【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering Ⅰ)

# Title of Project : Investigations on Multi-Hierarchical Structures of Turbulent Premixed Flame by Multi-Dimensional Combined Laser Diagnostics and GPU Cloud DNS

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Research Area : Engineering
Keyword : Combustion, Turbulence, Experimental fluid mechanics, Computational fluid dynamics, Energy utilization

## 【Purpose and Background of the Research】

Combustion technology of fossil fuels still covers about 85% of total primary energy supply in Japan. Combustors such as IC engine and gas turbine are required to be more efficient and lower emissions. These improvements directly resolve the global/urban environmental problems. The flow fields in many combustors used in engineering applications are in complex turbulent combustion state in which strong interactions between complex chemistry and turbulence occur. Characteristics of turbulent combustion are dominated by hierarchical structures of turbulence and flame. It can be expected that a hierarchical structure inside flame is newly caused by chemical reactions at high Reynolds number conditions, since interactions between flame surface and coherent fine scale eddies in turbulence are enhanced. At high pressure, the instability mode of flame and the hierarchical structures of flame surface and inside flame are considered to have complex interactions.

In this research project, the hierarchical structures of flame surface and inside flame in turbulent premixed flames are investigated by the world's most sophisticated laser diagnostics and direct numerical simulation. Turbulent flame structures at high Reynolds number and high pressure which can be observed in practical combustors will be clarified and modeled.

## 【Research Methods】

The most advanced laser diagnostics and direct numerical simulation of turbulent combustion in the world are conducted to investigate the hierarchical structures of flame surface and inside flame in turbulent premixed combustion, and the turbulent flame structures at high Reynolds number and high pressure. Simultaneous measurements of several chemical species and fluid velocity in multi-dimensions are developed by combining planar laser induced fluorescence (PLIF) and stereoscopic particle image velocimetry (PIV) in the experimental approach, and cloud computing technology of massive parallel graphic processing unit (GPU) is combined with direct numerical simulation technology of turbulent combustion in the numerical approach.

## 【Expected Research Achievements and Scientific Significance】

Turbulent combustion mechanism in the practical combustors is going to be revealed in this research project. The clarified turbulent combustion mechanism will be applied to the development of more efficient and lower emission combustors, which will contribute to the resolution of global/urban environmental problems in the medium- and long-term.

## 【Publications Relevant to the Project】

・Y.-S. Shim, S. Tanaka, M. Tanahashi and T. Miyauchi, Local Structure and Fractal Characteristics of $H_2$-Air Turbulent Premixed Flame, Proc. Combust. Inst., Vol. 33 (2011), pp. 1455-1462.
・M. Shimura, T. Ueda, G.-M. Choi, M. Tanahashi and T. Miyauchi, Simultaneous Dual-plane CH PLIF, Single-Plane OH PLIF and Dual-plane Stereoscopic PIV Measurements in Methane-Air Turbulent Premixed Flames, Proc. Combust. Inst., Vol. 33 (2011), pp. 775-782.
・M. Tanahashi, S. Taka, M. Shimura and T. Miyauchi, CH Double-Pulsed PLIF Measurement in Turbulent Premixed Flame, Exp. Fluids, Vol. 45, No. 2 (2008), pp. 323-332.

【Term of Project】 FY2011-2015

【Budget Allocation】 161, 500 Thousand Yen

## 【Homepage Address and Other Contact Information】

http://www.navier.mes.titech.ac.jp/kiban-s-2011/index.html