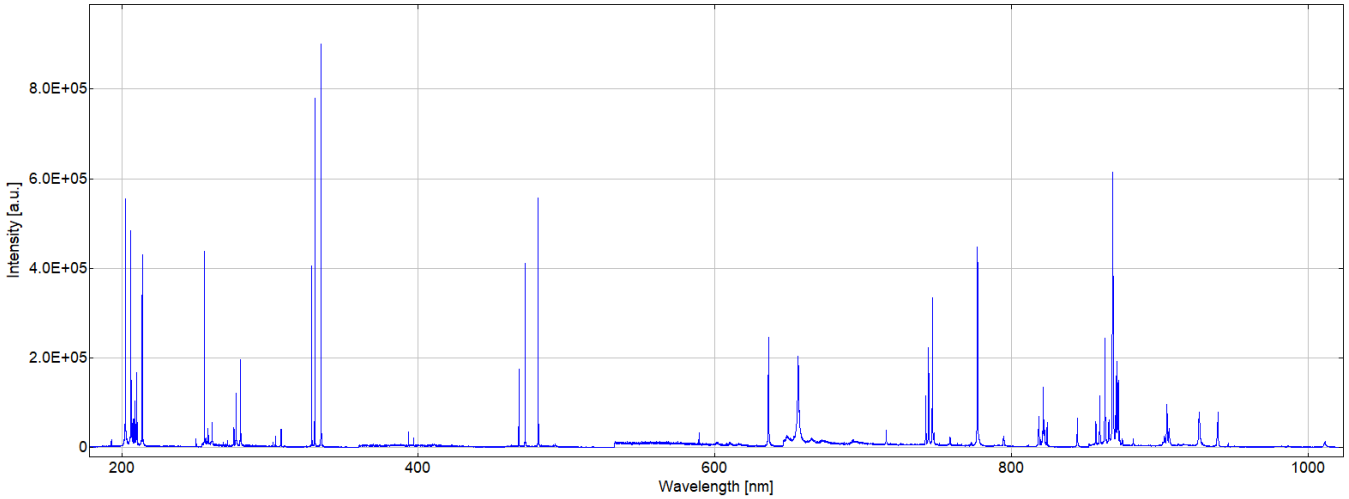
High purity aluminium (Argon) 3 µs integration delay



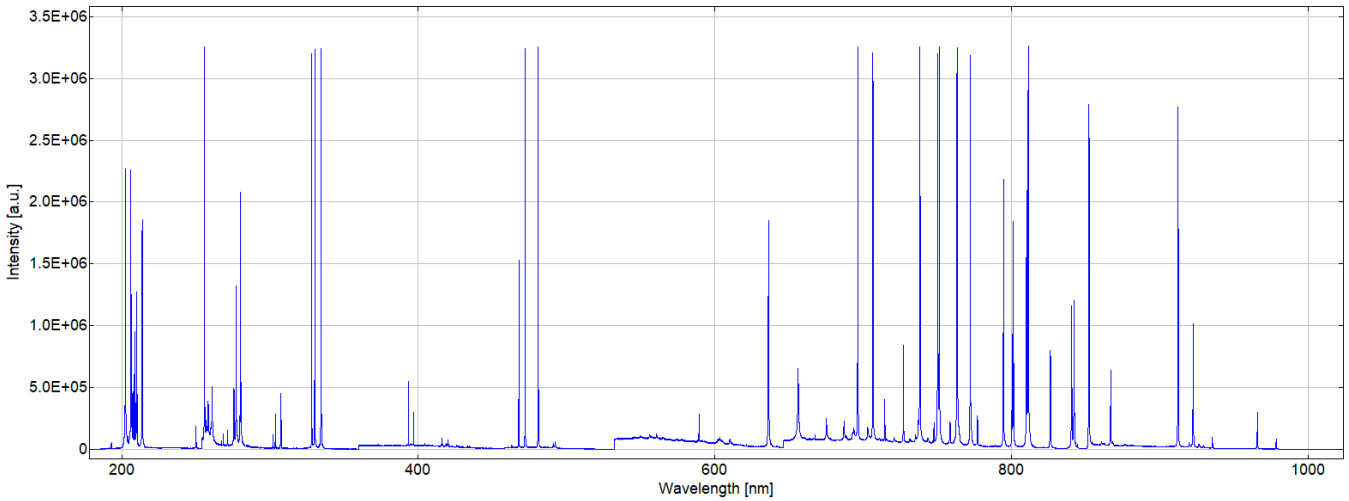
High purity aluminium (Argon) 10 µs integration delay



