UP-XP (Femto Laser BDS)

* Femtosecond laser not shown

Fast-track to functionality

- Turn-key operation for your femtosecond laser for ICP-MS, IR-MS, noble gas MS and LIBS
- Automated software control of the sample's motion, imaging and transport (carrier) gasses
- A beam delivery path that is designed to minimize losses and maximize the spot size range
- Integrates with all ICP-MS instruments for seamless operation

Tap the full potential of fs lasers for mass spectrometry

- Supports several makes and models of NIR and UV femtosecond lasers
- Achieve near-micron spots approaching the resolution of ion-microprobes
- Choose from a selection of calibrated, repeatable spot-sizes via software control
- Target multiple features, transects and zones for individual or continuous, auto-sampling analysis
- View and navigate samples using the Sample Mapping function

NEW WAVE™ RESEARCH

Specifications

The UP Solution

New Wave™ Research now offers its feature-rich hardware and software, found in the Universal Platform Series, for integration with femtosecond lasers. The UP-XP provides in-situ and bulk analysis capabilities via a full compliment of tools including auto-sampling, sample-mapping and other unique functions.

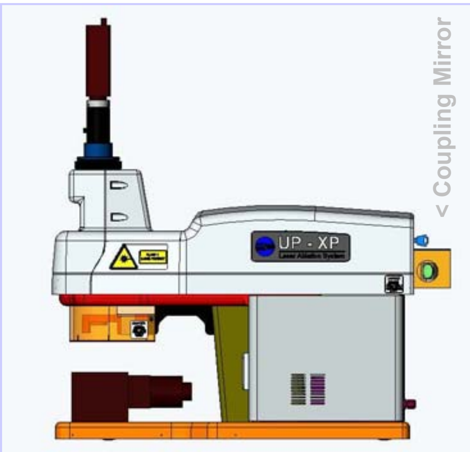
The UP-XP cuts the time and risk users encounter when working with femtosecond lasers while enhancing throughput, accuracy and precision of data generated on the mass spectrometer.

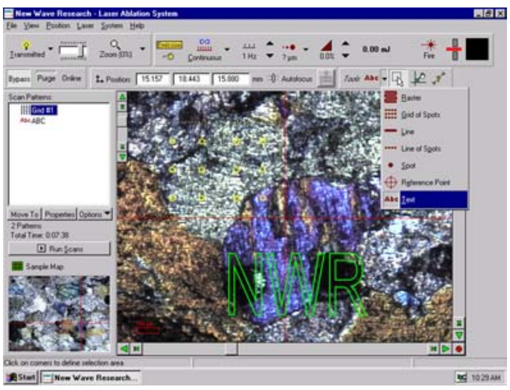
Configuration

The UP-XP (Femto BDS) mates to the ***customer supplied*** femtosecond lasers shown (see table) via a coupling mirror in the back. The laser is typically placed on an optical table along side of the Universal Platform pictured below.

The Universal Platform comes complete with color video microscope, motorized zoom magnification, aperture imaged beam delivery with motorized aperture wheel, ICP-MS sample chamber, XYZ stages, automated solenoids to route carrier gasses, transmitted / reflected and flood lighting, cross-polarizers and a class 1 enclosure.

HARDWARE





SOFTWARE

Specifications (Femto Beam Delivery)

Laser fire control	Software actuated, external trigger
Pulses per second[1]	Software controlled from 0 to 100
Spot selections[1]	Up to 13 software selectable, calibrated
Color Video Microscope	6X zoom views features down to <2 µm
X-Y Stages	52X52mm travel ; 0.25um resolution
Z Stage	25mm travel ; 0.25um resolution
Sample chamber	Quick-change drawer; 52mm ID X 52mm
Laser system classification	Class 1 (excluding coupling to laser)
System Dimensions[2]	27" (69mm) by 18" (46mm) footprint
Weight[2]	100lbs / 45kg
Voltage[2]	100-240 VAC 50/60 Hz

1. *Specifications depend upon make / model of customer supplied femtosecond laser*
2. *Not including laser*

Laser suppliers*	***NIR models***	***UV models***
Newport / Spectra-Physics		
Quantronix		
High Q		

* Partial listing of companies that offer 266nm output fs lasers and/or capability

Support

- New Wave™ Research, a laser manufacturer, is the leading supplier of laser systems for elemental and isotope analysis.
- New Wave™ Research provides global support and services by laser specialists via its regional offices in U.S., Europe, Japan, China and Taiwan.
- The Universal Platform (UP) series which includes the UP266, UP266MACRO, UP213 and UP193, is a proven design and industry standard instrument for laser ablation.

New Wave™ Research wishes to acknowledge the technical contributions and efforts of Dr. Ingo Horn of the University of Hanover and Dr. Rick Russo of the Lawrence Berkeley Laboratories.

