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Microphotonic Harsh Environment Sensors for Clean Fuel and Power Generation

Low cost, reliable, in-situ sensors are highly desired for advanced process control and lifecycle management in various power and fuel systems. Many energy generation processes involve harsh conditions throughout the operation that requires monitoring to assist in attaining and maintaining the goals of high efficiency and high environmental performance. General measurements of interest include temperature, strain, pressure, gas compositions, and trace contaminants/pollutants. Unfortunately, most existing sensors are incapable of operating directly in the harsh environment of typical power and fuel systems involving high temperature and high pressure with presence of particulates and corrosive atmosphere.
Funded by DoE/NETL, our group has been developing various novel microphotonic sensors for monitoring physical and chemical parameters under hostile conditions. The demonstrated sensors include the miniaturized inline fiber Fabry-Perot interferometer (FPI) fabricated by one-step femtosecond laser micromaching, the long period fiber grating (LPFG) fabricated by CO2 laser irradiations, the fiber inline core-cladding mode interferometers (CMMI), and the LPFG coupled CMMI sensors. These sensors can be directly used for the measurements of various physical parameters such as temperature, pressure and strain in a high temperature (tested up to 1100 degree C) harsh environment are presented. In addition, when coated with a thin layer of gas sensitive thin film (e.g., doped crystalline ceramic nanofilm), they can be used for measurements of various hot gases such as hydrogen, carbon dioxide, carbon monoxide, and hydrogen sulfide in high temperatures. With demonstrated advantages of small size, lightweight, immunity to electromagnetic interference, resistance to chemical corrosion, high sensitivity, remote operation capability, robustness and dependable performance in a hostile environment, these microphotonic sensor may find broad applications for process control and optimization in various fuel/power systems such as coal gasification, advanced engines, oil/gas extraction, fuel cell operation, coal/geothermal/wind/nuclear-based power generations, etc. We hope that this presentation will convey our interest in teaming up with UM researchers and industry partners to collectively explore future opportunities.