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SiC Sensors in Extreme Environments: Real-time Hydrogen Monitoring for Energy Plant Applications[1]

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Clean, efficient energy production, such as the gasification of coal (syngas), requires physical and chemical sensors for exhaust gas monitoring as well as real-time control of the combustion process. Wide-bandgap semiconducting materials systems can meet the sensing demands in these extreme environments consisting of chemically corrosive gases at high temperature and pressure. We have developed a SiC based micro-sensor for detection of hydrogen containing species with millisecond response at 600 $^\circ$C. The sensor is a Pt-SiO_2-SiC device with a dense Pt catalytic sensing film, capable of withstanding months of continuous high temperature operation. The device was characterized in robust sensing module that is compatible with an industrial reactor. We report on the performance of the SiC sensor in a simulated syngas ambient at 370 $^\circ$C containing the common interferants CO_2, CH_4 and CO [1]. In addition we demonstrate that hours of exposure to $\geq$1000 ppm H_2S and 15% water vapor does not degrade the sensor performance. To elucidate the mechanisms responsible for the hydrogen response of the sensor we have modeled the hydrogen adsorptions kinetics at the internal Pt-SiO_2 interface, using both the Tempkin and Langmuir isotherms. Under the conditions appropriate for energy plant applications, the response of our sensor is significantly larger than that obtained from ultra-high vacuum electrochemical sensor measurements at high temperatures. We will discuss the role of morphology, at the nano to micro scale, on the enhanced catalytic activity observed for our Pt sensing films in response to a heated hydrogen gas stream at atmospheric pressure.

[1] R. Loloee, B. Chorpening, S. Beers & R. Ghosh, Hydrogen monitoring for power plant applications using SiC sensors, Sens. Actuators B:Chem. (2007), doi:10.1016/j.snb.2007.07.118

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