Doping effects in Bi$_2$Se$_3$ and Bi$_2$Te$_3$ topological insulators

Y.S. HOR, A.J. WILLIAMS, J.G. CHECKELSKY, P. ROUSHAN, J. SEO, A. RICHTERella, Y. XIA, Q. XU*, H.W. ZANDBERGEN*, M.Z. HASAN, A. YAZDANI, N.P. ONG, R.J. CAVA, PRINCETON UNIV TEAM, *DELT INST OF TECH TEAM — Topological insulators are found to have a bulk electronic gap and a gapless surface state. The surface state has been observed in Bi$_2$Se$_3$ and Bi$_2$Te$_3$ by ARPES and STM, but is still considered a challenging problem for transport measurements due to the dominant bulk conductance. By chemical doping, the Fermi level can be tuned to fall inside the band gap$^2$ and therefore suppress the bulk conductivity. Non-metallic conducting Bi$_2$Se$_3$ crystals are obtained. Previously unobserved $p$-type behavior has been induced$^3$ and a novel magnetofingerprint signal$^4$ is seen through low level Ca-doping in Bi$_2$Se$_3$. Bi$_2$Se$_3$ can also be tuned to a bulk superconductor, with $T_c$ $\sim$3.8 K, by Cu-intercalation in the van der Waals gaps.$^5$

This shows that Cooper pairing is possible in Bi$_2$Se$_3$ with implications for Majorana fermion physics study and potential quantum computing devices. Mn-doped Bi$_2$Te$_3$ has ferromagnetic transition at $\sim$15 K, suggesting a possible magnetic topological insulator.

$^1$Funding: FAA9550-06-1-0530(AFOSR), DMR-0819860(NSF MRSEC).
$^2$Hor et al. PRB 79 195208 (09)
$^3$Ibid.
$^4$Checkelsky et al. arXiv:0909.1840
$^5$Hor et al. arXiv:0909.2890.