

Characterization of gasoline combustion with laser and spark ignition

Key Words: Laser ignition; Spark ignition; Pressure rise rate; Peak pressure; Heat release rate

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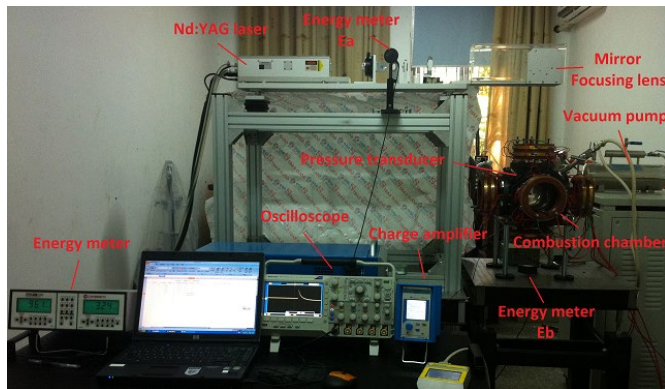
Background

- With increased environmental awareness, more stringent emission regulations, and the challenges of sustainable energy supply, development of internal combustion engines with high efficiencies and low emissions has become the focus of the studies.
- Lean combustion in gasoline engines has the potential of improving fuel economy while reducing emissions. However, there are many challenges in applying lean combustion technology.
- High-energy ignition is one solution, however it increases the voltage and energy demands for the conventional ignition system.
- Typical problems include secondary high voltage breakdown, poor timing sensor reliability, and electrode degradation and erosion, which lead to spark plug failure (Phuoc, 2006).

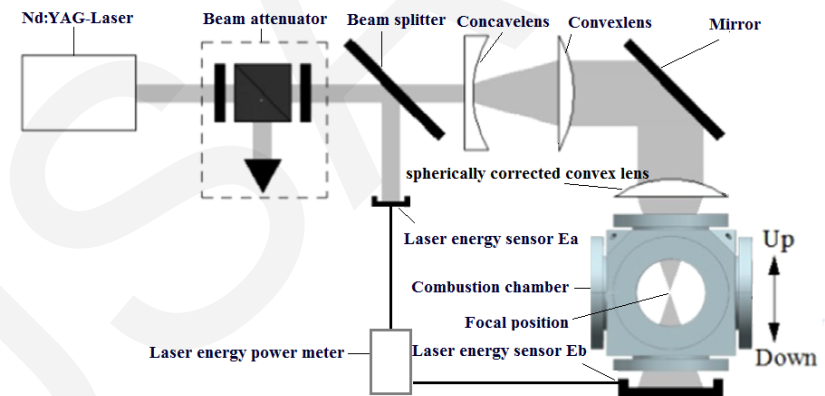
Solutions

- New ignition systems: plasma jet igniters (Chintala et al., 2006), laser-induced spark ignition (Richardson et al., 2004), and rail-plugs ignition (Gao et al., 2006).
- Most of the challenges listed above could potentially be solved by the use of laser-induced spark ignition because it has many potential benefits including better control over the timing and locations of ignition.
- Laser-induced spark ignition systems do not have electrodes, which potentially leads to a longer lifetime. More importantly, laser-induced spark ignition would allow ignition in multiple locations inside the chamber, shortening the combustion duration of the lean mixtures.

