Final Research Performance Report

Federal Agency and Organization: DOE EERE – Geothermal Technologies Program

Recipient Organization: General Electric Company
Recipient Address: 1 Research Circle, Niskayuna, NY, 12309
Project Title: 300°C Capable Electronics Platform and Temperature Sensor System For Enhanced Geothermal Systems
Project Period: 9/30/2008 to 11/30/2011

STATUS / ACCOMPLISHMENTS

Project Status Summary: The program has been completed in time with the demonstration of a 300⁰C capable SiC-based temperature sensor prototype and 1,000 hours test data on SiC operational amplifier, discreet components and ceramic based packaging. The development of above mentioned components and demonstration of their feasibility is a critical milestone in development of high temperature electronics platform. The developed baseline processes and devices will be utilized for new product introduction by GE Oil and Gas with the goal to enable high temperature tools and instruments to become available for Geothermal Exploration. The attached technical report summarizes project accomplishments and reports on the test data of developed components and integrated sensor system.

Status: The Gantt chart shown in figure 1 is an illustration of the program flow and completed tasks.

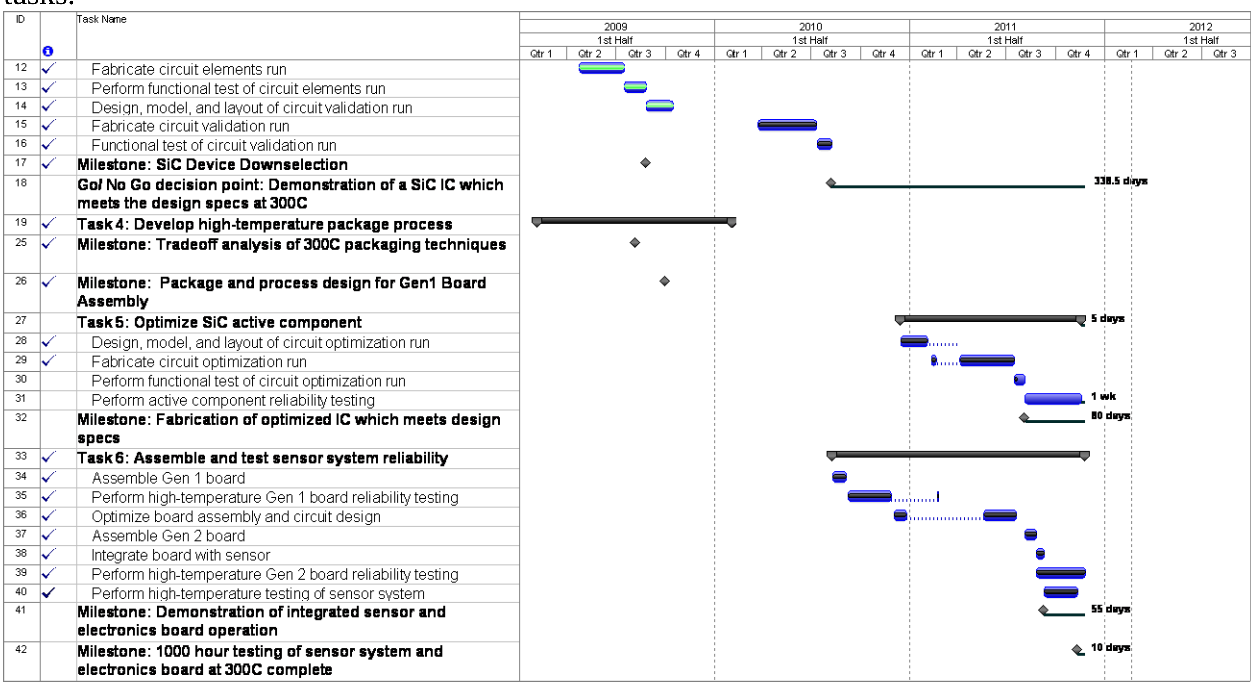
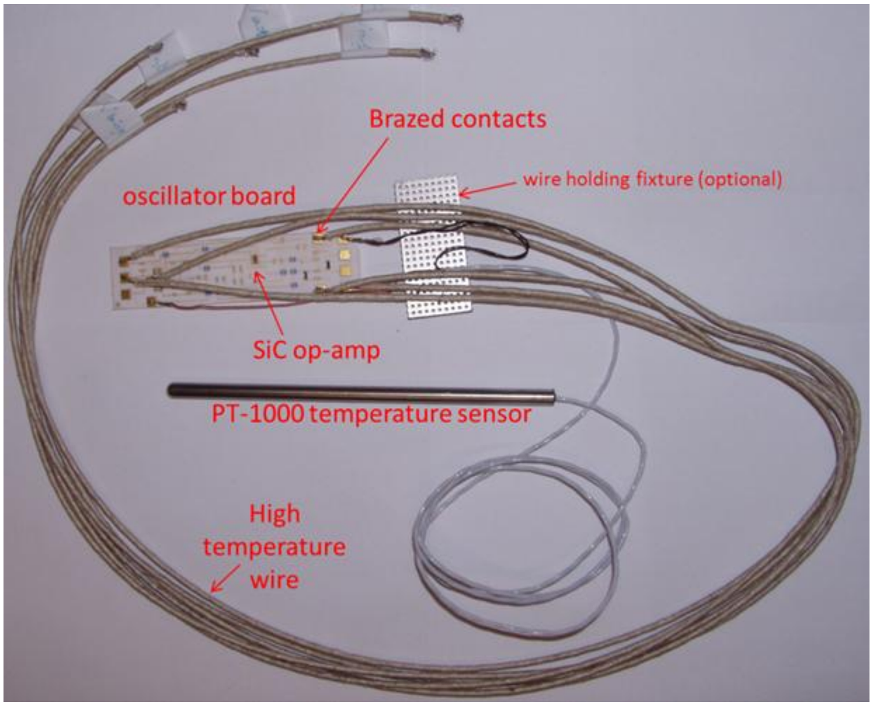


