In recent years, global environmental problems, particularly global warming due to carbon dioxide (CO$_2$), have become substantially evident. It is therefore necessary to investigate novel and efficient energy utilization methods, to significantly suppress CO$_2$ emission, and thus preserve the environment.

Our studies generally focus on environmentally friendly energy usage in terms of advanced combustion technologies, with our main research interests focusing on the following: (1) establishment of control technologies for clean coal/biomass combustion; (2) establishment of combustion technologies with the aim of investigating carbon capture and storage (CCS); (3) studies into renewable energy usage; and (4) development of high-powered diamond semiconductor devices.

*Environmental Energy Engineering Lab.*
Coal has received attention as a suitable fossil fuel energy resource because of its evenly distributed rich deposits throughout the world. However, CO$_2$ emission from burning coal is extremely large (1800–2410 g/kg-coal). Novel combustion technologies which decrease the environmental loading are therefore highly sought-after. In this context, the following two methods are currently under investigation: (1) a method by which a plant can be operated at high thermal efficiency; and (2) CCS combustion technologies that combust coal using an oxy-fuel mixture composed of exhaust CO$_2$ and pure oxygen, followed by burying the exhaust CO$_2$ underground. Our main aims are to (1) elucidate the mechanism of pollutants formation in pulverized coal combustion employing pure oxygen and CO$_2$; and (2) clarify the phenomena in integrated coal gasification combined cycle (IGCC) and pressurized fluidized bed combustion (PFBC) system.

[ Recent publications, Okumura ]


(3) Mechanism of Coal-Pyrolysis under Elevated Pressure and Rapid Heating Conditions, Transactions of the Japan Society of Mechanical Engineers (2005) , Vol.71, No.702, pp.702-710,


etc.
Rapid development of the heavy chemical industry has resulted in a number of pollution issues arising. During the high economic growth period from 1965 to 1984, Japan experienced a number of serious environmental crises, including Minamata disease, photochemical smog, acid precipitation, arsenic pollution, and water contamination (sludge). Although a number of novel technologies have been developed in recent decades, problems relating to new environmental pollutants such as PM2.5 and dioxin have developed. During our studies, we focus our attention on the environmental pollutants associated with coal/biomass combustion (PM2.5, nitrogen oxides, and sulfur oxides) and develop suitable suppression technologies. The mechanism of formation of the environmental pollutant must firstly be understood, after which the design of environmentally friendly equipment can be carried out.


To decrease CO$_2$ accumulation in air with the aim of reducing global warming, investigation of effective utilization of renewable energy (biomass resources) and efficient utilization of energy is required. For example, biomass power generation, biomass gasification technologies, and distributed biomass combustors are being actively developed. The gasification at low temperatures (below 600°C) is essential for constructing exergy-recuperative gasification systems for biomass. However, simultaneous achievement of both a “low temperature” and a “rapid gasification” process is challenging, as the two generally contradict each other. Nowadays, gasification is carried out in a high temperature (partial combustion) at approximately 1000–1200 °C. We therefore aim to achieve a rapid gasification by lowering the temperature to approximately 600 °C for next-generation gasification.

(3) Development of renewable energy utilization technologies (Low temperature, rapid biomass-gasification technologies)

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[ Recent publications, Okumura ]


(2) Enhancement of Gasification Rate of Biochar under Low-Temperature Conditions by Directly Supported Catalysts, Transactions of the Japan Society of Mechanical Engineers (2013), Vol.79, No.808, pp. 2798-2809.


etc.
The discovery of novel materials has led to the rapid development of new sciences and technologies. Such development began at the start of humankind, where stone was initially used for making tools, followed later by iron. Much further down the line, silicon was found to be useful for application in electric devices (semiconductors), with this discovery revolutionizing information and communication technologies, thereby ensuring a rich living environment for humankind. It is expected that in the near future, carbon materials (ex. diamond) will be important in the development of novel technologies. Our aim is to use an artificial synthesized-diamond-film to prepare semiconductors for use in high-powered electric equipment and electric trains driven by high voltages.


[ Recent publications, Okumura ]


(3) Electrical Characteristic of Diamond Film Synthesized by Combustion Flame


Although natural energy sources such as solar, wind, water, and wave power in sea are considered ideal energy sources, they also have a number of issues, such as low energy density and large supply fluctuation. In this context, the hydrogen energy infrastructure has been developed to give an energy source with a stable infrastructure and small supply fluctuation. Toyota recently developed and sold the “Mirai” fuel cell car, and provided the patent for its technology free of charge. Honda and Nissan also plan to launch fuel cell cars in 2016 and 2017, respectively. Our studies focus on the development of an effective method for producing amounts of hydrogen from biomass and waste. In addition to these renewable sources, hydrogen is a storable clean energy source, which can also be obtained from natural gas and water electrolysis.

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**Recent publications, Okumura**