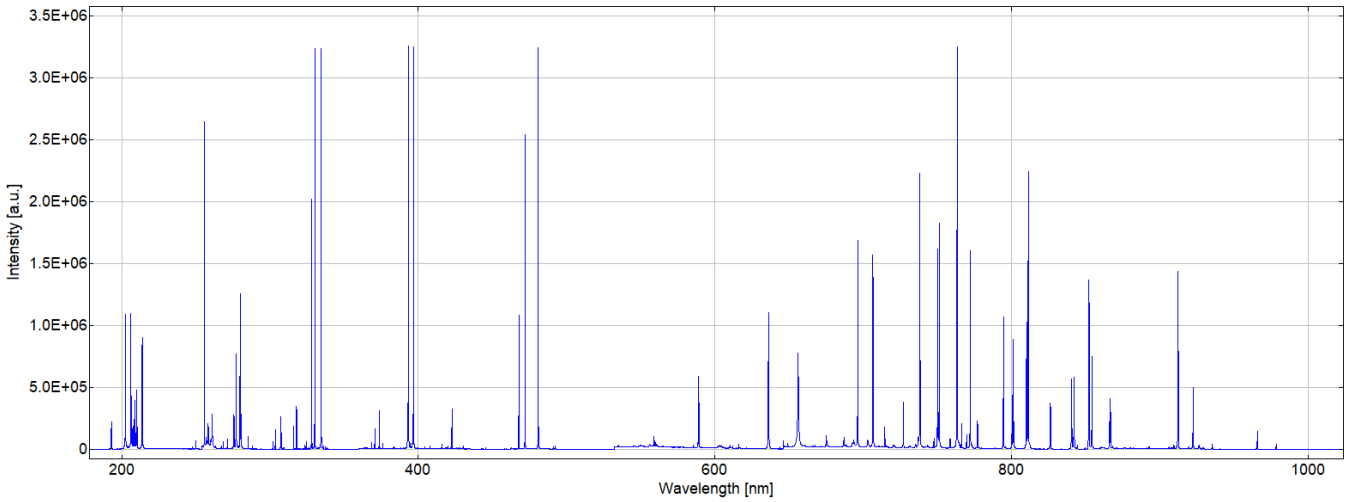
High purity zinc (Air) 3 µs integration delay



