Laser focus ignites fuel efficiency

Laser-based ignition systems could help to improve fuel efficiency in combustion engines and reduce our overall carbon footprint. Continued collaboration, knowledge-sharing and effective training are central to the ongoing development of laser spark plug technology, says **Dr Nicolaie Pavel** of the LASIG-TWIN project

A reliable, robust and effective laser ignition system could help mitigate the environmental impact of combustion engines, improving fuel efficiency and leading to e.g. greener cars in the automotive sector. This topic lies at the heart of the LASIG-TWIN project, an EC-backed initiative bringing together researchers from four different European countries. "One of the subjects we are working on is laser ignition. The project is a collaboration with a number of institutes from around Europe," outlines Dr Nicolaie Pavel, a Senior Researcher at the INFLPR in Magurele, Bucharest, the coordinator of the project. With a laser ignition system, more of the fuel is burned, improving combustion efficiency and so improving the performance of a vehicle. "With laser ignition, there is an increase in power, which is a key point in terms of reducing fuel consumption," continues Dr Pavel.

There are some significant technical challenges to deal with before these engines can be more widely applied however, which Dr Pavel and his colleagues aim to address in the course of LASIG-TWIN. The project itself is a twinning initiative, designed to enhance research capacity in Romania by building teams of excellence to develop new ideas, as well as by strengthening links with other institutes and sharing knowledge with international partners. "Some of my colleagues from our institute travel periodically to collaborate with our partners, and they discuss specific topics related to laser ignition," says Dr Pavel. "For example, our partners at Bayreuth University have a lot of experience in characterising combustion, while we here in Romania have deep knowledge of laser spark plugs. So we have some complementary areas of expertise."

Knowledge base

This gives researchers the opportunity to gain knowledge and skills in different areas, which they in turn can pass on to students, boosting the research base and the capacity for technical innovation. While Dr Pavel and his colleagues hold extensive expertise in certain aspects of laser ignition, he says they still benefit from exposure to new concepts and ideas. "We don't know how to characterise certain things around the engine, for example how plasma behaves. So one aspect of the project is around gaining new insights into this kind of area," he outlines. There is also a strong focus on training within the project, with Dr Pavel and his colleagues aiming to widen the knowledge base, strengthening the foundations on which future research can be built. "Alongside spending time with our partners, we are also holding workshops," he says.

A Dacia car that was run at INFLPR by laser spark plugs is shown.

Insets present laser spark plug prototypes in comparison to standard spark plugs.

The first workshop (September **2016**, Magurele, Romania) looked at the history, status and future of laser ignited combustion engines, while further events are planned over the course of the project addressing a range of topics, including the measurement and characterisation of combustion, or solutions for the integration and packing of a laser spark plug. There is also scope for further collaboration beyond the project; the **5**th international Laser Ignition Conference (LIC '**17**) was recently held in Bucharest, in June **2017**, which Dr Pavel says proved to be a very successful event. "The LIC '**17** was held this year in Bucharest, which was

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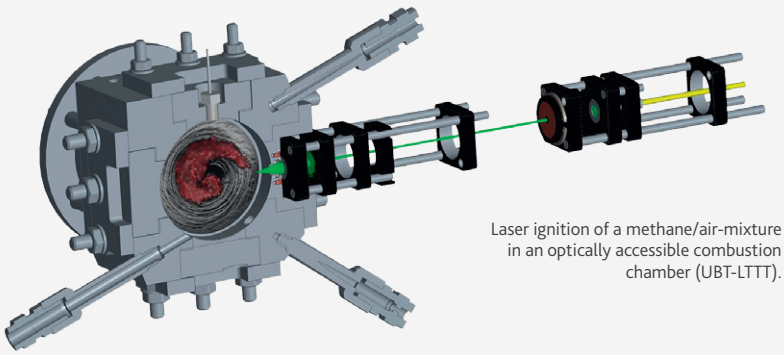


Laser ignition of a methane/air-mixture in an optically accessible combustion chamber (UBT-LTTT).

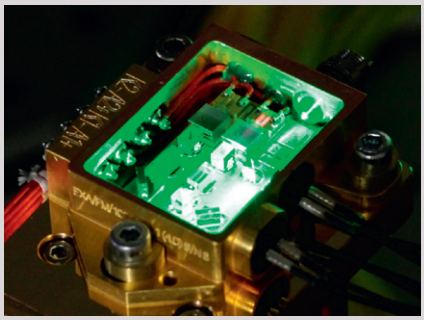
the first time it had been held in Europe - it was a highly successful conference," he says. Summer schools are also among the purposes of this project, laying the foundations for continued research. "A summer school was held in July **2017** in Brasov, Romania, mainly with students from Romania, but also with some participation from other parts of Europe," outlines Dr Pavel.

