Reference (PR No. 10000020870) RFx No. 6100000786
Technical specifications for Deep Reactive Ion Etching System(DRIE)

1. Key Generic Requirements:

a. The tenderer must provide an installation scheme showing the physical space (footprint) of the machine(s) as well as space required for routine access and all installations including the gas lines, MFCs, and other related accessories.
b. The vendor should have installed similar types of systems in centrally funded technical institutes or government research labs. Purchase order(PO) and user list should be provided as supporting evidence.
c. The compliance sheet should be provided by the vendor. The absence of the compliance sheet may result in the cancellation of the purchase order.
d. For each compliance, supporting evidence such as manuals, SEM images, and other necessary and supporting documents needs to be provided.
e. The vendor should have an Indian representative which can take care of the urgent troubleshooting or any process related queries on an urgent basis.
f. Safety features like interlocks to prevent errors in operation, RF interlock, emergency shut-down options along with necessary protocols should be separately mentioned.

2.(a) Technical Specifications (Generic):

a. The system must be cleanroom compatible with all the necessary support systems such as vacuum systems, cooling systems, power supply systems, computer hardware, and software provided.
b. The machine must be software controlled with appropriate software and hardware interlocks to protect the machine from any possible operational or non-operational failure thereby ensuring the safety of the operator as well as the machine.

c. The process is required to contain all the necessary sensors and control to aid in safety monitoring, performance monitoring, automatic operation, and diagnostic of the system. A complete set of system operation and maintenance manuals must be provided.
d. A library of process recipes for materials that can be processed by the machine well documented by the company must also be included.
e. Suitable gauges calibrated as per international traceable standard must be provided for monitoring vacuum in the process chamber as well as load-lock and providing feedback for controlling process pressure in the chamber. Further, pressure gauges to monitor the lines between chamber and turbopump, and turbopump to backing pump should be included to ensure the best possible vacuum performance.
f. The process pressure control in the reactor chamber should be automatic and closed-loop through software-controlled throttle valves.
g. The control computer system/PLC should be a state-of-the-art system with a pre-loaded operating system and the software required for running the machine. The control panel must contain all the buttons required to operate the machine.
h. The software must allow for configurable user groups with different access privileges. Three different modes operator, engineer, and admin should be provided for easy and safe handling of the tool.
i. The software must allow the user to write and edit machine recipes.
j. The software must provide full system monitoring and recording of full system states in log files.
k. The system must provide access to sample process history and security protocols.
l. The system must provide system fault detection and diagnosis.
m. Automatic and manual control modes should be available in the software.
n. Installation, training, and SiC etch process demonstration.

2.(b) Technical Specifications (Specific):

a. The system is targeted towards deep Silicon Carbide (SIC) etching through standard processes.

b. The system should be capable of carrying out etching on small pieces mounted on a suitable and compatible carrier wafer. The source diameter should be suitable to achieve uniformity over a 4-inch wafer diameter also. The chamber diameter and load-lock transferring mechanism should be able to accommodate 4-inch wafers to enable future up-gradations.

c. The wafer mounting chuck should enable electrostatic clamping.

d. Standard MFCs controlled 6 lines (Cl_2, BCl_3, argon, O_2) along with CF_4 and SF_6 should be closely coupled to the plasma source to enable minimum cycle time. Provisions for more gas lines to be able to hook up with the system to enable future upgradations, if any, should be provided.

e. The reaction chamber should be machined from a single metal block (preferably aluminum) with an anodized inner surface for chlorine processes. A separate air-inlet port (for by-products protection), as well as a viewing port, should be provided with the main reaction chamber.

f. The loading mechanism should be a software (recipe) driven and fully automated with a robotic transfer mechanism to move the wafer from loadlock into the process chamber and back on the execution of a process recipe. There should also be an option to manually override the transfer.

g. The substrate should be cooled using through Helium backside circulation. The helium flow rate and pressure are considered process parameters. The flow rate/pressure should be controlled through a software-controlled MFC.

h. The substrate electrode temperature should be from -10 ^{0}C to +40 ^{0}C settable with the stability of 1-2 ^{0}C or better.

i. The system should come with provisions for separate pumps for the reaction chamber (RC) and the load lock chamber (LLC). Altogether there should be 3 pumps, 1 Turbomolecular pump with a pumping speed of 1300 litres/sec or better, 2 dry pumps (one each for RC and LLC) with a pumping speed of 1500 litres/min or even better.

j. Regarding TMP pump and Dry pump, additional each one (TMP & Dry pump) will be supplied as spare pump at IIT Bombay site, or the vendor should keep each pump at the vendor's side in case of emergency.

k. The load lock chamber vacuum pumps must be able to pump the load lock chamber down to approximately 10^{-1} Torr. suitable for typical wafer transfer to the main process chamber within approximately 10 minutes. It should be able to pump down to $5x10^{-5}$ Torr. with overnight pumping.

l. The main chamber must be able to reach and maintain a vacuum level of less than 0.1 - 10 Pa ($7.5\ x10^{-4}$ - $7.5x10^{-2}$ Pa) during standard etching processes.

m. Oil-free dry backing pump with 1300 lpm or more rating with N_2 purge standby to minimize N_2 usage when no etching is in progress. The backing pump must be resistant to corrosive gases.

n. The backing pump must include a microprocessor-based diagnostic accessory for quick identification of faults that may occur from time to time.

o. The plasma should be inductively coupled with an operating frequency of standard 13.56 MHz. The plasma generator power/bias rating should be 1 KW/300 W or better with a maximum power upgrade of 600 W. Suitable matching techniques should be provided to minimize reflected power. The vendor should also provide detail about techniques/methods.