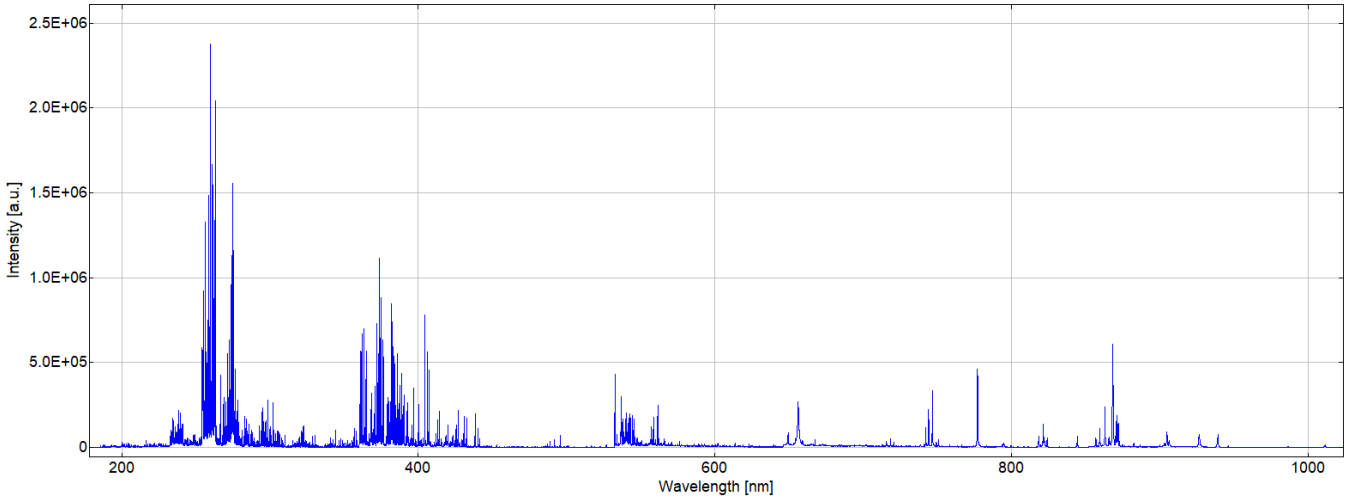
High purity zinc (Argon) 3 µs integration delay



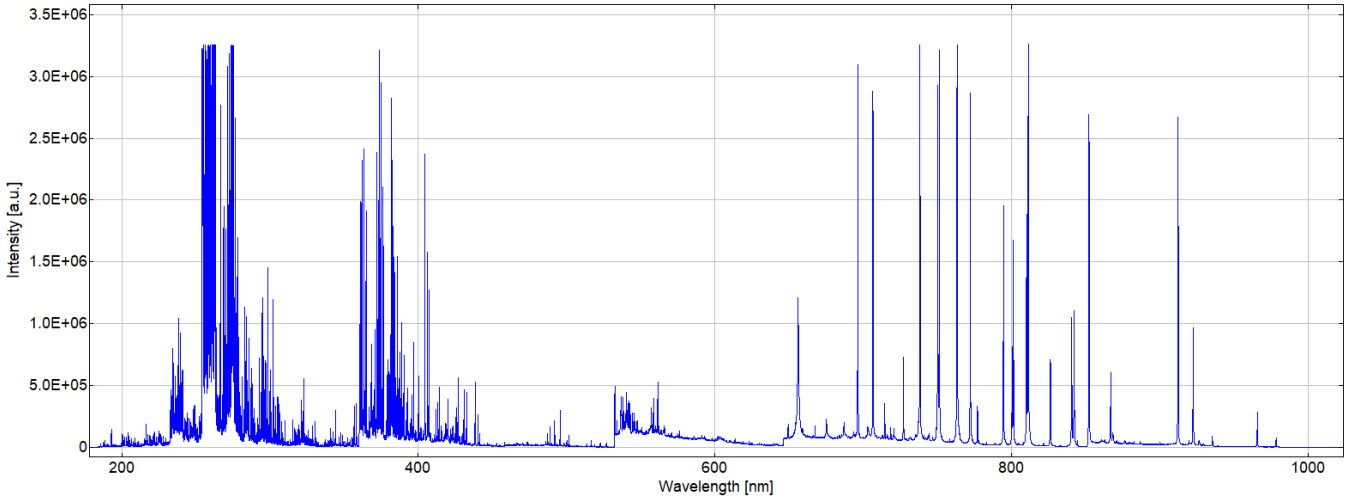
High purity zinc (Argon) 10 µs integration delay



