Time-resolved detection of Hydrogen in steel products

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Application Note

Introduction and Set-up

The present ICCD camera (Andor iStar DH720-18F-03) is integrated in a LIBS (Laser Induced Breakdown Spectroscopy) experimental set-up (Fig. 1) intended for analytical measurements. LIBS is an OES technique with a plasma generated by irradiating the sample with intense laser pulses. The focus of this research project is on hydrogen distribution mapping of metallic samples. For this purpose a Ti:Sapphire femtosecond laser beam is focused on metallic samples placed in a low pressure chamber. Low pressure is necessary to avoid collisional line broadening which is especially severe for light elements as hydrogen. Following each irradiating pulse sample material is evaporated, forming short-lived luminous plasma. Crucial for the purpose of this project is adequate sensitivity and selectivity, and the prevention of thermo-diffusion induced redistribution of the element.

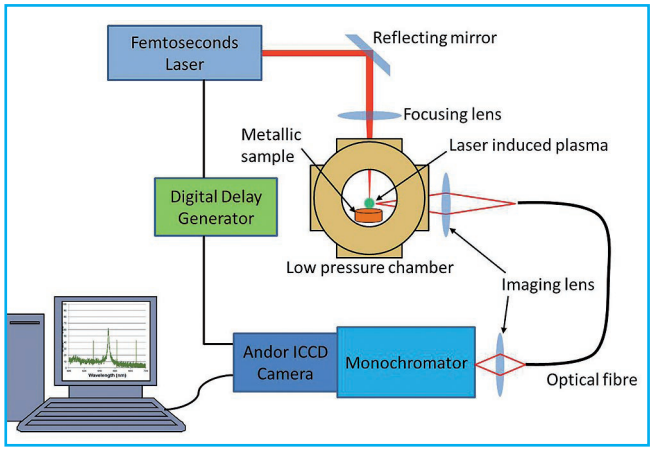

Figure 1 Basic experimental LIBS set-up.

A major problem arises because of the ubiquity of hydrogen (e.g. water, hydrocarbons). However, the laser generated plasma prevents the sample specific hydrogen from mixing with hydrogen coming from the surrounding environment. At least for certain times and region (i.e. the shock wave) inside the plasma such non-mixing conditions are possible. Identifying this very specific moment during the evolution of the plasma requires nanosecond time-gated imaging making the application of intensified CCD mandatory. Imaging and high-resolution spectroscopy during exploration and later analytical application rely on the possibility of precisely delayed and gated detection.

Results

First experiments have been conducted in the imaging mode. A notch filter width a central wavelength of 650 nm and a bandwidth of 20 nm is place in front of the camera. The plasma is imaged on the detector which is gated "open" for 1 µs and an increasing delay time after the laser shot. The temporal and spatial characteristics of the hydrogen line can be directly and simultaneously imaged over the whole plasma. Figure 2 demonstrates that it is possible to image differences in hydrogen emission correlated with background gas and working pressure.

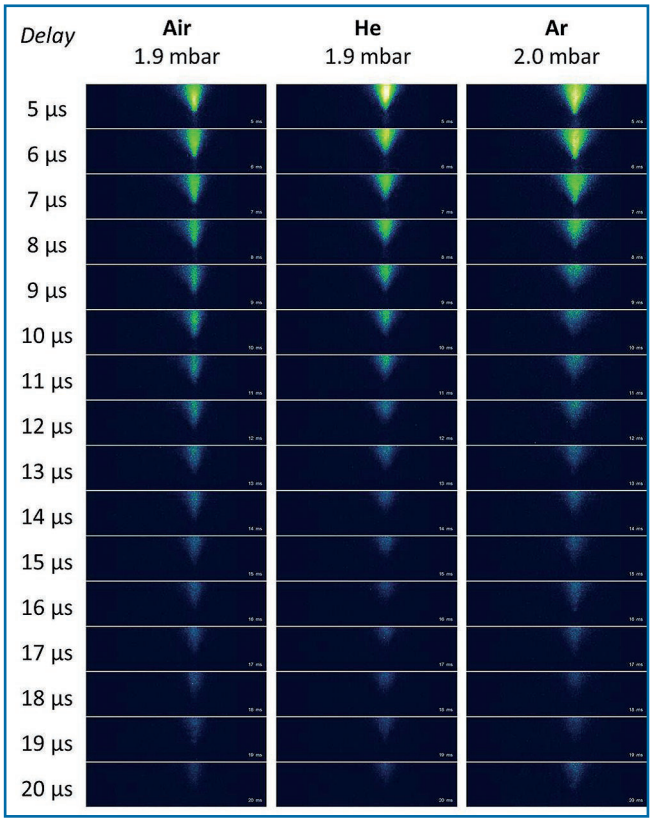

Fig. 2 Images of expanding hydrogen containing plasmas in different background gases and at different delay. Gating time was 1 µs. The sample is located at the bottom. Image height is approximately 20 mm. Sample Cu:benzophenone (5/1).

Reference

Gurevich, E. L. and R. Hergenroder (2007). "Femtosecond laser-induced breakdown spectroscopy: Physics, applications, and perspectives." Applied Spectroscopy 61(10): 233A-242A.

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