A Novel Platform for High-Speed, High Resolution LIBS Imaging

Shayne Harrel[1,*], Jean-Michel Laurent[1], Antoine Varagnat[1], Adrian Tercier[2], Vincent Motto-Ros[2]

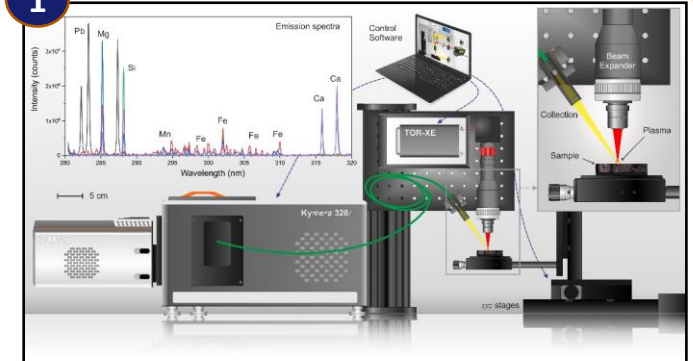
*s.harrel@andor.com

1. Andor Technology, Belfast, UK
2. Institut Lumière Matière, UMR5306, Univ. Lyon 1-CNRS, 69622 Villeurbanne, France

Abstract

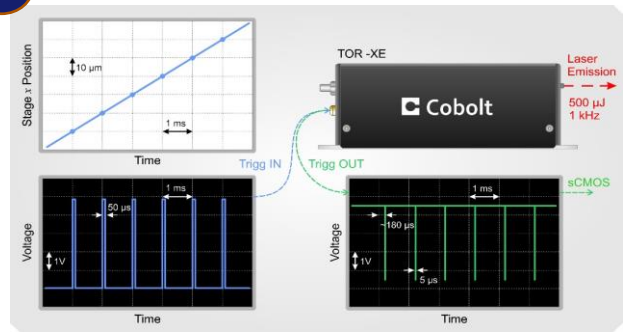
Latest generation fast gated cameras based on sCMOS sensor technology provide significant enhancement in terms of high acquisition rates and simultaneously high dynamic range compared to CCD, Interline or EMCCD-based gated detectors. We present examples of advanced micro Laser-Induced Breakdown Spectroscopy (µLIBS) Imaging enabled by gated sCMOS technology and ultra-stable kilohertz Q-switch diode lasers. LIBS images with up to 4K definition (3840x2160 pixels) and spatial resolution down to 10 µm, obtained in less than 3 hours, are presented. Such results show the spatially resolved elemental distributions for several geological samples demonstrating high throughput and a great reduction in experimental time, while preserving chemical information integrity.

1



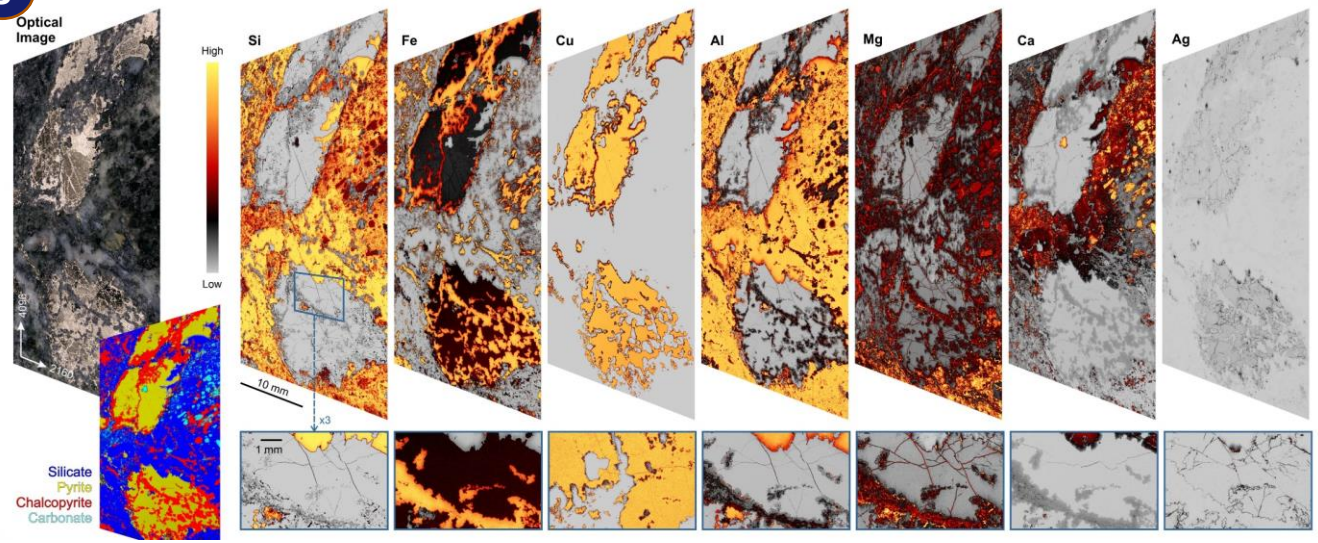
LIBS imaging experimental setup and example of single shot spectra