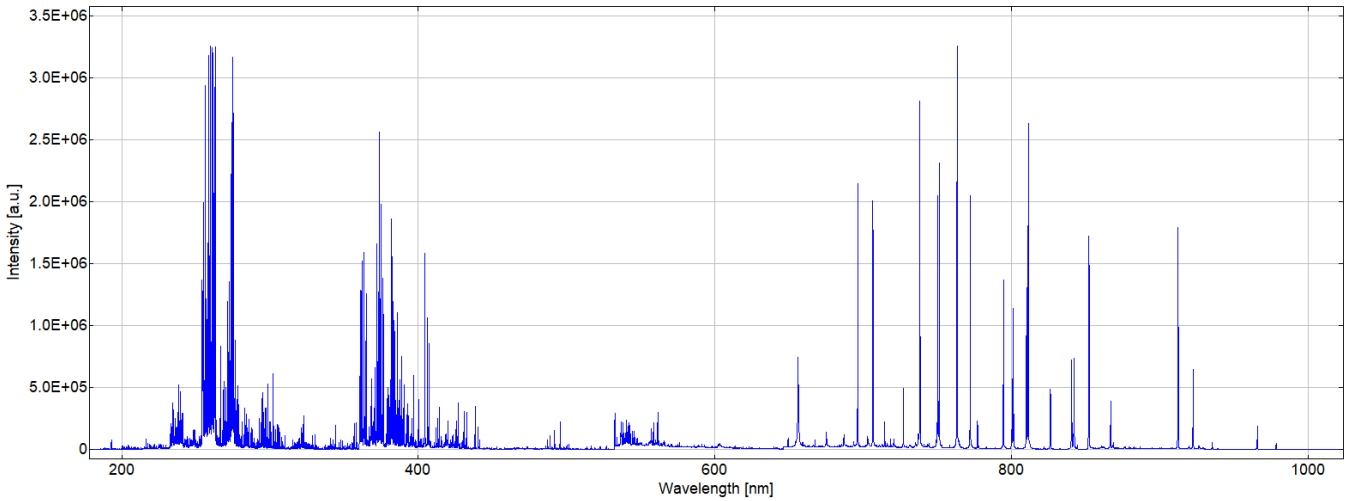
High purity iron (Air) 3 µs integration delay



