At present some 80% of our energy is derived from the combustion of chemical fuels, whether for transport, heating or power generation. While this is an inexpensive way of meeting our energy needs, the burning of fossil fuels by current methods leads to the production of harmful soot particles, noxious compounds such as nitrogen oxides, and greenhouse gases.

Understanding the complex chemistry of combustion is important for improving the efficiency of the reaction, leading to increased energy output with decreased emissions of harmful by-products. Owing to the global extent of combustion as a source of energy, an improvement in efficiency of even just a few percent will have a major impact on our transport systems and environment.

A crucial factor in combustion affecting the efficiency of, and emissions from, engines is the temperature of the internal gas both before and after ignition. It has been notoriously difficult to measure this temperature with sufficient precision and accuracy since it needs to be done remotely without affecting the engine operation.

Research in Professor Paul Ewart’s group in Oxford’s Physics Department has overcome the main difficulties using a new method derived from their fundamental research in non-linear optics and laser spectroscopy. The technique uses two crossed laser beams to create a tiny hologram using the gas molecules in a flame or inside the engine. A third laser beam is reflected off the hologram and oscillations in this beam, caused by sound waves, are used to measure the temperature. The precision achieved is more than ten times better than the previous best method and has allowed subtle, but important, changes to be measured accurately.

In collaboration with Jaguar/Land Rover, BP and Shell, this new method is being used to improve the design of the next generation of engines and fuels, including bio-fuels. It is also providing data to inform improved computer models, developed in collaboration with theoretical chemists, that could lead to a reduction in combustion-generated soot particles that are harmful to health.