Application

Since the mid-1980's laser ablation mass spectrometry has been gaining increasing viability as a truly quantitative analytical technique. Over this same period of time greater insight into the mechanisms associated with laser-material interactions, particularly with respect to its effect on the accuracy and precision of in-situ elemental analysis, has been gained. Laser fluence (energy density), laser wavelength and laser pulse width are the three dominant factors effecting the quality of the results obtained. The general consensus is that short pulse width (< 0.5ps), UV (<300nm) lasers will bring us a step closer toward matrix independent analysis and high spatial resolution.

Background

Ideally laser ablation will generate an aerosol vapor stoichiometrically identical to that of the parent material. Toward this goal, early solid state systems operating at 1064nm wavelength and ms pulse widths have given way to short UV, 213nm and 193nm, wavelength with ns pulse widths. These design changes have led to improved precision, reduced fractionation and smaller sample spot size (< 5µm).

Fundamental research into laser-material interactions continue to give us insight into the complex mechanisms of ablation. [1,2] The temporal relationship between plume formation and pulse width appears to play a significant role in defining the character of the aerosol delivered to the spectrometer.

Moments after the laser irradiates the sample surface; first electrons (Fig 1a) then atoms and molecules (Fig 1b) form a rapidly expanding plume. During this period the plume will absorb incoming laser radiation, shielding the sample (Fig. 2). In contrast to the nanosecond regime the femtosecond pulse will transfer all its energy to the sample before the onset of electron emission.[2,4]

Whereas nanosecond ablation displays significant elemental fractionation, Fig. 3A, in certain materials, femtosecond ablation at the same wavelength (266nm) displays no such fractionation, Fig. 3B.[5]

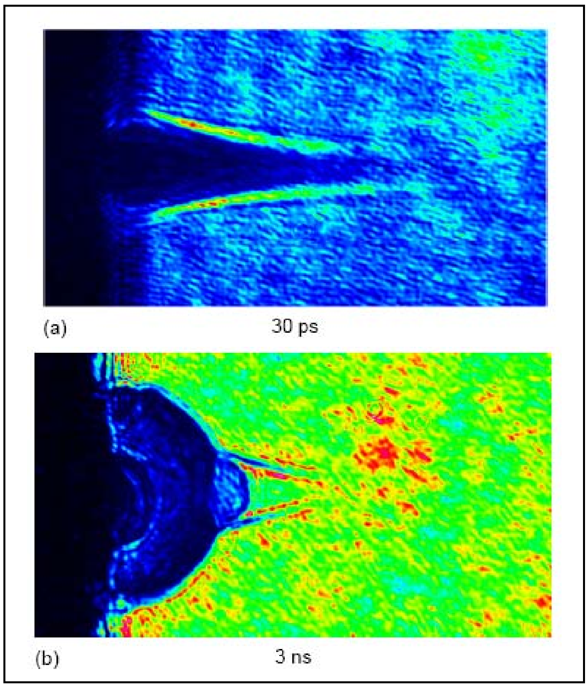


Figure 1: Laser plume formation and mass ejection
In the early stage of laser irradiation electrons leave the surface forming a plasma (a) followed by the ejection of atomic vapor (b). This expanding plasma will absorb incoming radiation from a nanosecond pulse, shielding the sample surface and reducing ablation efficiency. [Russo et al, Anal. Chem. 2002]

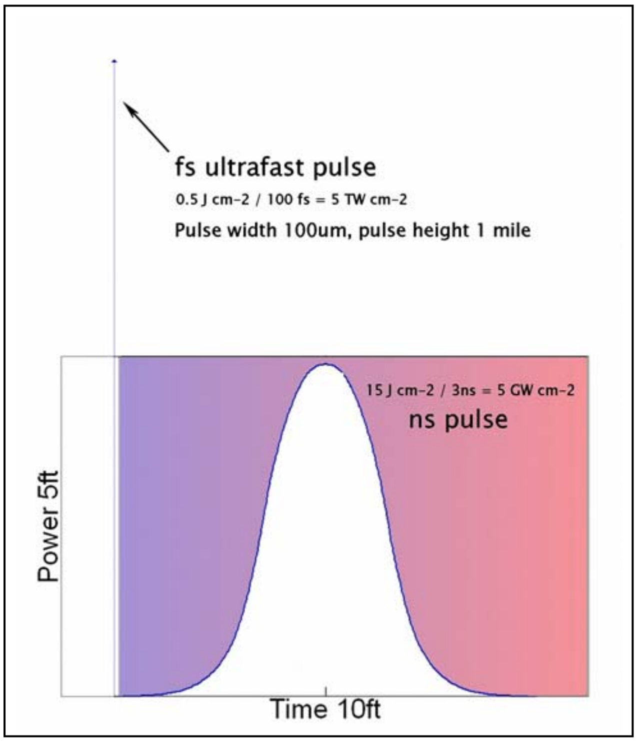


Figure 2: Laser pulse: nanosecond vs. femtosecond
If we represent a 3ns, 15J cm^{-2} pulse as 10ft wide x 5ft high a 100fs, 500mJ cm^{-2} pulse, by comparison, would be 100µm wide x 1 mile high. The area shaded in blue correlates to the electron plasma, Fig. 1a. The area shaded in red represents the ejection of atomic vapor, Fig. 1b. Note the position of the fs and ns pulses. [Wisdom, NWR 2002]

