FMA (Fellow Mentor Advisor) Program 2014-2015

Student (Fellow): Chris Chen
Advisor: Prof. Debbie Senesky
Mentor: Andy Brayshaw, BP

Project: Harsh Environment Microsystems for Localized Subsurface Characterization

Keywords: MEMS; pressure prediction; sensors; GaN; high-temperature sensing

Problem Statement: Pore pressure of formations is a critical problem in the oil and gas industry. Based on current technology, it is still difficult to accurately estimate the pore pressure while drilling. This can cause serious problem such as allowing formation fluids to enter the well and blow-outs to occur. The development of enhanced well-bore system has been studied to better predict the pore pressure and avoid catastrophic events. However, the high temperatures, complex geochemical and geophysical properties in the exploration area make data collection challenging. Therefore, more reliable sensors are needed for the drilling engineers to visualize the down-hole drilling environment such that they can make precise and in-time decisions.

Research Plan: Based on the above my research plan aims to (1) design a sensor which can perform pressure detection in harsh environment, (2) fabricate the sensor in the Stanford Nanofabrication Facility (SNF), (3) characterize the effects of change in temperature and dynamic responses of the sensor, and (4) establish and verify a practical sensor to predict the pressure ahead at a range of frequencies and temperature.

In this project, micro-electro-mechanical systems (MEMS) will be utilized to design the gallium nitride (GaN) heterostructures based sensor. GaN offers a promising material platform for sensing within extreme environments because it is temperature resistant (electrically stable above 600°C), chemically stable, and radiation-hardened properties. Currently, an opto-acoustic design is proposed and being designed in the SNF as the first generation sensor.

My experiments on testing the device will rely on shaker testing (and acoustic stimulation) of individual opto-acoustic sensor at a range of frequencies. Through these experiments we will observe and examine the frequency response of the device. Additionally, a high-temperature (600°C) probe station will be utilized to conduct similar experiment at elevated temperatures. The results from these experiments will help us better understand the performance of the first-generation acoustic sensor prototype for subsurface well-bore environments.