High purity iron (Argon) 3 µs integration delay



High purity iron (Argon) 10 µs integration delay

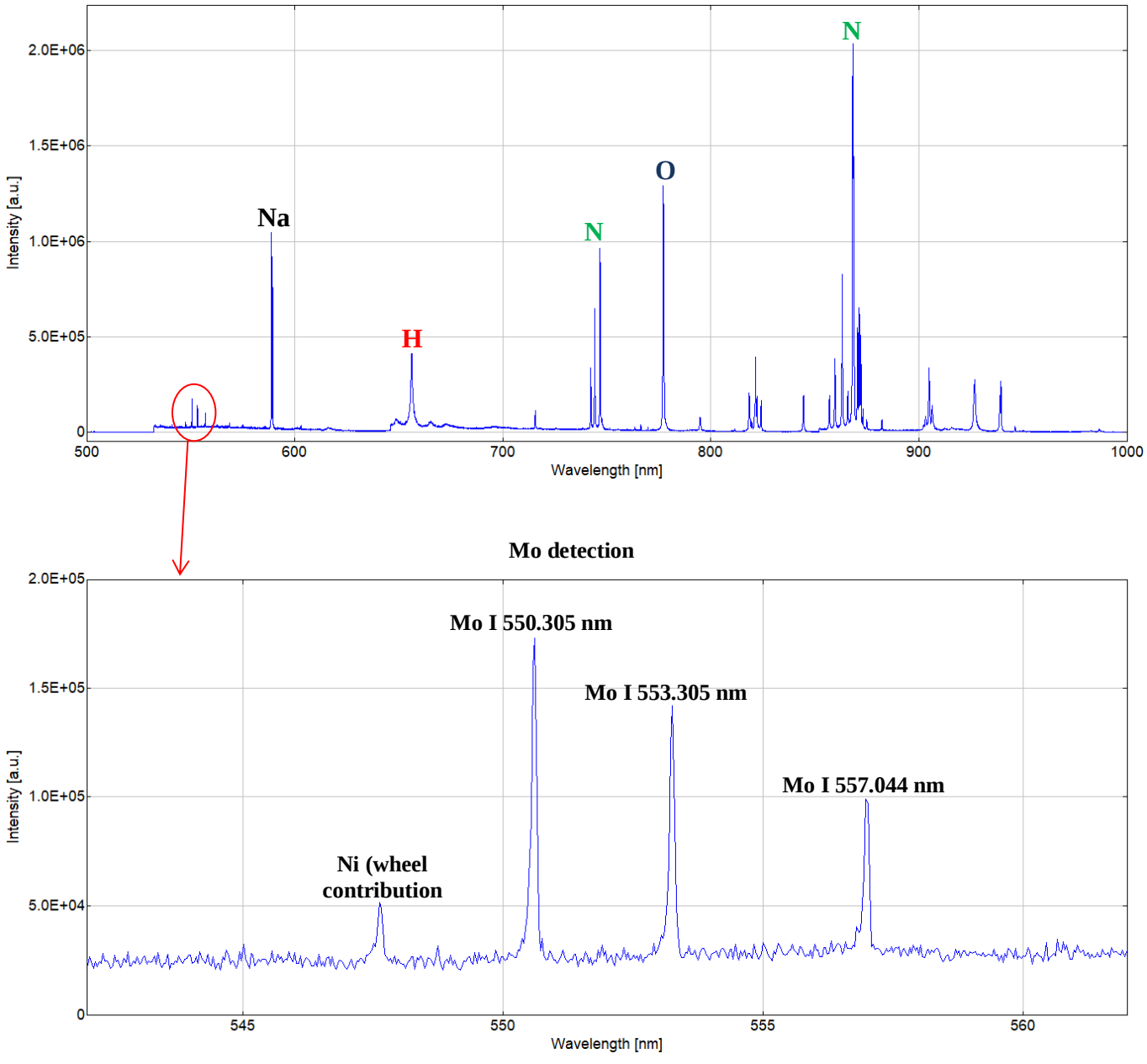


SC-LQ2 test results

The LIBS system was tested using a prepared aqueous solution of Na_2MoO_4. A spectrum of a solution containing 2500 ppm by mass of Mo was obtained using the following experimental parameters.

- 100 accumulation shots
- 50 µs integration time
- 3 µs integration delay
- Laser pulse energy at sample = approx. 100 mJ
- 5 Hz laser pulse repetition rate
- Motor speed controller knob position indicator 4 (wheel rotational speed approx. 18 rpm)
- Wheel micrometer position 5 mm
- Air purge gas

LIBS spectrum of Na_2MoO_4 (2,500 ppm Mo) in distilled water (spectral range: 500 -1023 nm, purge gas: Air)