2



Timing diagram showing triggering scheme for translation stage, excitation laser and intensified camera

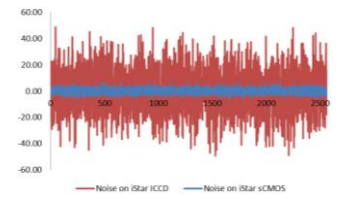
3

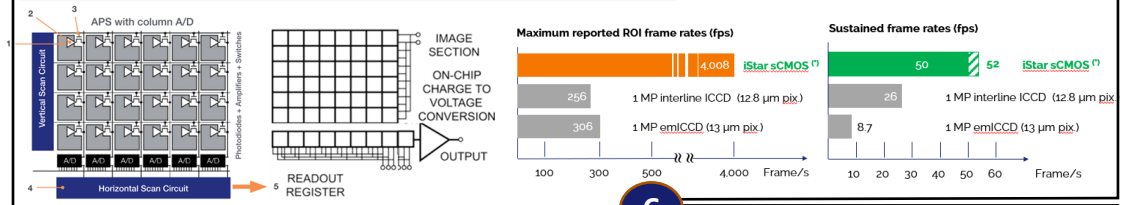


4K LIBS image of geological samples showing elemental distributions of Si, Fe, Cu, Al, Mg Ca and Ag (100 µs/point, resolution: 10µm)

4

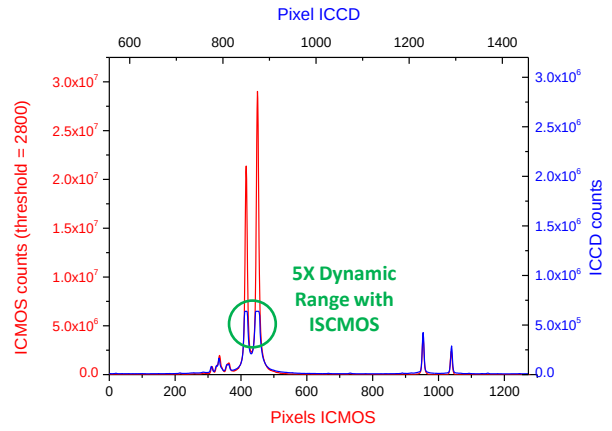
	iStar sCMOS (13 µm pix [2x2 bin])	1 MP Interline ICCD (12.8 µm pix.)	1 MP emICCD (13 µm pix.)
Pixel read noise (full frame max. rate)	5.2 e-	70 e-	90 e-
Gain to overcome sensor noise floor	~x31	~ x420	~ x540* *dual MCP and EM gain
Pixel well depth	120,000 e-	130,000 e-	400,000 e- (EM register)
Dynamic range	~3,870:1	~310:1	~740:1





sCMOS allows for low readout noise at high readout rates allowing for fast data acquisition while maintaining high dynamic range

5



LIBS spectrum showing a 5X increase in dynamic range with IsCMOS vs. ICCD

6

	Cobolt TorTM XE
Trigger mode	Internal, External, Gated
Wavelength in air (nm)	1064.2 ± 0.6
Pulse Energy (µJ)	500 ± 50
Repetition Rate (kHz)	Single pulse up to 1 kHz
Pulse Width (ns)	2.5 ± 1.0
Long-term stability (8 hrs ± 3°C)	< 3 %
Spatial mode (TEM00)	M2 < 1.3
Beam diameter at aperture (mm)	0.7 ± 0.1

Conclusion

We demonstrate a novel platform for high-speed, high resolution LIBS imaging based on latest generation gated camera on sCMOS technology combined with ultra-stable kilohertz passive Q-switch laser pulses. LIBS images with up to 4K definition and spatial resolution down to 10 µm can be obtained in less than 3 hours without sacrificing chemical integrity information. This high-throughput approach provides a platform for which many new LIBS applications may be explored.

Acknowledgments

We would like to thank- C. Dujardin, S. Hermelin (UCBL, Optolyse), Florian Trichard (Ablatom SAS), Cécile Fabre (GeoRessources), and Elena Vasileva (Hünber photonics) for their help and support.