Basal Plane Dislocation Mitigation via Annealing and Growth Interrupts

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Basal plane dislocations (BPD) in SiC are high-voltage bipolar device killers that source Shockley-type stacking faults in the presence of an electron-hole plasma [1]. Multiple research groups have been successful in mitigating their propagation from the substrate into the epitaxial layer [2-5]. While these are sufficient for typical SiC devices, for high pulsed power current density or high surge current capability applications, the injected carrier concentration is significant enough to expand converted BPDs. Here, we will report results from comparisons of H_2 etching to Ar annealing and the use of H_2 versus Ar during growth interrupts to prevent BPD expansion.

SiC epitaxial layers were grown using a CVD reactor on 4° off-axis substrates toward the [11-20] that are known to have BPDs. A H_2 etch or Ar anneal was performed before the buffer layer (BL) growth while a growth interrupt in H_2 or Ar was conducted prior to the intentionally low doped drift layer. Ultraviolet photoluminescence (UVPL) imaging was used to image the samples before and after UV stressing up to 13 $kWcm^{-2}$.

The H_2 etch and H_2 growth interrupt prevented BPDs from expanding under UV stress of 13 $kWcm^{-2}$ and it is believed that the H_2 treatment specifically inhibited this expansion. To confirm the role of H_2, we performed a growth using the same conditions as the H_2 etch/interrupt, however, an Ar anneal was used instead of a H_2 etch and the growth interrupt was conducted in an Ar atmosphere instead of H_2. The sample was UV stressed up to 1000 Wcm^{-2} and it was found that four BPD expanded from the substrate into the epilayer. For comparison, a sample grown with a double H_2 etch (before the buffer layer growth and drift layer) and a sample grown with a H_2 etch plus H_2 growth interrupt did not produce faulting at the same power density. This indicates that H_2 influences BPD expansion. We will present detailed parametric results of samples grown with various etching/ annealing, growth interrupts, anneal times, buffer layer thickness, gas flow rates and interrupt temperature, both in H_2 and Ar.

[1] J.P. Bergman, *et. al.*, Mater. Sci. Forum Vol. 353-356, 299 (2001).
[2] N.A. Mahadik *et.al.*, Mater Sci Forum 858, 233 (2016).
[3] R. E. Stahlbush, et *al.*, Appl. Phys. Lett. 94, 041916 (2009).
[4] M. Kato, *et al.*, Sci. Rep., 12, 18790 (2022).
[5] N.A. Mahadik *et. al.*, Appl. Phys. Lett., 100, 042102 (2012).

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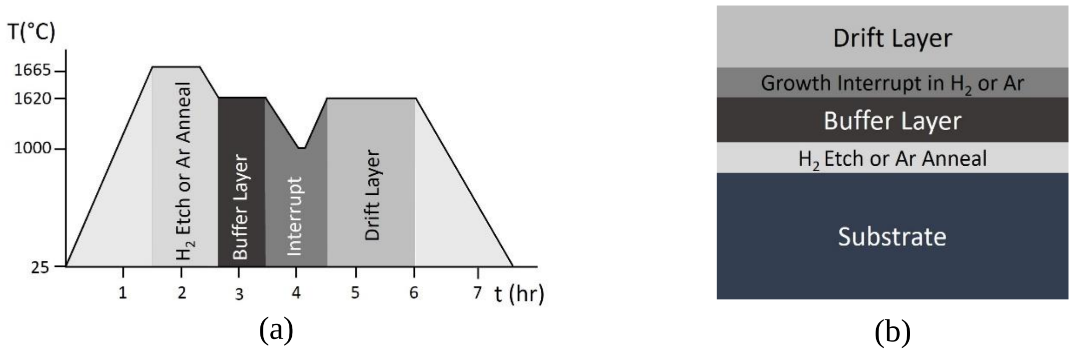

Fig. 1. (a) Growth schedule including a H_2 etch or Ar anneal prior to the buffer layer and a growth interrupt in H_2 or Ar before the drift layer. (b) Cross sectional view of the epitaxial layers grown with a H_2 etch or Ar anneal and interrupt for BPD reduction.

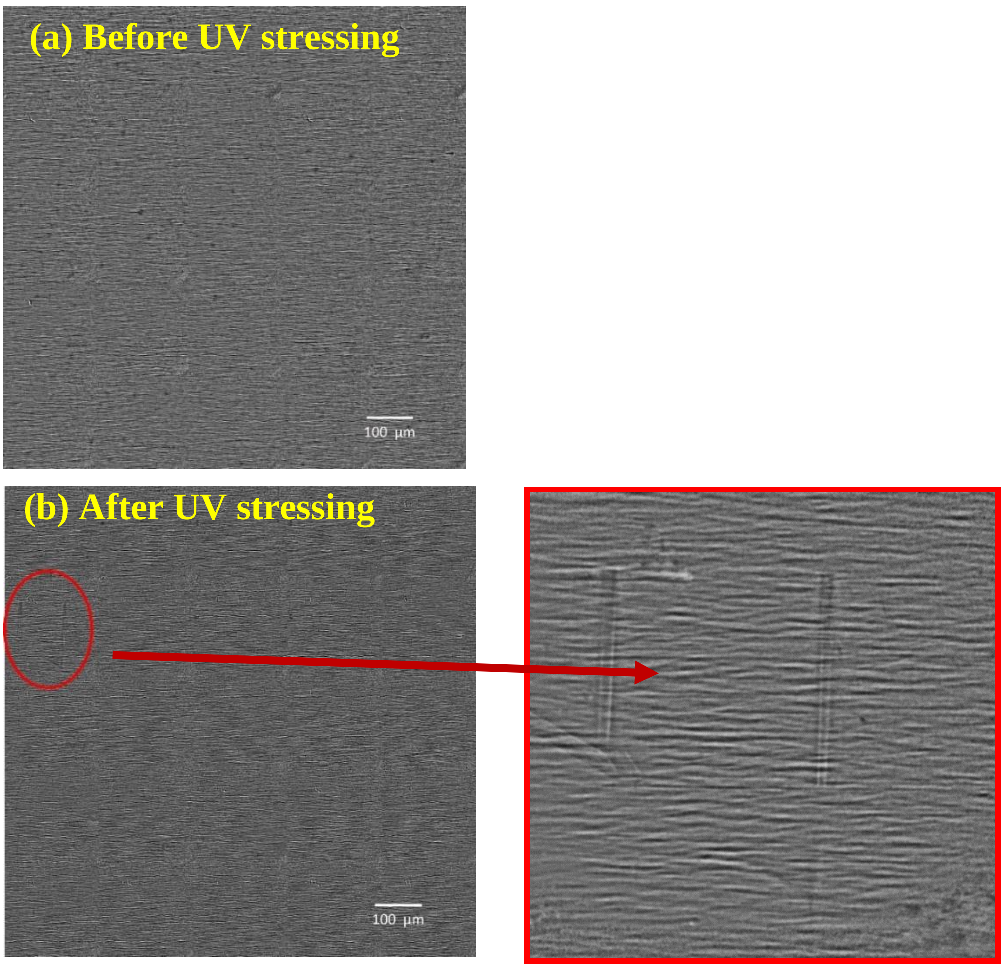

Fig. 2. UVPL images of epitaxial sample with Ar anneal before BL and growth interrupt in Ar before drift layer (a) before stressing (no BPD in epilayer) and (b) after UV stressing at 1 $kWcm^{-2}$, showing a BPD that expanded from the substrate.