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Initial data by researchers in both the ICP-MS and LIBS communities have demonstrated significant improvements in analytical performance using femtosecond laser ablation, especially in terms of precision, accuracy, reduced matrix effects and reduced fractionation.[1] Due to the femtosecond time scale ablation is essentially non-thermal. This is particularly important for complex matrices with components of differing physical properties (Fig. 3). By contrast the length of the nanosecond pulse enables photon energy to dissipate into the sample lattice, inducing thermal effects.[4]

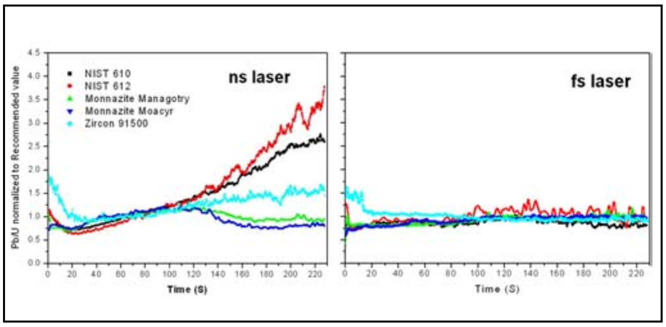

Figure 3: Evolution of atomic $^{206}Pb/^{238}U$ ratio obtained by LA-ICP-MS
Nanosecond and femtosecond laser ablation of silicate glasses and geological samples display a significantly different level of matrix dependence. [Poitrasson et al, 2003]

It has been proposed that the difference in particle size generation (Fig. 4), within a femtosecond vs. nanosecond regime, is related to the laser sample – laser plasma interactions.[6] The characteristics of femtosecond ablation have also been associated with a reduction in fractionation and improvement in accuracy and precision enabling enhanced matrix independent calibration.[7]

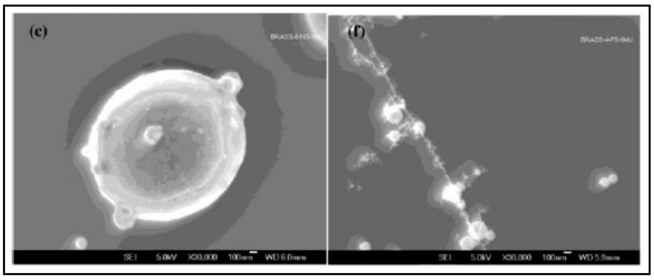

Figure 4: SEM images of ablated brass particles from nanosecond (c) and femtosecond (f) laser ablation (30,000x magnification). The imaged nanosecond particle (c) is > 1µm the femtosecond particles (f) are between 50nm to 250nm [Liu et al 2004].

The same physical characteristics that improve the chemistry of the ablated aerosol in laser ablation studies offer significant advantages to other material science applications such as laser cutting and trimming of semiconductor materials.[3]. Below (Fig. 5) are displayed two lines of 10µm spots in fused silica; one in the ns regime, the other in the fs regime. The ability to couple to materials without fracturing is an important consideration in both micro-sampling and micro-machining. Femtosecond laser systems appear to offer a clear advantage in a number of key applications.

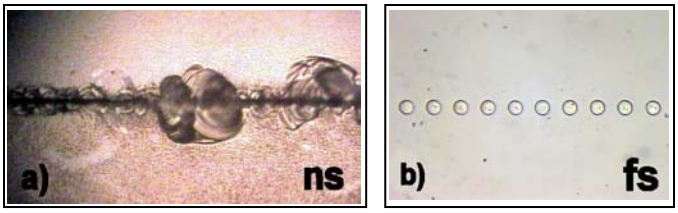

Figure 5: Line of spots in fused silica
355nm, 6ns, 10µm line of spots (a) and 790nm, 120fs, 10µm line of spots (b). [Wisdom, 2002]

Conclusion

Lasers are becoming an increasingly more elegant tool for probing complex materials with improved spatial resolution. There is a growing demand for systems that can drill micron sized holes without altering the chemical nature of the aerosol or physical integrity of the substrate. Femtosecond laser ablation is a logical next step toward the direct elemental and isotopic analysis of materials. Laser wavelength and fluence parameters have approached a practical limit in commercial solid sampling introduction systems for mass spectrometry (193nm, 40J cm^{-2}). There is growing evidence to suggest that working in the femtosecond regime may offer significant analytical advantages.

References

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6) Liu, C., Mao, X.L., Mao, S.S., Zeng, X., Greif, R., and Russo, R.E., Nanosecond and femtosecond laser ablation of brass: Particulate and ICP-MS measurements. Anal. Chem. 76, (2004). 379-383.

7) Gonzalez, J., Liu, C., Mao, X., and Russo, R.E., UV-femtosecond laser ablation ICP-MS for analysis of alloy samples. J. Anal. Atom. Spectrom., 19 (2004). 1165-1168

Warranty

One year warranty, details provided upon request.

www.new-wave.com

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