Supplementary Material (ESI) for Chemical Communications


## Electronic Supplementary Informaiton

# A new system for synthesis of high quality nonpolar GaN thin films

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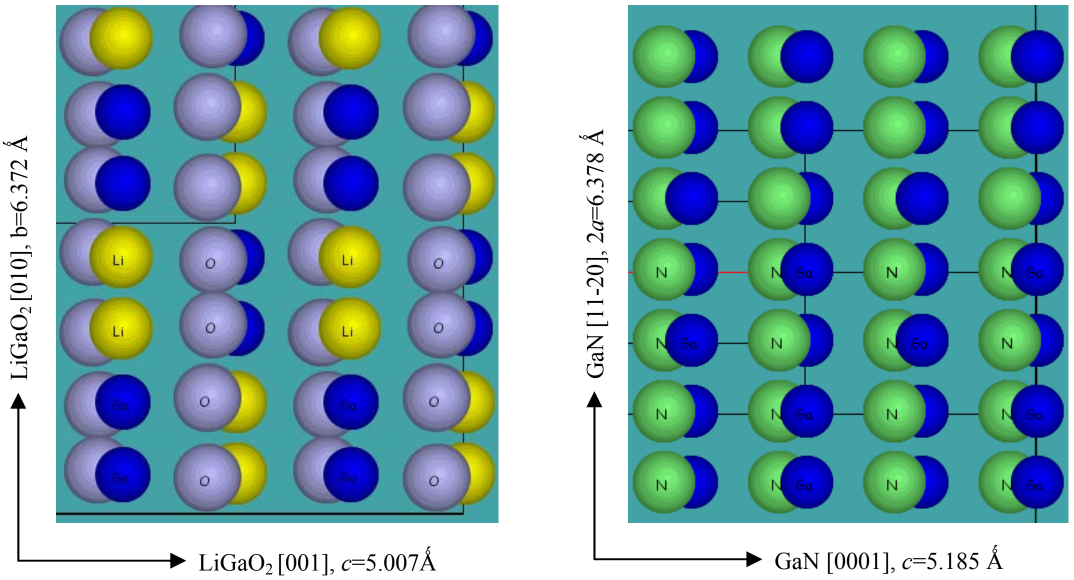
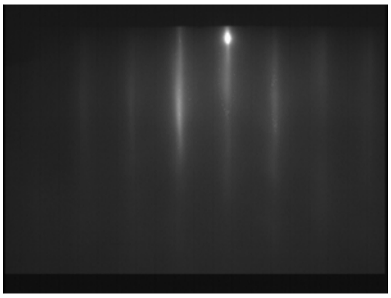
**Supporting Information**

