Low stress silicon carbide processing at the U.C. Berkeley Microlab

D.R. Queen

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Summary:

Doped SiC films were grown in Tystar 15 using DCS, DSB, and NH_3. A deposition rate of 16 nm/min was determined by etching the film in lam 5 and measuring the resulting step height on the ASIQ. The etch rate of the SiC in lam 5 was measured to be 135nm/min. Spectra of SiC and SiO_2 by-products in the etch plasma were determined to be similar enough to make endpoint detection difficult. Si_3N_4 is offered as an alternative underlayer for endpoint detection in lam 5.

Film preparation:

SiC films were deposited on 4" and 6" wafers both with and without an oxide underlayers. A closed 6" boat was added to the pump end of the furnace for deposition onto 6" wafers.

Recipe	15VDSICC
DSB	43.6 sccm
DCS	19.4 sccm
NH3	2sccm
Temperature	800°C
Process Pressure	170mTorr
Time	20 min

Characterization:

Resistivity:

Film resistivity was measured on the 4ptprb to be 958 Ω/□ which corresponds to a resistivity of 3.07e-2 Ω·cm. This resistivity implies that the N doping is approximately 0.5 at. %.[1]

Film thickness:

The film thickness was measured using five points on two wafers with SiC on Si using the "SiC on Si" program on the nanospec. The average thickness was measured to be 347 nm with a standard deviation of 17%. The large error bar is due to only one half a period of the interference oscillation being present for these thicknesses. This data implies a deposition rate of 17 nm/min.

Etching:

The SiC films on 4" wafers were etched in lam5 using the 6001 Main Etch recipe to determine etch and deposition rates. The 4" wafers were patterned with 1µm of i-line photoresist with an exposed area of ~25%. The photoresist was hard baked in the uvbake. These wafers were then mounted to oxide coated 6" wafers using a thin layer of Cool Grease™. The resistance of the SiC film was monitored between etch

steps and the film was considered completely etched when the multimeter read an open circuit. The step height of the etched area was measured after stripping the photoresist and a small correction was made for the etched oxide. The etch rate was measured to be 135 nm/min and the deposition rate was 16 nm/min.

Endpoint detection in Lam 5:

Broadband spectral measurements were made on the etch plasma in lam5 to find candidate wavelengths for endpoint detection. These measurements were made with the help of Barton Lane from Pivotal Systems. For this experiment we used patterned and unpatterned 6" wafers coated with SiC both with and without oxide underlayers. Shipley 210-0.6 DUV resist was used to pattern the wafers with ~10% exposed area. This resist was found to etch very rapidly using the 6001 main etch recipe and was completely removed well in advance of the SiC. A clear distinction between the SiO_2 and SiC by-products was not present in the plasma spectra. Only a slight change in slope was observed. There were clear increases in spectral intensity at multiple wavelengths for the poly Si by-products.

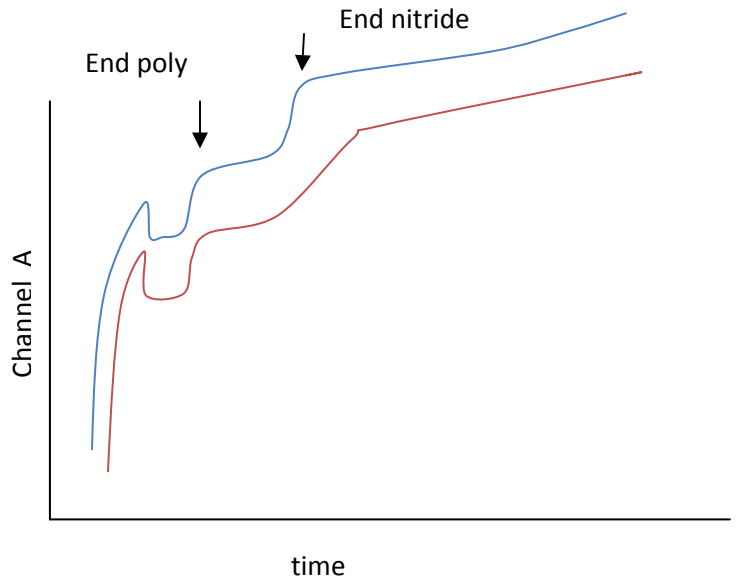

Figure 1. Lam 5 endpoint channel A for wafers with poly/nitride/Si (blue) and poly/nitride/oxide (red).

Nitride coated wafers were also etched in lam5 as possible endpoint detection option. The channels A (Figure 1) and B (Figure 2) of the endpoint signals were monitored while etching a poly/nitride/Si stack (blue) and poly/nitride/oxide stack (red). Oxide was used as a substitute for SiC for this test due to the similarity of the oxide and SiC spectra. These unpatterened wafers had poly and nitride thicknesses of 100 nm and 50 nm, respectively.

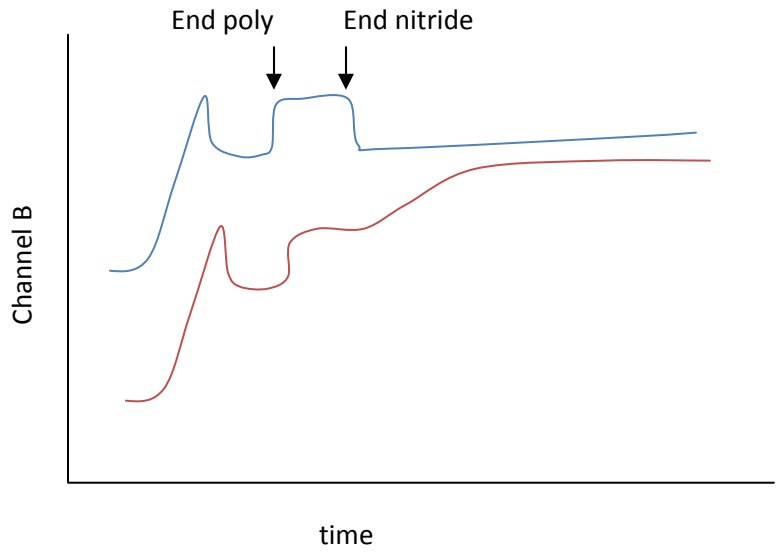

Figure 2. Lam 5 endpoint channel B for wafers with poly/nitride/Si (blue) and poly/nitride/oxide (red).

Conclusion

Doped, low stress SiC films can be processed in the U.C. Berkeley Microlab with the recipe outlined above. To reliably process these films it is recommended that the resistivity of a representative test structure be monitored during the etch to ensure that the film is etched completely. Endpoint detection is possible in Lam 5 on channel B when SiC is grown on nitride. Further tests are recommended to monitor the endpoint detectors on Lam 5 for undoped carbide films with various underlayers.

[1] C.S. Roper, Ph.D. thesis, University of California, Berkeley (2007).