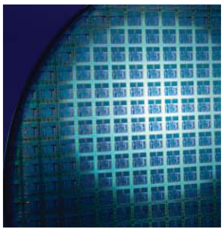
Silicon Carbide, Sapphire & Gallium Nitride
Substrate Preparation

Introduction



The search for cost reduction in semi-conductor device production remains driven by volume and yield. Silicon Carbide, Sapphire and Gallium Nitride are two increasingly popular materials capable of providing competitive cost reductions, when compared to traditional semiconductor technology. Logitech has a successful means of processing Silicon Carbide, Sapphire and Gallium Nitride substrates to within EPI ready status.

Sapphire is particularly attractive to those working within the laser industry due to its uniform dielectric constant and high quality crystalline structure. This has led to an increase in the use of sapphire substrates for blue laser diodes whilst the sapphire has become the basis of today's RF switch applications.

Silicon Carbide's characteristics include high thermal conductivity, high resistance towards oxidation, chemical inertness and a high mechanical strength. Making it an ideal material for use in a range of applications.These include biomedical materials, high temperature semiconductor devices, synchrotron optical elements and lightweight, high strength structures. Silicon Carbide possesses superior physical and electronic properties compared to both silicon and gallium arsenide for certain short wavelength ptoelectronic, high temperature, radiation resistant and high power applications.

Gallium Nitride is currently being used in high power transistors capable of operating at high temperatures. These transistors take advantage of Gallium Nitride's ability to produce a high output of power from a small physical volume. This coupled with the material's high efficiency in power amplifiers at ultra-high and microwave frequencies make Gallium Nitride an ideal material for future development in a wide range of applications within the optoelectronic field.

Application requirements

In each case the objective of Sapphire, Silicon Carbide and Gallium Nitride wafer polishing is to reduce the final thickness of the substrate to the required target value, with a TTV of better than +/-2 microns and an improved surface roughness of less than 2nm. This is achieved by firstly bonding the wafer(s) to a rigid glass substrate, using the Logitech Wafer Substrate Bonding Unit (WSBU).

Once bonded, the wafer(s) require to be lapped in order to remove the excess material prior to being polished. The lapping process is carried out using a PM6, LP50 or DL machine with a Logitech PP5, PP6 or PP8 Precision Polishing Jigs.

Logitech PM6 Lapping & Polishing System

For lapping to take place the jigs are loaded onto a cast iron lapping plate and a variety of automated or manual display options are available to allow material removal to be monitored.

After lapping, the wafers are manually cleaned and removed from their glass support disks. They are then transferred to specially designed wafer template holders for the DP1 or DP4 Driven Head Precision High Speed Polishing Systems. Using either of these systems allows wafers of all three materials to be polished in a wide variety of quantites to repeatable levels of optical grade polish.

Logitech PP6 Polishing Jig

System specification

Logitech offer a number of different systems for polishing Sapphire, Silicon Carbide and Gallium Nitride dependent upon the number of wafers being processed. Each system will, however, consist of the following:

Bonding Unit	WSB2	Single Station	research level
	WSBU	Three Station	production level
	WSB300	Single Station	production level
Lapping System	PM6	Single Station	research level
	LP50	Three Station	low level production
	DL1	Single Station	small batch production
	DL4	Four Station	full production level
Holding Fixtures	PP5	Max 3" substrate	PM5, LP50, DL
	PP6	Max 4" substrate	PM5, LP50, DL
	PP8	Max 6" substrate	PM5, LP50, DL
	PP9	Max 8" substrate	DL
Polishing Systems	PM6	Single Station	research level
	LP50	Three Station	low level production
	DP1	Single Station	small batch production
	DP4	Four Station	full production level

Processing

Mounting, retention & lapping

The Sapphire, Silicon Carbide or Gallium Nitride wafers are temporary wax bonded, fabricated face down, onto glass support discs using the Wafer Substrate Bonding Unit. This system produces consistently high standards of wafer to support disc parallelism, irrespective of whether one large wafer or a number of smaller wafers of differing thicknesses are being bonded. Once successfully bonded, the support discs can be mounted onto the vacuum chuckface of a Logitech lapping jig. The jig is then inverted and placed face downwards onto a cast iron lapping plate on the PM6 Precision Lapping & Polishing system which is then set to rotate at speeds of up to 100rpm whilst Logitech abrasive slurry is fed across the plate surface at a constant flowrate via metered abrasive peristaltic pumps which are controlled via the Graphical User Interface, where the user can easily control the amount of slurry distributed to the plate.

