Epitaxial Growth of Cubic Silicon Carbide on Silicon Using Hot Filament CVD

P. Hens[1]*, R. Brow[2], H. Robinson[2], M. Cromar[2], B. Van Zeghbroeck[1,2]
[1]ECEE Department, University of Colorado Boulder, Boulder, CO, USA
[2]BASiC 3C, Inc., Longmont, CO, USA

Cubic silicon carbide (3C-SiC) epitaxially grown on silicon has important applications ranging from high power electronic switching devices (MOSFETs), to MEMS devices, to templates for the growth of gallium nitride [1]. Still, cost effective growth of high quality 3C-SiC has been a significant challenge and a key technical barrier for mass adoption in these applications. We present a new approach for the epitaxial growth of 3C-SiC using hot filament chemical vapor deposition (HF-CVD) [2]. We demonstrate first growth of high-quality single-crystalline layers on 4 inch silicon substrates using this type of process.

3C-SiC epitaxy on silicon is traditionally carried out using a classical hot wall CVD approach [1]. HF-CVD has been used for the deposition of polycrystalline layers of silicon carbide, but its adaptation to epitaxial growth has yet to come to fruition. Since the precursor species are decomposed at the filament, this technique enables growth at lower substrates temperatures than in hot wall CVD [3]. Furthermore, the filaments can act as a second heat source to allow temperature gradient tuning, which is vital when optimizing gas phase chemistry.

In this paper, we present characterization results on 2 to 15 μm thick epitaxial layers produced in our vertical high-vacuum HF-CVD system. In particular, the XRD omega double rocking curve FWHMs versus layer thickness follow the best literature trend, reaching as low as 333 arcsec for a 15 μm thick 3C-SiC film. Along with these, we will present strain and doping results obtained by micro-Raman, and surface structures as seen by high resolution SEM. We will present growth process details using silane and propane precursors and will detail the growth dynamics from the initial carbonization step, to establishment of proper substrate and filament temperature gradient, and to steady-state growth at 2-3 μm/hour.

[1] A. Severino, Silicon Carbide Epitaxy, ISBN: 978-81-308-0500-9, 145-191 (2012).
[2] J. Robbins and M. Seman, United States Patent 8,409,351, Issued April 2, 2013.
[3] Z. Zhang et al., Mater. Sci. Eng. B75, 177–179 (2000).

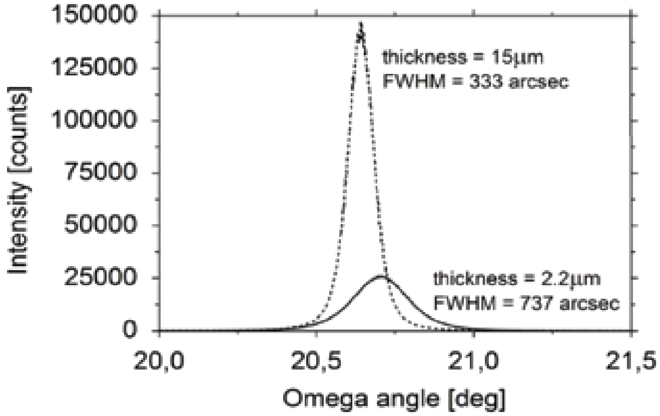

Figure 1. XRD Omega (Rocking) scans on 2.2 μm (solid line) and 15 μm (dashed line) thick epi layers.