Figure 1 Gantt chart of completed program.

Technical Results and Summary:

The key component of the high temperature sensor system is the active SiC-based component – operational amplifier. The completed program has focused on the development of SiC lateral MOSFET devices, their compact models and fabrication processes which were used as building blocks for the operational amplifier circuit development. High temperature passive components have been selected and screened for high temperature functionality in addition to the development of ceramic-based high temperature packaging and die attach methods. Completed research and development of novel materials, structure, methods and processes has enabled a novel high temperature electronics platform.

In the final task of the program a high temperature prototype of a temperature-to-frequency converter system has been developed and tested at 300⁰C. The lifetime of all system components has been evaluated and shown in the table next to the picture of the prototype, Figure 2.



lifetimetest summary, 300⁰C	
SiC operational amplifier	>1,000 hours
resistors	1010 hours
capacitors	17,000 hours
ceramic board	very little degradation
die attach and bonding	>1,500 hours

Figure 2. Integrated temperature sensor system

The developed prototype is the resistance to frequency converter (oscillator), where the sensor element is a temperature sensitive resistor (PT-1000). High temperature insulated wires were brazed to the contact pads of the assembled sensor system board. PT-1000 temperature sensor was attached to the resistive feedback loop of the oscillator using the same high temperature brazing process.

Temperature sensor system has been tested to obtain calibration curve of oscillation frequency versus temperature, Figure 3. All the components used to assemble temperature system were proved to survive 300⁰C long term test for at least 1,000 hours.

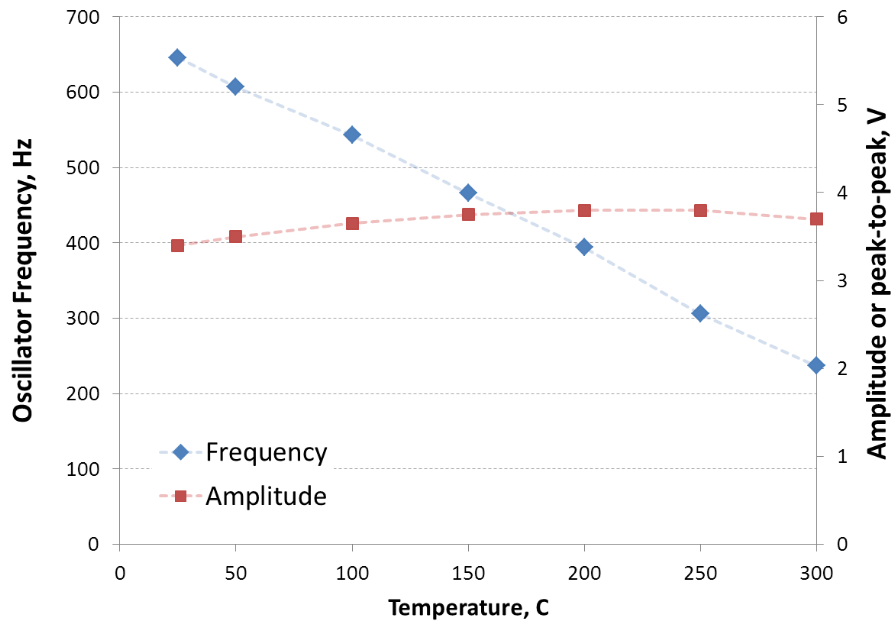


Figure 3. Frequency versus temperature test of SiC-based temperature sensor prototype

The developed prototype is a unique demonstration of SiC and high temperature packaging technology which will be extended in the future to other high temperature electronic systems and is expected to greatly impact the development of down-hole tools for geothermal exploration and well monitoring.