Materials Science & Engineering Doctoral Defense

Growth of Novel Semiconducting Nano and Heterostructures

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abstract

This dissertation presents research findings on the three materials systems: lateral Si nanowires (SiNW), In_2Se_3/Bi_2Se_3 heterostructures and graphene. The first part of the dissertation was focused on the growth and characterization of lateral SiNW. Lateral here refers to wires growing along the plane of substrate; vertical NW on the other hand grow out of the plane of substrate. It was found, using the Au-seeded vapor−liquid−solid technique, that epitaxial single-crystal SiNW can be grown laterally along Si(111) substrates that have been miscut toward [11-2]. The ratio of lateral-to-vertical NW was found to increase as the miscut angle increased and as disilane pressure and substrate temperature decreased. Based on this observation, growth parameters were identified whereby all of the deposited Au seeds formed lateral NW. Furthermore, the nanofaceted substrate guided the growth via a mechanism that involved pinning of the trijunction at the liquid/solid interface of the growing nanowire.

Next, the growth of selenide heterostructures was explored. Specifically, molecular beam epitaxy was utilized to grow In_2Se_3 and Bi_2Se_3 films on h-BN, highly oriented pyrolytic graphite and Si(111) substrates. Growth optimizations of In_2Se_3 and Bi_2Se_3 films were carried out by systematically varying the growth parameters. While the growth of these films was demonstrated on h-BN and HOPG surface, the majority of the effort was focused on growth on Si(111). Atomically flat terraces that extended laterally for several hundred nm, which were separated by single quintuple layer high steps characterized surface of the best In_2Se_3 films grown on Si(111). These In_2Se_3 films were suitable for subsequent high quality epitaxy of Bi_2Se_3.

The last part of this dissertation was focused on a recently initiated and ongoing study of graphene growth on liquid metal surfaces. The initial part of the study comprised a successful modification of an existing growth system to accommodate graphene synthesis and process development for reproducible graphene growth. Graphene was grown on Cu, Au and AuCu alloys at varioua conditions. Preliminary results showed triangular features on the liquid part of the Cu metal surface. For Au, and AuCu alloys, hexagonal features were noticed both on the solid and liquid parts.

May 28, 2014; 3:00 PM; ENGRC 490