Further events will be held in future, while staff exchanges and expert visits are also being organised, reinforcing the project's commitment to knowledge sharing. "We invite specialists from abroad to discuss specific subjects in front of not only our partners, but also students from the institute or from various faculties," says Dr Pavel. This will heighten awareness among students of the wider possibilities in research, and also potentially encourage the development of new projects. "It's good to bring together young people with an interest in this subject, who are interested in working in this area in future," continues Dr Pavel. "With some support from the European Commission, you can then start to think about other collaborations and other research projects."

Commercial applications

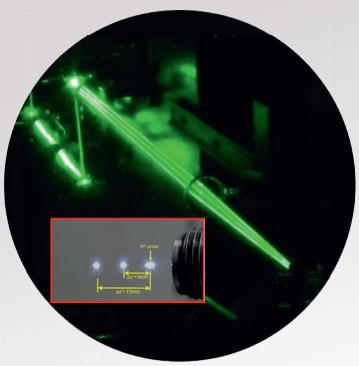
This also holds importance in terms of potential commercial applications arising from the project's research. While laser spark plug technology could help improve car efficiency, Dr Pavel says the project's work is also relevant to other areas, including powertrains, the space industry, marine propulsion and large IC engines for co-generation, or even hybrid car engines. "We have already had some discussions with private companies about laser ignition, following on from the LIC '**17** in Bucharest. There is interest in laser ignition for certain aerospace and satellite applications," he says. There is also interest from the automotive industry in this technology; Dr Pavel believes it's important to involve industry in research if the project's work is to have a wider impact. "We would really need the help and involvement of automobile companies," he stresses.

The cost of a laser spark plug is still a major consideration in this respect. While a classical spark plug is relatively inexpensive, at this stage of development a laser spark plug is still significantly more costly, a context in which the commercial sector can play an important role. "If laser spark plugs reach mass production they will become much cheaper, but this requires more input from the commercial sector, including both small companies and bigger companies," explains Dr Pavel. However, while the project's work holds wider relevance to industry, Dr Pavel says commercialisation is not on the immediate agenda, so his focus is more on continued research, deepening the knowledge base and strengthening links with other institutes with complementary areas of expertise. "We are discussing laser ignition technology with our partners, and we also have some further workshops and a summer school to organise" he outlines.



Robust packaged green laser for the Raman experiment of the EXOMARS mission (IOF).

A multi-point ignition offline test is shown. Inset present variable 3D spark location at optical plug exit (UL).



From left to right: UBT: Mark Bärwinkel and Sebastian Lorenz; IOF: Erik Beckert; CNRS: Laurent Zimmer and Gabi-Daniel Stancu; INFLPR: Nicolaie Pavel; UL: Geoffrey Dearden.

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Laser Ignition - A Twinning Collaboration for Frontier Research in Eco-Friendly Fuel-Saving Combustion

Project Objectives

The collaboration between National Institute for Laser, Plasma and Radiation Physics (INFLPR), Magurele, Romania and the four institutions from Germany, the UK and France is expected to provide an opportunity for research excellence, technological innovation and industrial exploitation in the fields of laser spark plug fundamentals and applications.

Project Funding

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Project Partners

Professor Dieter BRÜGGEMANN, University of Bayreuth (UBT), Department of Engineering Thermodynamics and Transport Processes (LTTT), Germany • Professor Geoffrey DEARDEN, University of Liverpool (UL), School of Engineering, United Kingdom • Dr Laurent ZIMMER, Centre National de la Recherche Scientifique (CNRS), CentraleSupélec, Université Paris-Saclay, France • Dr Erik BECKERT, Fraunhofer-Institute for Applied Optics and Precision Engineering (IOF), Germany

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Dr Nicolaie Pavel

Dr Nicolaie Pavel is a Senior Researcher at INFLPR; he conducts research on diode-pumped solid-state lasers and on some laser applications (including laser ignition). He is a recipient of two postdoctoral scholarships: JSPS (1999-2001, Okazaki, Japan) and Alexander von Humboldt Foundation (2005-2006, Hamburg, Germany); in 2013 he obtained the degree "Dr. habil." in Physics.

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