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Review

## Ultrafast Laser-Based Spectroscopy and Sensing: Applications in LIBS, CARS, and THz Spectroscopy

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**Abstract:** Ultrafast pulsed lasers find application in a range of spectroscopy and sensing techniques including laser induced breakdown spectroscopy (LIBS), coherent Raman spectroscopy, and terahertz (THz) spectroscopy. Whether based on absorption or emission processes, the characteristics of these techniques are heavily influenced by the use of ultrafast pulses in the signal generation process. Depending on the energy of the pulses used, the essential laser interaction process can primarily involve lattice vibrations, molecular rotations, or a combination of excited states produced by laser heating. While some of these techniques are currently confined to sensing at close ranges, others can be implemented for remote spectroscopic sensing owing principally to the laser pulse duration. We present a review of ultrafast laser-based spectroscopy techniques and discuss the use of these techniques to current and potential chemical and environmental sensing applications.

**Keywords:** laser-induced breakdown spectroscopy; Raman spectroscopy; terahertz spectroscopy

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