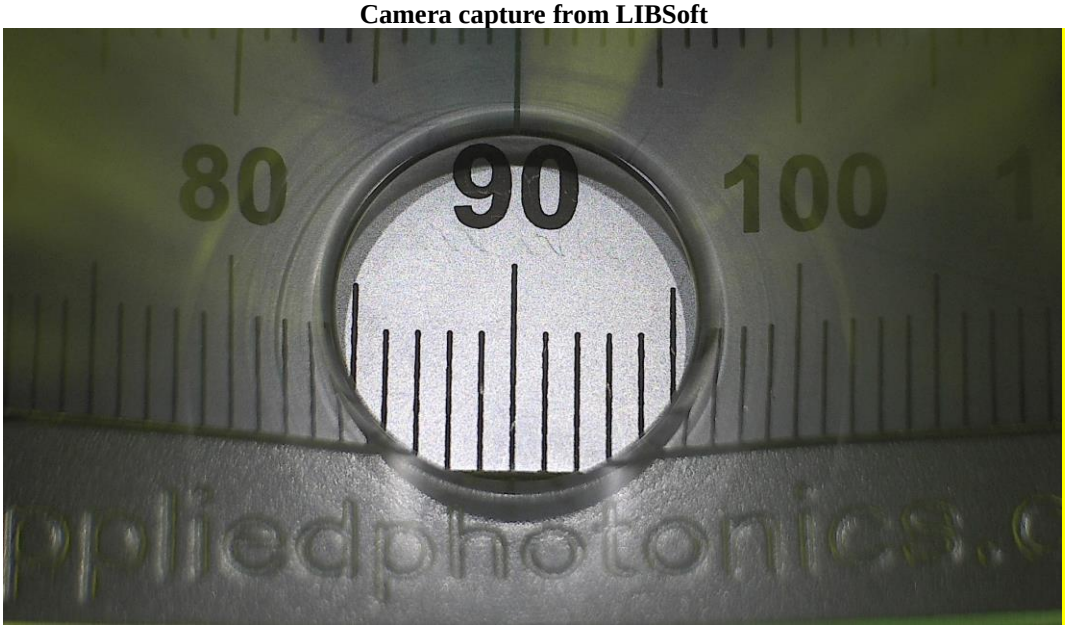
Wheel rotational speed

The wheel rotational speed was measured by varying the knob position indicator (on the Motor Speed Controller) and the results are shown in the following table.

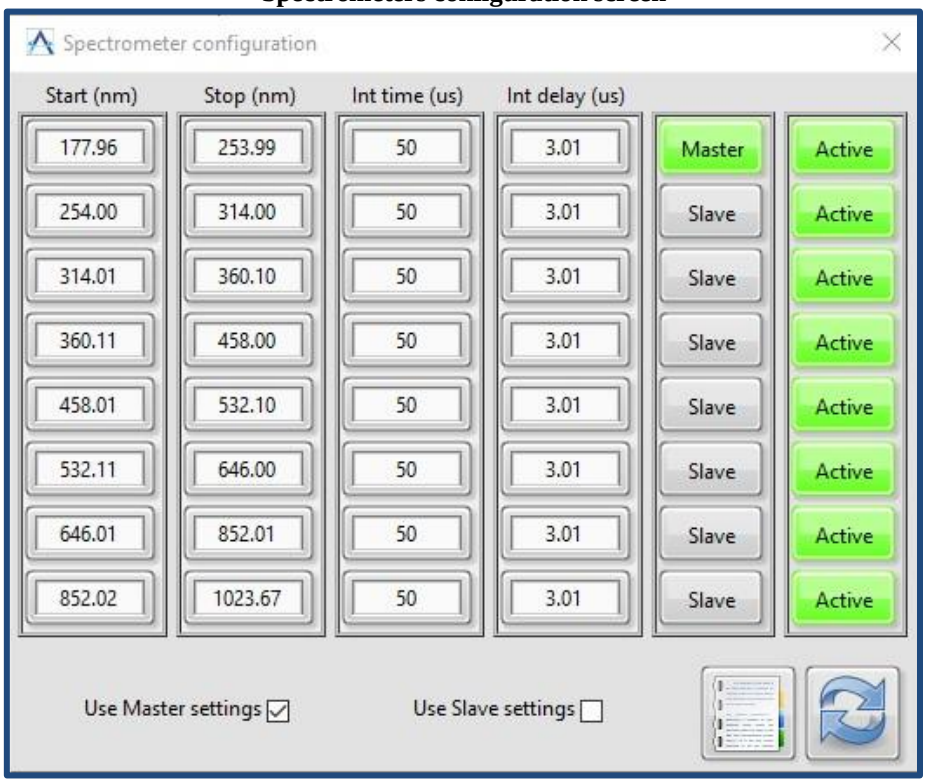
Motor Speed Controller knob position indicator	Revolutions per minute (RPM) (approx.)
1	0.5
2	7
3	13
4	18
5	21
6	24
7	25
8	26
9	27
10	27

Test of sample imaging camera

Camera capture from LIBSoft



Spectrometers configuration screen



End of Test Report