Filament Induced Breakdown Spectroscopy for Long Distance Applications

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Abstract: Remote Laser Induced Plasma Spectroscopy with filaments was demonstrated at distances up to 180 m. Recorded spectra exhibited clear chirp dependence, opening a perspective for the optimization by pulse shaping techniques.

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Recent development of femtosecond lasers, which today can deliver pulses of intensities a few thousand times above the filamentation threshold in air, has driven a strong interest in practical applications of filaments [1-2]. One of first successful realizations of this idea was the broadband atmospheric absorption spectroscopy using a super continuum from these plasma channels [3]. There are, however, much more remarkable features, which make filaments interesting for various applications. For example, a highly collimated propagation mode, which remains practically unaffected even at long, few hundred meters, distances [4]. A high intensity flux (above the ablation threshold of most materials) confined inside a filament and its ability to overcome the diffraction limit of linear optics provides the opportunity for the long distance Laser Induced Breakdown Spectroscopy (LIBS).

Using filaments generated by a femtosecond laser system - Teramobile, we demonstrated for the first time Remote Filament Induced Breakdown Spectroscopy (R-FIBS) [5]. In this novel approach, no sophisticated beam expanders or even focusing optics was necessary to detect atomic and molecular emission of samples located 180 m from the laser. Recorded spectra exhibited no interference from ambient air, a feature which could not be reproduced with nanosecond pulses. Detailed analysis of the fluorescence signal in a focused beam configuration revealed strong non-linear features manifested by the clear chirp dependence [6]. This observation suggests that an adequate spectro-temporal shape of the pulse could lead to the increase of fluorescence efficiency, opening the perspective for pulse-shaping LIBS. The pulse optimization according to the specific emission line or a specific material would not only improve the sensitivity, but could also lead to the selective elemental detection incase of multi-component materials.

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