Concept Demonstration of Dopant Selective Reactive Etching in Silicon Carbide

Investigator(s): Dr. Robert S. Okojie (PI)/RHS at NASA GRC, Dorothy Lukco/Vantage Partners, LLC. At NASA GRC, and Laura Evans/RXS at NASA GRC

Purpose

The purpose of this project is to demonstrate the concept of dopant selectivity during the reactive ion etching of single crystal silicon carbide (SiC) wafers. The validation of the concept will pave way for the fabrication of sub-micron structures for various applications. Preliminary results from experiments with sulfur hexafluoride (SF_6) plasma showed the first evidence of etch-rate selectivity between semi-insulating (SI) and highly doped n-type SiC substrates. The result and the potential benefits to NASA missions, provide the motivation to perform a full factorial design of experiments in order to reproduce the experiments and optimize the process for higher etch-rate selectivity.

Background

Technology gap exists in the capability to directly and accurately measure sub-psi dynamic pressures in combustors for the purpose of improving experimental validation of computational fluid dynamic codes at high temperature, and also to monitor the onset of thermoacoustic instabilities. These codes currently have unacceptably large uncertainties and require experimental validation to improve them. While SiC pressure sensors have been demonstrated to operate at 600 °C, the fidelity degrades at below 5 psi where critical thermo-acoustic instabilities must be accurately quantified. This is because current SiC fabrication technology cannot produce the ultra-thin diaphragms (higher sensitivity) and suspended sub-micron conductive structures needed to improve sensor fidelity at such low pressure.

Our discovery of Dopant Selective Reactive Ion Etching (DSRIE) (patent pending) in SiC represents a potentially new technique for the fabrication of ultra-thin (~2 μm) planar and 3-D structures. A routine RIE of the backside of a thick SI-SiC wafer to obtain thin 10-μm diaphragm pressure sensors resulted in accidental over-etch that punctured holes through sections of the diaphragms (see Fig. 1). Surprisingly, sections of the thin (2 μm) highly doped n-type SiC resistor residing directly on the over-etched SI-SiC remained intact. This resulted in suspended n-type SiC resistor elements while the remaining sections were still attached on the surviving SI-SiC diaphragm. The phenomenon was hypothesized to be DSRIE in SiC. Preliminary results from experiments with sulfur hexafluoride (SF6) plasma showed the first evidence of etch-rate selectivity between SI and highly doped n-type SiC substrates.