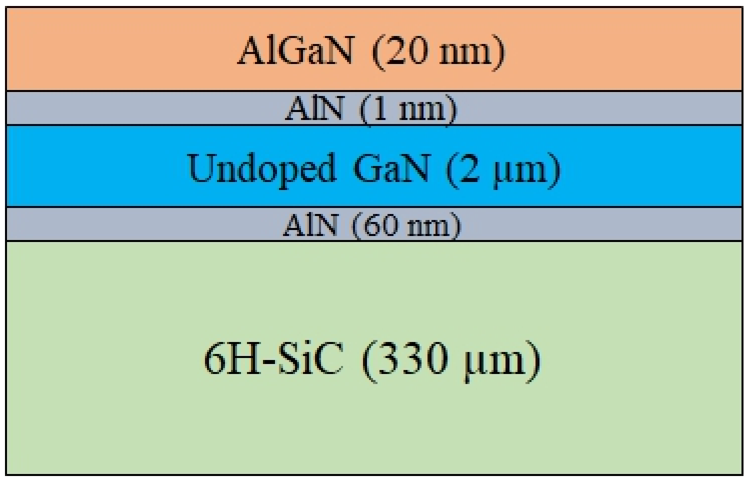
p. The power supply cooling can be either air-cooled or water-cooled. Any specific requirements for this (ex: Chiller) should be mentioned as a mandatory item along with the system.

q. The RF coupling to plasma should be done through Alumina, AlN, or, any other suitable dielectric.

r. The circulator will be required to be controlled remotely from the touch-screen of the main system, e.g. its switching ON/OFF, set & monitor the temperature.

3. (a) Process demo:

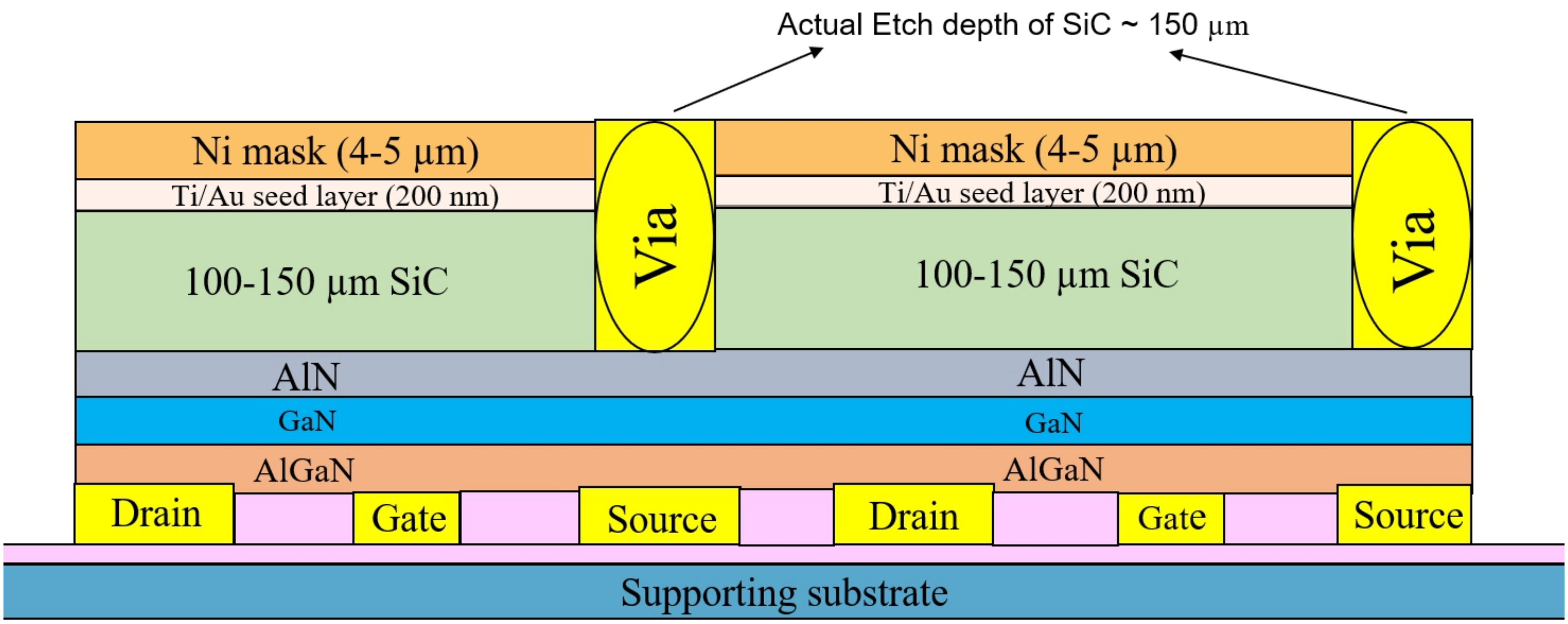
The system is going to be extensively used for etching SiC. The demo process of etching on samples provided from IITB (Details of the sample mentioned below) should be carried out to develop the process. The process recipe needs to be replicated by the installation engineers on a similar set of samples after the installation of the machine is



completed at the IITB site.