Experiment Apparatus of Laser induced spark ignition



Applied Device



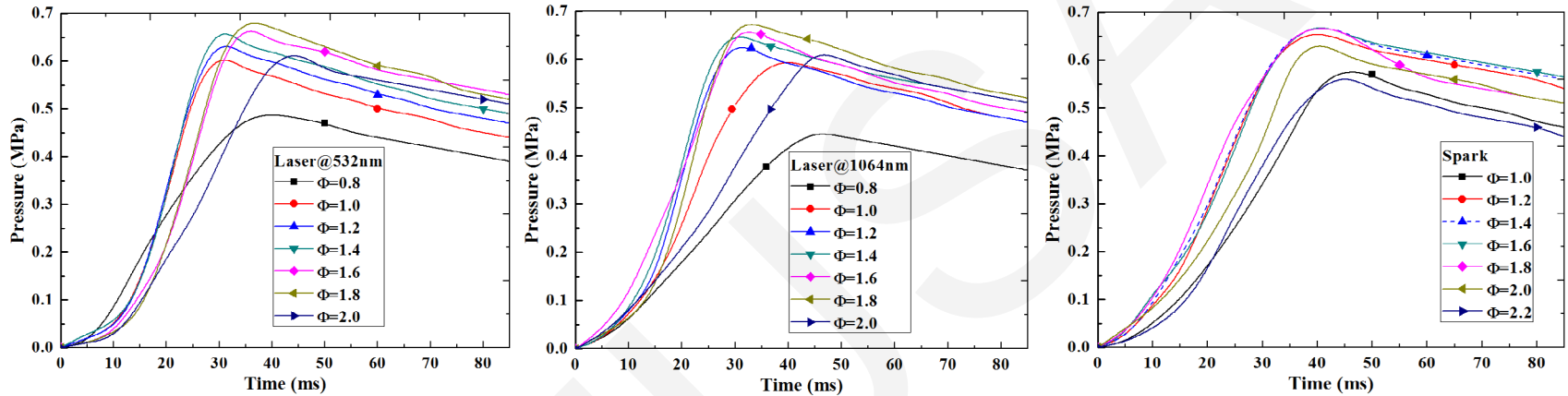
Schematic Diagram

- For all experiments reported in this study, the initial experimental conditions were identical.
- This study provided pressure history under various initial conditions (ignition and equivalence ratio).

Innovations

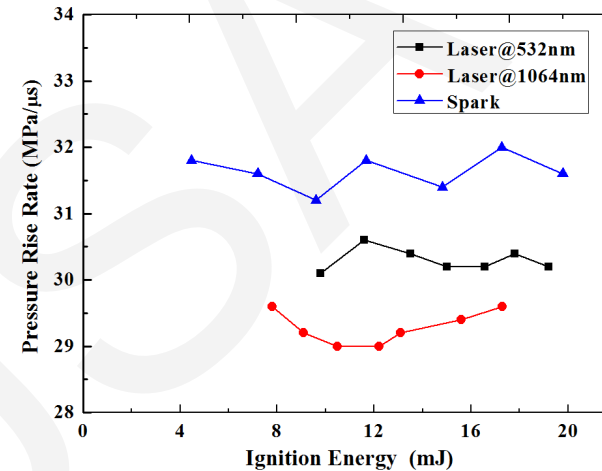
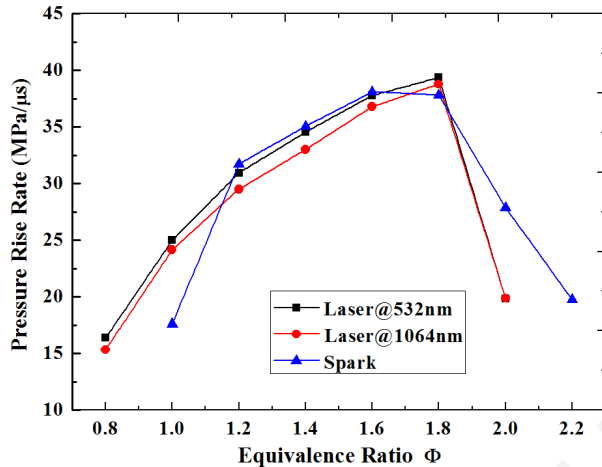
- ◆ Testing laser and spark ignition at the same time to keep the comparison exact
- ◆ For laser induced spark ignition, comparing the laser of both 532nm and 1064nm wavelength
- ◆ Studying gasoline instead of the alternative of gasoline

