Exploring Light Elements in Steel via LIBS in the Vacuum-UV (VUV)

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LIBS, or Laser Induced Breakdown Spectroscopy, is a well-established technique for the classification (identification), and, under appropriate circumstances, the quantification, of elements (the analytes) in host materials (the matrices) [1]. LIBS dates back almost to the invention of the laser [2] and has found application in a wide range of sectors [3], spurred on mostly by its inherent simplicity. In essence, every element has a unique optical spectrum (signature or fingerprint) allowing it to be identified by a simple wavelength measurement, and quantified by a complementary intensity measurement. The use of a laser for elemental excitation has many other advantages, remote/standoff operation, spatial scanning, no sample preparation, etc. extensively discussed in literature [3].

Although LIBS in the VUV spectral region suffers from one clear disadvantage, it has two saving graces which are especially important if only trace amounts of the element of interest are present in the host material, e.g., for low levels of carbon in steel, a material we use as a benchmark for optimising LIBS for light element detection. Firstly, working in the VUV allows access to an abundance of resonance (connected to the ground state) transitions in atoms and ions at which are, in general, stronger than transitions between excited states (figure 1).

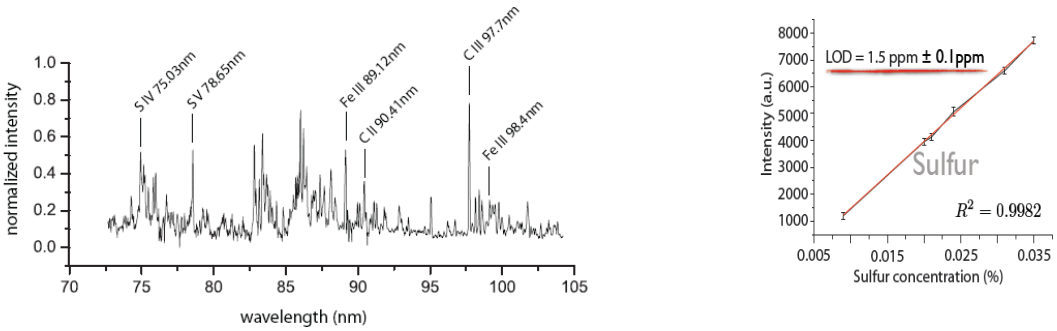

Figure 1. Steel VUV spectrum showing some C and S lines along with a LOD for sulphur [4].

Hence one obtains spectra with a better signal-to-noise ratio (SNR), and also a better signal-to-background ratio (figure 2). Secondly, the wavelength spacing between spectral lines in the VUV region is significantly larger compared to the visible and infrared regions, especially for ions. As result the spectra are less cluttered with more distinct, and easier to select, spectral lines. The combination of the two can lead to improved limits-of-detection (LOD), as we have shown some time ago for carbon in steel [5]. One can of course translate many of the methodological developments used to improve LOD values in Visible-NIR LIBS, such as double pulse LIBS [6] into the VUV [7,8]. Most recently we have investigated the use of line plasmas versus point plasmas [9] and single channel time resolved VUV LIBS 10], first explored in [11].

The talk will provide an historic overview of the above work and try to provide a perspective on possible future work focused on the detection light elements in steel. All of our work to date has focused on univariate approaches where a well isolated spectral line of interest is used for classification and quantification. As an aside, we recently investigated multivariate analyses for classification of pharmaceuticals [12], which has worked well in separating compositionally very closely related multielement materials. Time permitting. it might be worth discussing the application of such to steel and metals analysis in general.

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