Fig. 1 Schematic of the as-grown heterostructure (Before actual fabrication) used for the process development at IITB.

Fig. 2 Schematic of the fabricated device showing the actual depth of SiC required to be etched using the DRIE process. In the above diagram, Ni thickness can be



increased to 10-15 um.

3. (b) Sample preparation for DRIE (Process description): Figure 2 shows the schematic of the final fabricated HEMT device with all the electrodes (Source, drain & Gate) and etch depth of SiC (Via) for reference. The device is fabricated on AlGaN/GaN-based heterostructure grown using MOCVD on a SiC substrate. The structure comprises a 6H-SiC substrate (~330 µm) followed by a 60 nm AlN buffer layer and a 2 µm of undoped GaN layer. The undoped GaN is followed by a thin layer of 1 nm AlN and finally, a 20 nm of AlGaN barrier layer is grown on the top.

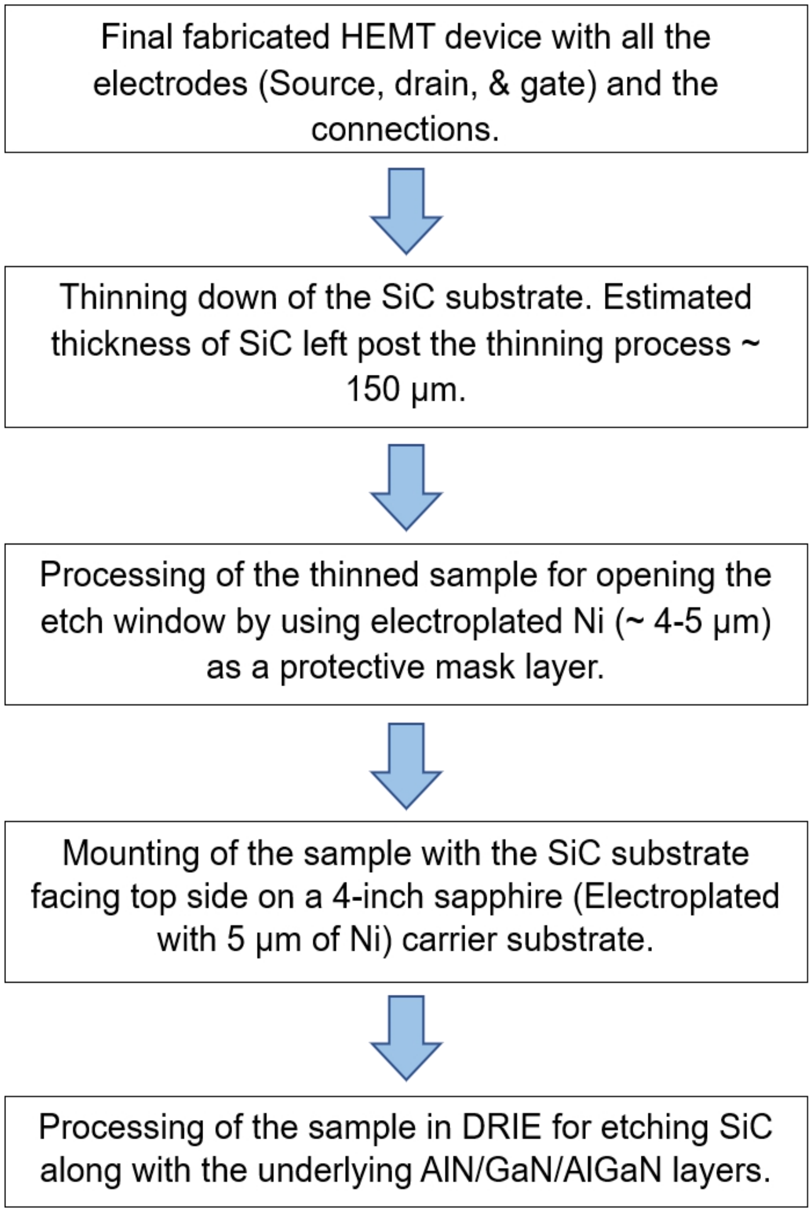


Fig. 3 Process flow for preparation of the samples required for the DRIE process post the fabrication of final HEMT devices. In the above flowchart, Ni thickness can be increased to 10-15 um.

Figure 3 shows a top to bottom approach process flow for preparation of the samples required for the DRIE process post the fabrication of final HEMT devices. As shown in the schematic in figure 2, the total etch-depth is approximate ~150 µm of SiC (~ 145-150 µm),

. Additional N2 process gas line.