# TECHBRIEF

## MICROWAVE ACTIVE METAL OXIDES FOR $CO_2$ DRY REFORMING OF METHANE

### OPPORTUNITY:

This patent-pending technology establishes a novel system and method for the microwave-assisted dry reforming of methane. The technology is available for licensing and/or further collaborative research from the U.S. Department of Energy's National Energy Technology Laboratory.

### CHALLENGE:

Traditional steam reforming of methane to produce hydrogen ($H_2$), which is then reacted with carbon (CO) to produce methanol and other industrial commodity chemicals, is an extremely energy intensive process with large carbon footprint. For example, the steam reforming reaction produces 10 tons of carbon dioxide ($CO_2$) for every ton of $H_2$. Methane dry reforming uses an alternative reaction that uses $CO_2$ as a soft oxidant to produce CO and $H_2$ from methane, which can be further processed into methanol or hydrocarbons. Further, using $CO_2$ to produce commodity chemicals, such as $H_2$ and CO, can generate revenue to offset carbon capture costs, reduce the carbon footprint of fossil-fuel powered processes, and allow sustainable use of fossil fuel resources.

Traditional dry reforming techniques are extremely energy intensive and require very high temperatures (>800C) that make it unpractical economically compared with the lower-temperature, carbon-positive, methane steam reforming. Microwave-assisted catalysis has been demonstrated as an enabling technology to promote high temperature chemical processes. Unlike traditional thermal heating, microwaves can rapidly heat catalysts to extremely high temperatures without heating the entire reactor volume. This reduces heat management issues of conventional reactors and enables rapid heating/cooling cycles. Ultimately, this can allow reactors to utilize excess renewable energy on an intermittent basis (load follow) to promote traditionally challenging, thermally-driven reactions for on-demand chemical production.

Microwave absorption is a function of the electronic and magnetic properties of the material, and a properly designed catalyst may function as a both a microwave heater and a reactive surface for driving the desired reaction. Microwave absorption is extremely sensitive to the catalyst's chemical state and electronic structure, and effective catalysts must maintain microwave activity across a wide range of temperatures in both oxidative and reductive environments.

### OVERVIEW:

NETL researchers have developed materials and methods to synthesis and demonstrate new microwave active metal oxide catalysts for converting $CO_2$ and methane into hydrogen and carbon monoxide. This invention will allow the development of modular reactors that use of intermittent renewable electricity to power a reaction that is currently not economically viable due to extreme energy demands. The invention will consume 22 tons of $CO_2$ for every ton of $H_2$ produced. The alternative steam reforming process to convert methane into $H_2$ produces approximately 10 tons of $CO_2$ for every ton of $H_2$.

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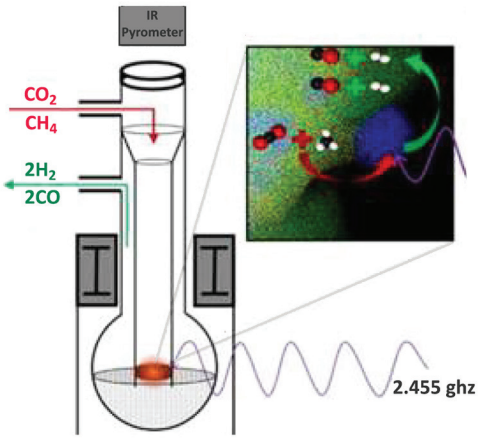

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## ADVANTAGES:

- Carbon negative hydrogen and carbon monoxide production
- Instantaneous heating
- Low power requirements
- New catalyst design concepts
- On-demand chemical production
- Load following
- Utilization of flared natural gas and $CO_2$

## APPLICATIONS:

- Advanced Materials
- Combustion Technology & Fuel Cells
- Environmental
- Natural gas utilization
- Carbon dioxide utilization
- Reduced greenhouse gas emissions
- Carbon mitigation

## PATENT STATUS:

U.S. Patent Pending (non-provisional patent application)

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