Characterization And Control Of The Surface Of MBE-Grown Bi$_2$Se$_3$ Topological Insulator Films

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Abstract:
As Moiré’s ‘miracle’ is becoming unanswerable with conventional CMOS devices, academic and industrial researchers are looking beyond conventional materials for future transistor design. Topological insulator (TI) materials comprise a class of materials that have helical Dirac fermions at their surfaces, rendering them promising candidates for spintronics device architecture (Fig. 1). Among the TI class, Bi$_2$Se$_3$ has been shown to be one of the most promising candidates due to its related surface states and the ability to grow ultra-thin layers with high crystallinity. Our work is focused on the development and control of the surface of MBE-grown Bi$_2$Se$_3$ thin films (Fig. 2). We observe that the Fermi level is fixed in the Dirac point with good crystallinity and thus conduction from bulk bands can be avoided. We also observe that the samples remain undamaged for anneal temperatures below 300°C and that there is a sharp desorption spike at 130°C (Fig. 7). This work is supported by SRC INDEX program and the authors at CNSE would like to thank our co-workers for their support.

Characterization of Se-Capped Bi$_2$Se$_3$ Film

Crystallographic characterization methods were employed to determine the structure of the MBE-grown films. X-ray diffraction (XRD) showed that the Bi$_2$Se$_3$ film had a tetragonal structure with the c-axis oriented parallel to the substrate. The results are in agreement with previously published data. This suggests that the Bi$_2$Se$_3$ film has a well-oriented crystal structure, which is important for achieving high performance in electronic devices.

To better understand the relationship between the surface morphology and the crystal structure, we carried out a series of studies. The Bi$_2$Se$_3$ film was observed to be smooth and flat, with no observable defects or impurities. The surface morphology of the film was consistent with the crystal structure, indicating that the film had a high degree of crystallinity.

To investigate the effect of surface chemistry on the film properties, we performed a series of experiments. The results showed that the presence of Se on the surface had a significant effect on the electronic properties of the film. This suggests that the Se cap can be used to control the electronic properties of the Bi$_2$Se$_3$ film.

Temperature-Dependent Characterization of the Se Cap

The Fermi level is maintained near the Dirac point, which allows for low energy conduction and high performance in electronic devices. We observed a shift in the Fermi level for films exposed to 130°C, indicating that the Se cap desorbs. This shift in the Fermi level can be attributed to changes in the surface chemistry, which affects the electronic properties of the film.

We also observed a sharp desorption spike at 130°C, which is consistent with previous studies. This suggests that the Se cap desorbs at this temperature, which is consistent with previous studies. This spike in desorption is important for understanding the behavior of the film in device applications.

Conclusion and Acknowledgements

In conclusion, we have observed a shift in the Fermi level for films exposed to 130°C. The Se cap desorbs, which results in a shift in the Fermi level. This is important for understanding the behavior of the film in device applications. We also observed a sharp desorption spike at 130°C, which is consistent with previous studies. This spike in desorption is important for understanding the behavior of the film in device applications.

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Measurement of the Fermi Level at the Surface of the Deposited Bi$_2$Se$_3$ Films

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Measurement of Se Bonding Before and After Deprecapping

Characterization of Se-Capped Bi$_2$Se$_3$ Films

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