Mounting, Retention & Polishing

After removing excess material from the substrates by lapping it is necessary to polish the wafer surface using the DP Driven Head High Speed Polishing System. This will produce a high quality optical grade surface on each of the wafers.

Logitech DP4 Driven Head Polishing System

The DP System uses a detachable carrier system for holding and retaining each individual wafer without the need for using a glass support disc. For this reason, the wafers are dismounted from the disc prior to being set into their individual holders on the DP carrier template. Each template is made to suit individual customer requirements, thereby ensuring the best result possible is achieved from the polishing process.

Whether the single station DP1 or four station DP4 is being used, the Silicon Carbide or Sapphire wafers will be polished within a very quick time frame. This is due to the high speed rotation of the polishing plate, combined with the independent rotation of the carrier head. With a constant supply of polishing slurry being fed across the plate it is possible for the DP System to reduce polishing times for both of these traditionally difficult to process materials. This can be over 50% faster when compared to non-high speed systems. The high rotational speed used by the DP System creates frictional forces on the process plate which in turn creates an elevated process plate temperature. This heat is highly beneficial to the material removal rate and is essential to the successful polishing of each of these materials.

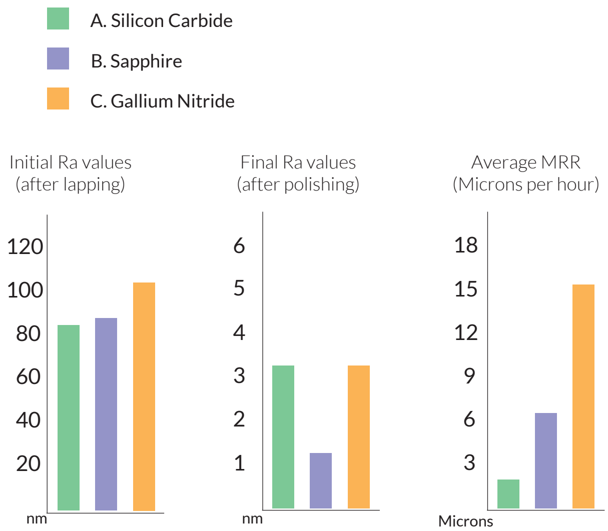
Throughout the polishing process, the DP system offers a high level of controllability, as manual manipulation of the process can be carried out "in situ". Process parameters such as plate speed, downward load on the carrier(s) and slurry flow rate can be instantly and accurately altered and controlled via the touch screen Graphical User Interface (GUI).

Results

By using a Logitech polishing system to complete the preparation of Silicon Carbide, Sapphire or Gallium Nitride substrates, it is possible to achieve ideal surface roughness in advance of further processing using traditional CMOS techniques. Each polished wafer will have had a uniform amount of material removed during the process and a consistently flat surface produced.

By varying the pressure (load) applied to the substrates during processing it is possible to achieve an optimal Material Removal Rate (MRR) of 6 microns per hour with Sapphire and 1-2 microns per hour with Silicon Carbide.

The following Silicon Carbide and Gallium Nitride results are taken from a batch of 12 x 2" diameter wafers processed on the DP1 research unit, whilst the Sapphire results are taken from a batch of 84 x 2" diameter wafers processed on the DP4 production level unit.



A. Silicon Carbide wafers

Diameter:	2"
Material Removal Rate (MRR):	1-2 microns per hour
Final Ra value:	<3nm
Flatness:	+/- 2 microns
Bow:	<25 microns

B. Sapphire wafers

Diameter:	2"
Material Removal Rate (MRR):	6 microns per hour
Final Ra value:	<1nm
Flatness:	+/- 2 microns
Bow:	<25 microns

C. Gallium Nitride wafers

Diameter:	2"
Material Removal Rate (MRR):	15 microns per hour (face dependent)
Final Ra value:	<3nm
Flatness:	+/- 2 microns
Bow:	<25 microns

Using a Dektak 150 surface profilometer.

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