Light response in buffer leakages related with current collapse and its application for epi quality development in AlGaN/GaN HEMT structures

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Outline

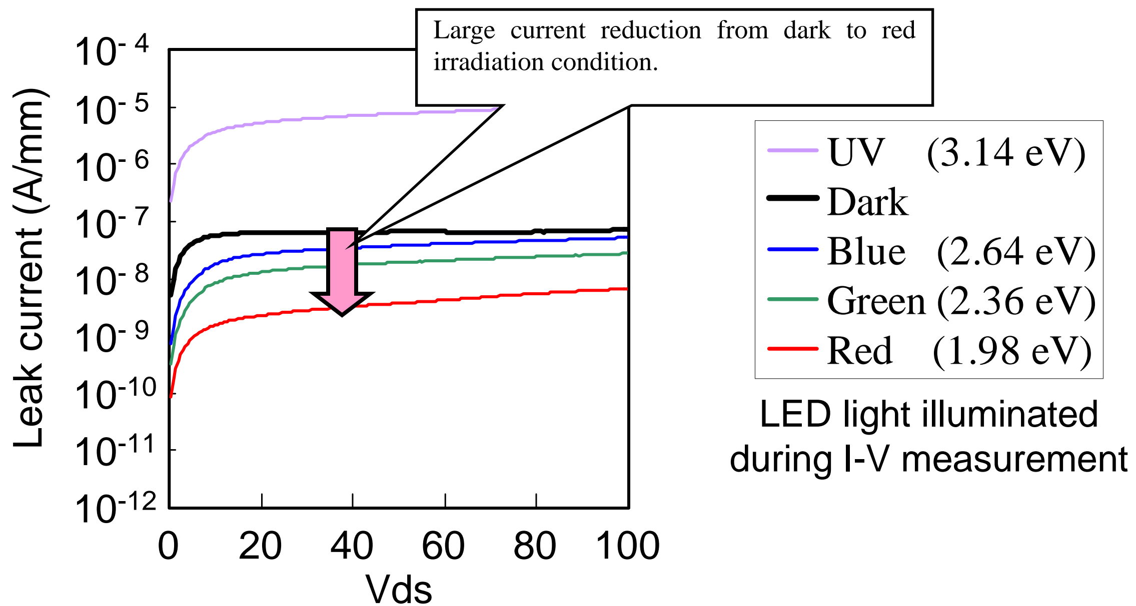
As a tradeoff between current collapse and buffer leakage is a severe challenge in designing AlGaN/GaN HEMT epi design, characterization and swift feedback of these device performances are essential in optimizing and balancing the epitaxial structure. We have found a unique light response of buffer leakage in GaN, in which irradiation of low energy light to the samples switches the devices into collapsed states without biasing [1]. Analysis of this light induces buffer collapse seemed to be quite useful in characterizing GaN material quality. In this work, we will provide background model of the light induces buffer collapse and then present how our epi materials were developed using this characterization method.

Experimental and discussion

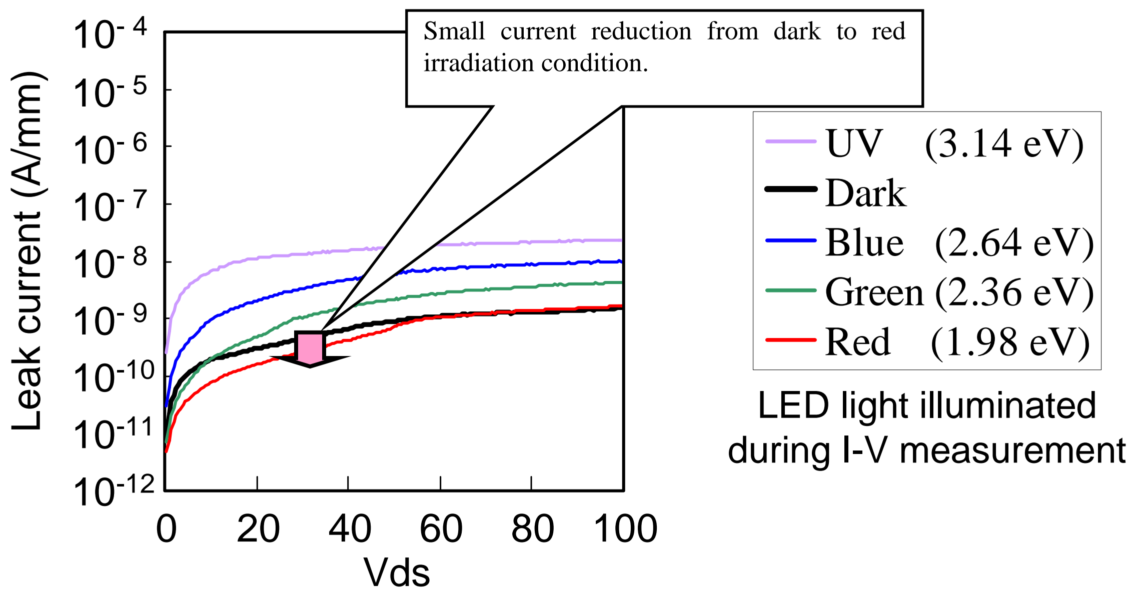
Nitride buffer structures without barrier layers were grown on substrates by MOVPE. Ti/Al metallization was formed directory on the buffer surfaces as source/drain contacts, without making device isolation, surf-ace passivation, nor contact annealing. This device fabrication process took only 3 hours. The devices were tested under 1.98eV light irradiation from 625nm red LED and 0-100V drain voltages were applied for Id measurement. Then the Id was compared with a current in a dark environment and decrease of the Id was analyzed. It is counterintuitive that the Id decreases under the light irradiation, but this could be explained by a trapping of electron excited by the low energy light. Under this consideration, magnitude of the light response was connected with the density of electron traps that could cause current collapse buffer-wise.

Typically, devices with small leakage lead to large collapse. In structures with high trapping states and low background carriers, trapping states are mostly open and thus they are vulnerable when devices operate. Modification on the MOVPE parameters for nitride growth conditions could minimize the trapping state density in the buffer itself, which led to the moderate balance between the current collapse and buffer leakage as shown in Fig 1(b). These quick process and simple characterization method were found to be very useful in developing buffer-wise nitride quality in AlGaN/GaN HEMT epitaxial structure.

[1] T. Tanaka, et.al, phys. stat. sol. (c) 4, No. 7, 2585–2588 (2007)



(a) Sample #1; low leakage and high trap density



(b) Sample #2; low leakage and low trap density

Fig 1 Light response of GaN buffer leakage in MOVPE grown samples.