Results—Pressure history



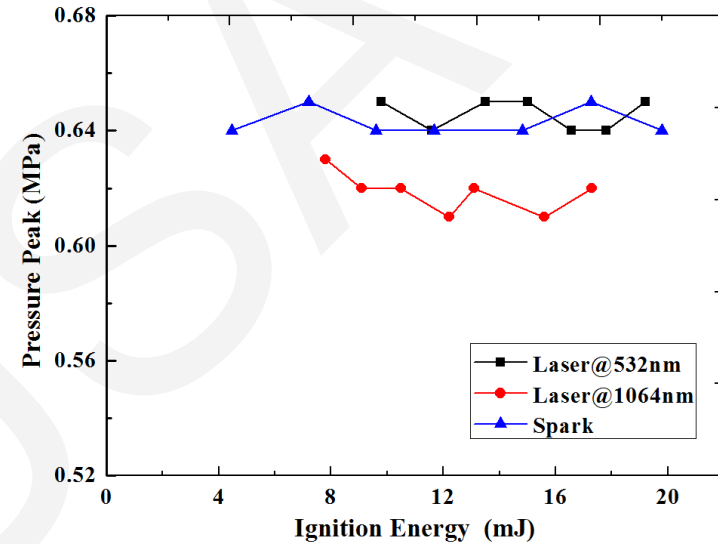
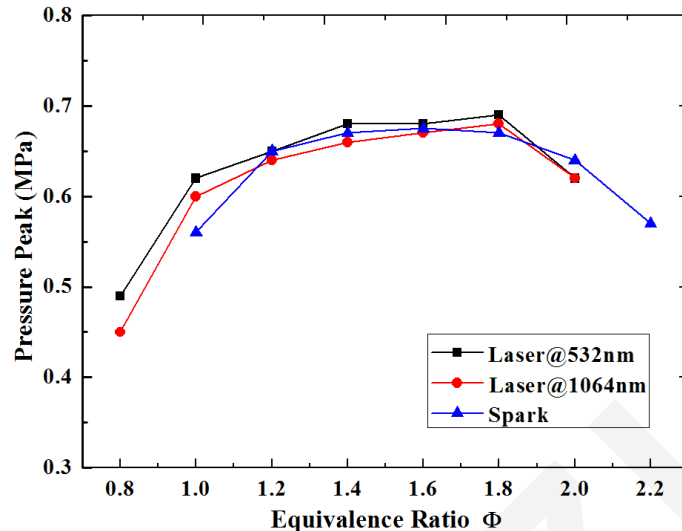
- For laser ignition, the incident laser energy has to be discerned from the absorbed laser energy; the absorbed energy is exactly the energy necessary to yield ignition inside the combustion chamber, and incident energy determined by working voltage is the total pulse energy needed to generate ignition.
- In this study, laser ignition energy means the absorbed laser energy.

Results—Pressure rise rate



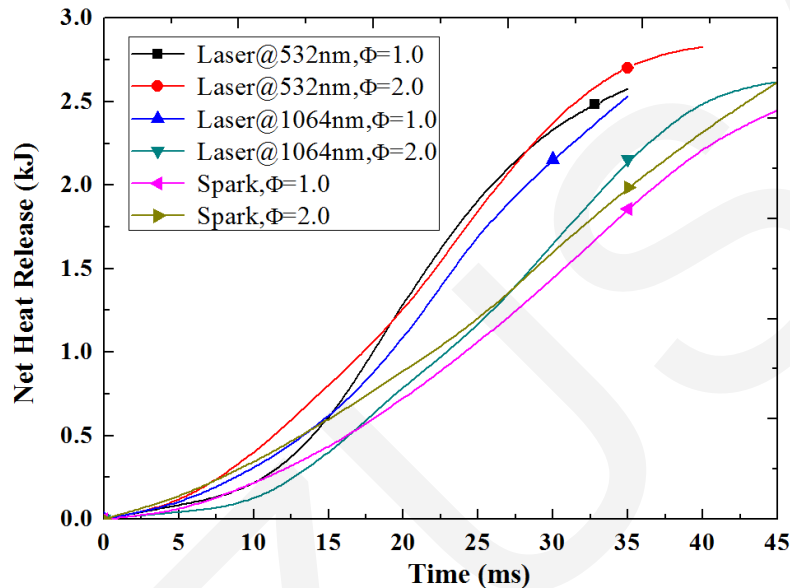
- At the equivalence ratio of 1.8, the pressure rise rates for laser ignition with wavelengths of 532 and 1064 nm were 39.4 and 38.8 MPa/μs, respectively.
- When the equivalence ratio was changed from 1.8, the pressure rise rates were reduced.
- The maximum pressure rise rate for spark ignition was 38.1 MPa/μs, achieved at an equivalence ratio of 1.6.
- There was no significant effect of ignition energies on the pressure rise rate for laser wavelengths of 532 and 1064 nm.

Results—Peak pressure



- The maximum peak pressures for both wavelengths of 532 and 1064 nm were obtained at an equivalence ratio of 1.8, which were 0.68 and 0.67 MPa, respectively.
- The peak pressure remained almost unchanged with different ignition energies for both laser and spark ignition.

Results—Heat release



- Heat release was in accordance with the variation of pressure history. For the leaner mixtures, at an equivalence ratio of 1.0, the combustion duration was shortened by laser ignition, which can lead to higher power output.