The 2007 F. M. Becket Summer Research Fellowship — Summary Report

Development of a 3C-SiC Deposition System

by Michael Orthner

Several material properties make using SiC advantageous over Si for use in micro-pressure sensors and in high power switches. Specifically 3C-SiC is a wide bandgap material that can operate at elevated temperatures, higher power densities, and/or in harsher environments than conventional Si-based devices.[1] Mechanically 3C-SiC is a very hard material with elastic moduli that are roughly twice that of silicon. Plastic deformation onset and the increase of the intrinsic carrier concentration to significant values are also shifted to higher temperatures when using SiC. Silicon carbide's biocompatibility is also currently being investigated for use in medical implants.

Previous work details the initial design and development of a low pressure chemical vapor deposition (LPCVD) reactor (Fig. 1) for deposition of 3C-SiC on Si.[2] This unique coupling of epitaxially grown 3C-SiC creates a material system that can be readily processed using standard semiconductor processing while providing SiC as the active layer. The most current technologies are utilized in creating a low cost (< $60,000) system that can be easily adapted to perform a variety of thin film studies on individual devices up to 6-inch wafers. Another particular advantage is that it allows growth of thin films in a temperature range of 600°C to 1500°C while maintaining pressures from 50 mtorr to several torr. Precise control of a wide range of process parameters (temperature, pressure, precursor concentrations) allows for customization of silicon carbide's thin film properties for use in novel sensor devices.

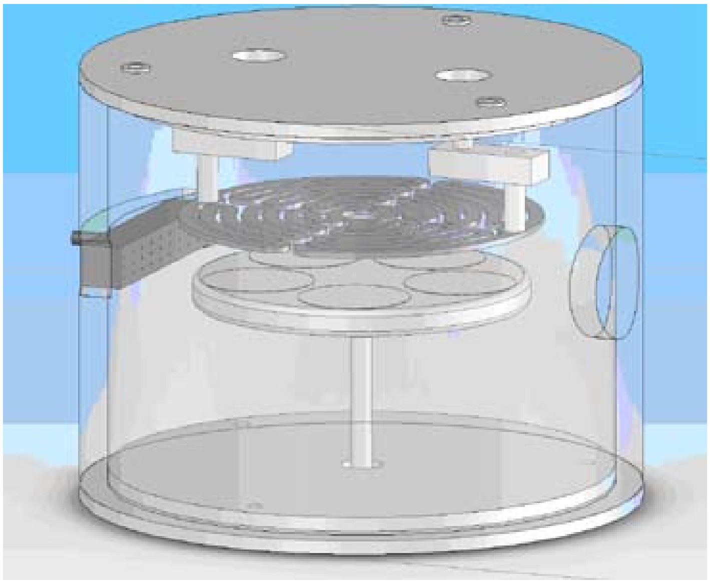

Fig. 2. *Computer aided design (CAD) model of the LPCVD growth chamber used for hot zone studies.*

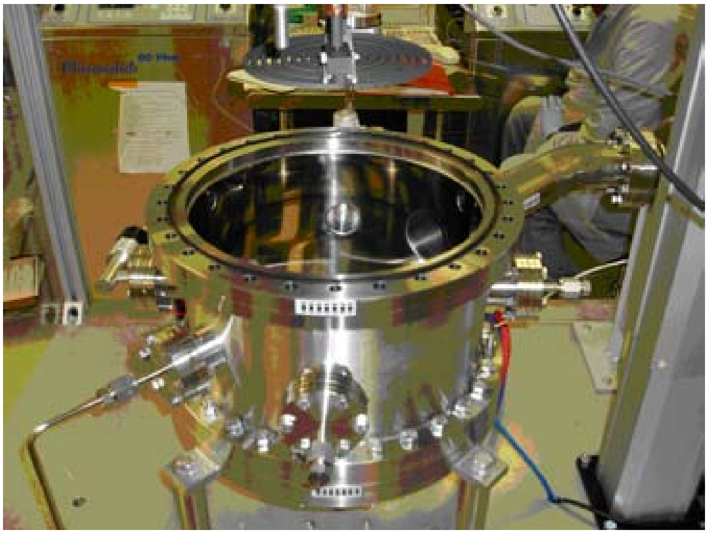

Fig. 1. *Photograph of the low pressure chemical deposition (LPCVD) reactor used for epitaxial growth of SiC thin films.*

Much of the work done this past summer has been to stabilize and model the temperatures in the hot zone of the LPCVD reactor. This unique geometry as shown in Fig. 2 uses a resistively heated graphite heater suspended above a graphite sample holder. The heater is mounted on the top of the chamber and graphite wafer chuck is rotated by a stepper motor from below to increase uniformity of SiC films.

An optical pyrometer is used in conjunction with a temperature controller to measure and control the temperature of the heater. Previously growth was limited to several hundred nanometers of SiC or 20-30 minutes before electrical feedthroughs that attached to the graphite heater would overheat due to thermal conduction. A water-cooled feed-through system has been developed to conduct heat away from the electrical feedthroughs. Alumina silicate refractories were also initially used to maintain stable temperatures within the growth chamber but quickly degraded due to thermal cycling contaminating the chamber with particulates.

Purified graphite heat shields have been designed and are being manufactured to replace the old refractories. The improved design will increase the thermal efficiency of the reactor providing longer growth runs. Subsequently thicker 3C-SiC films allows for the creation of devices previously not realized.

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References

1. R. Okojie, A. Ned, and A. Kurtz, *Technical Digest, 1997 International Conference on Solid-State Sensors and Actuators*, IEEE, pp. 1407 (1997).
2. M. Orthner, Master's Thesis, University of Utah, Salt Lake City, UT, (2006).

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