SELECTIVE EPITAXIAL GROWTH OF 4H-SiC AND ITS APPLICATIONS FOR POWER DEVICES

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ABSTRACT

The excellent material properties of SiC make it an interesting semiconductor for devices operating at high temperature and high power. Selective epitaxial growth (SEG) of semiconductor materials is of both scientific and industrial interests, providing new insights into the growth mechanism as well as enabling novel device structures. This thesis focuses on the studies of selective homoepitaxial growth of 4H-SiC and its applications in power devices.

A new high temperature mask has been developed for selective growth of SiC. Detailed investigation on the selective growth of 4H-SiC show that selective growth is orientation dependent due to the influence of step flow growth. It is also shown that growth rate increases with increasing mask width when the mask width is below 100 μm for the temperature range from 1753 K to 1833 K, indicating growth is dominant and is enhanced by diffusion of species from the mask. On the other hand, enhanced etching by mask is also observed when the mask width is > 100 μm, probably caused by excess atomic hydrogen produced by the mask at high temperatures. In addition, dependence of growth rate and selectivity on various growth parameters is investigated.

Another key contribution of this thesis is the demonstrations of the devices fabricated by selective epitaxial growth of 4H-SiC. PN junction diodes and 4H-SiC bipolar junction transistors (BJTs) utilizing selective growth technique have been successfully fabricated. I-V characteristics of PN diode fabricated by selective epitaxial growth indicate that formed junction interface by selective trench re-fill is as good as that of mesa etched PiN diode. A novel self-aligned selective re-growth based epitaxial emitter BJT is demonstrated by selectively growing p+ contact layer in the trench with mask on emitter mesa. It is evident from the experimental forward I-V curves that the selectively grown devices show on-resistance $R_{on,sp}$ (32 mΩ-cm^2) below the unipolar value, as compared to $R_{on,sp}$ of 56 mΩ-cm^2 for conventional implanted devices. A clearly visible quasi-saturation region is also observed in I-V characteristics of new BJT devices, indicating conductivity modulation.