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All fiber-based LIBS feedback system for endoscopic laser surgery

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There has been a particular interest to use laser-induced breakdown spectroscopy (LIBS) as a feedback mechanism for laser surgeries in the past decade [1-6]. However, none of the mentioned setups [1-6] is suitable for endoscopic applications due to their bulky free-space configurations. In minimally-invasive surgeries, the major challenge is to integrate ablating laser waveguides and also all sensors inside the narrow channel of the endoscope. In this paper, we present a LIBS setup, which uses a multimode silica fiber for both delivering the inducing laser pulse and collecting the plasma emission light through the endoscope. The fiber-based LIBS setup consists of a frequency-doubled Q-switched Nd:YAG laser (Q-smart 450, Quantel, 532 nm, 5 ns, 60 mJ, 1 Hz), a cleaved large-core silica fiber (1.5 m-long, 1500 um-core, 0.39-NA, 70 mm-bending radius), and an in-house Echelle spectrometer (See Fig. 1). A 75 cm plano-convex laser line lens (Thorlabs, LA1978-YAG) was used to couple the laser beam into a multimode step-index silica fiber. Such a long focal length convex lens was used to avoid breakdown process in air. Moreover, the input face of the fiber was placed at 1 cm behind the focal point to maintain the laser power density below the damage threshold of the fiber. Two tight-focusing lenses were placed in front of the fiber end face to collimate the highly divergent laser beam and refocus it onto the sample surface. The light emitted from the microplasma generated at the surface of the sample (bone and its surrounding soft tissues) was collected by the same optics and directed to the spectrometer for characterization. The performance of the developed fiber-based LIBS setup for classification of different tissues has been investigated and compared with the free-space LIBS. The feedback provided by this fiber-based LIBS setup can be used in minimally-invasive laserosteotomies in order to stop the laser before causing any collateral damage to surrounding tissues.

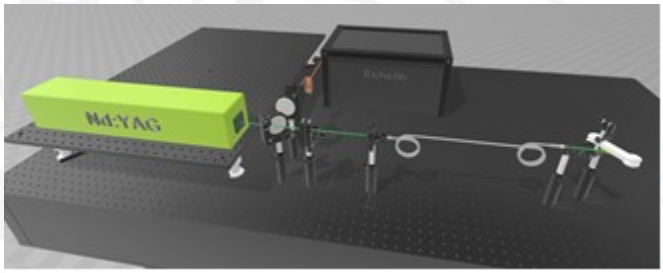

Figure 1. CAD design of the fiber LIBS setup.

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