1. Synthesis and characterisation of *m*-plane GaN films on $LiGaO_2$ (100) substrates

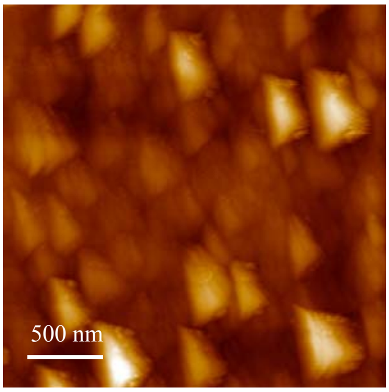
As-received $LiGaO_2$ (100) substrates were annealed at 1000 °C in air for 4 hours to obtain atomically flat surface before growth. After cleaning in organic solvents to remove surface contamination, the substrates were introduced into the ultrahigh vacuum (UHV) PLD chamber with the background pressure of $3.0\times10^{-10}$ Torr. A Q-switch pulsed Nd:YAG laser with working wavelength 355 nm and pulse width 5 ns was used to ablate a Ga metal target (99.9999% purity) with an average pulse energy of 150 mJ and a pulse repetition of 20 Hz. The laser beam was introduced into the chamber at an angle of 45° and focused on the rotating Ga target. The ablated Ga species were supplied onto the substrates that were kept at 200 ºC and mounted 5 cm away from the target. The substrate temperature was measured by a thermocouple embedded in the substrate holder beneath the substrate mounting area. During the growth, high purity $N_2$ with the pressure of $6\times10^{-6}$ Torr was supplied through an inert gas purifier and a radio-frequency plasma radical generator operated at 320 W. In situ reflection high-energy electron diffraction (RHEED) was used to monitor the growth condition during the whole course. GaN films with various thicknesses from 20 to 200 nm were grown in this way. As-grown GaN films were evaluated by X-ray diffraction (Bruker D8 X-ray diffractometer with Cu Kα1 X-ray source $\lambda$=1.5418 Å) rocking curves for crystallinity and by atomic force microscopy (AFM) for surface morphology. Transmission electron microscopy (TEM) was employed to characterize the interface between the substrates and GaN films and microstructure of GaN films. TEM cross-section samples of *m*-plane GaN films grown on $LiGaO_2$ (100) substrates were made by mechanical polishing followed by low-energy and low-angle ion milling (Fischione 1010 Low Angle Ion Milling & Polishing System), ending up with sample edge thickness of about 20 nm. The cross-section samples were then put into a JEOL 3000F field emission gun TEM working at a voltage of 300 kV, which gives a point to point resolution of 0.17 nm. Electron energy loss spectroscopy (EELS) collections were carried out under Scanning TEM mode, where a spot formed by a 0.6 nm diameter electron beam was used to scan across the interface with an interval of 1 nm between two spots.



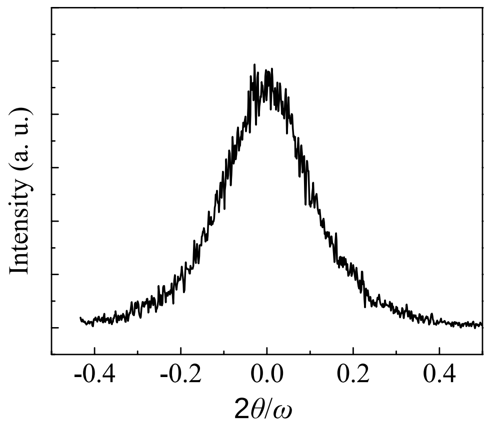

**S Fig. 1.** Atomic models for (a)$LiGaO_2$ (100), and (b) GaN (1-100) planes, where lattice constants and each type of atom are denoted.



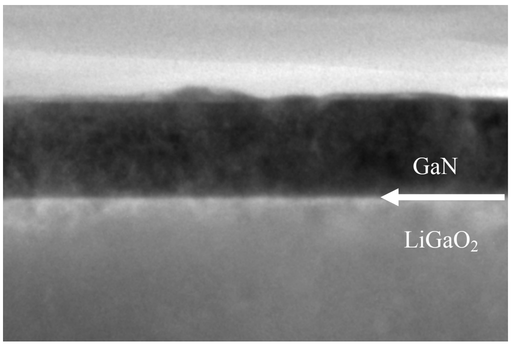
**S Fig. 2.** A typical RHEED pattern for GaN films grown on $LiGaO_2$ (100) substrates at 200 ºC with the electron beam incidence along GaN [11-20], which is a good indication of *m*-plane GaN film growth. The streaky RHEED pattern also suggests a smooth surface of the as-grown GaN films.




**S Fig. 3.** An AFM image of a 120 nm thick *m*-plane GaN film grown on $LiGaO_2$ (100) substrate. The root-mean-square (RMS) value of this surface is 0.95 nm.




**S Fig. 3.** (1-100) X-ray rocking curve from the 120 nm thick *m*-plane GaN film grown on $LiGaO_2$ (100) substrate. Its FWHM is about 0.25º.




**S Fig. 4.** A bright field cross-section TEM image at low magnification, from which we can find that the interface between $LiGaO_2$ (100) substrate and *m*-plane GaN film (indicated by the white arrow) is abrupt, and the thickness of the film is about 200 nm.