Magnetic Doping Effects on the Surface State (SS) of Topological Insulators (TIs): Comparison between MBE-grown Bi$_2$Se$_3$ and (Bi,Sb)$_2$Te$_3$ bilayer samples CHIEN-CHANG CHEN, ANKIT KUMAR, NAI-CHANG YEH, Dept. of Physics, Caltech, LEI PAN, KOICHI MURATA, KANG L. WANG, Dept. of Elec. Eng., UCLA — We report studies of MBE-grown bilayer structures with one quintuple layer (QL) of pure TI on top of 6-QL of Cr-doped TI. Here TI is either Bi$_2$Se$_3$ or (Bi,Sb)$_2$Te$_3$. For 10% Cr-doping, both systems exhibited a similar bulk Curie temperature $T_{c}^{SD} \sim 35$ K from the onset of anonymous Hall effect (AHE). However, the AHE was much weaker in the Bi$_2$Se$_3$ system. Scanning tunneling spectroscopic (STS) studies revealed a gap opening in the SS below $T_{c}^{2D}(\sim210$ K) for both systems, but the gap in the Bi$_2$Se$_3$ system was much more inhomogeneous, probably due to larger lattice strain variations from Cr doping. Given that the SS gap only opens under out-of-plane long-range magnetization, strain variations could induce varying orientation of magnetic domains, thus the appearance of gap inhomogeneity. Double spectral resonances associated with topological spin textures around isolated magnetic impurities were also observed along the boundaries of gapped and gapless regions only in the Bi$_2$Se$_3$ system. Theoretically finite coupling among these isolated topological spin textures could be induced by tuning the Fermi level of the TI away from the Dirac point. We shall verify this prediction by studying the spectral evolution of the double resonances in the Bi$_2$Se$_3$ system with a backgate voltage.

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Chien-Chang Chen
Caltech

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