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Sabsabi, Mohamad; Doucet, Francois R.; Bouchard, Paul; Héon, René; Hamel, André; Laville, Stéphane; Gravel, Jean-Francois

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#### Publisher's version / Version de l'éditeur:

*2010 Winter Conference on Plasma Spectrochemistry [Proceedings], 2010-01-04*

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## **Use of high power pulsed fiber lasers for LIBS analysis and recent developments on LIBS for real time analysis**

M. Sabsabi, F. R. Doucet, P. Bouchard, R. Héon, A. Hamel, S. Laville, and J.F Gravel.

National Research Council Canada (NRC), Industrial Materials Institute (IMI), Boucherville (QC), J4B 6Y4, Canada

Laser-Induced Breakdown Spectroscopy is a method of optical emission spectroscopy that uses a laser-generated plasma as the source of vaporization, atomization and excitation. Although the LIBS method has been in existence for more than 40 years, prior to 1980, interest in the technology centered mainly on the basics of plasma formation. A few instruments based on LIBS have been developed but have not found widespread use. In the last decade, there has been a renewed interest in the method for a wide range of applications. This is due to the unveiling of significant technological developments in the components (lasers, spectrometers, detectors) used in LIBS instruments as well as emerging needs to perform real time measurements under conditions to which conventional techniques cannot be applied.

Recently, fiber lasers have become one of the hottest topics in photonics as the technology has grown in robustness and reliability. In fiber lasers, the optical fiber itself acts as the resonator cavity. These lasers are being commercially adopted at a rate faster than any previous laser technology, with "real world" applications ranging from marking, welding, cutting, telecommunications, surgery and micromachining operations to remote sensing. There are many attributes which make fiber lasers very attractive for LIBS applications such as their lower cost, robustness, broad range of wavelengths, energy delivery by fiber optics, excellent beam quality, capability of focusing on smaller spot sizes (few  $\mu\text{m}$  range), inherent user friendliness, high conversion efficiency rate from electrical to optical, virtually maintenance free (> 100,000 hours) etc. However, their use for spectrochemical quantitative analysis by LIBS has not been evaluated yet.

In this work we will report the use of these fiber lasers for LIBS applications. We will highlight the analytical figure of merit by comparison to traditional LIBS setup using conventional flash lamp pumped lasers. We will discuss their advantages and drawbacks in terms of sensitivity, standoff, reproducibility, ablation, energy delivery, thermal heating of the sample, repetition rate etc.

Furthermore, we will give an overview of LIBS activities for on-line measurements and examples of different LIBS applications in our laboratory and elsewhere will be presented: molten materials, metal ore processing, effluents, slurries, liquids, LIBS for nuclear industry, pharmaceuticals, etc.