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Superlattice valley engineering for designer topological insulators

XIAO LI, The University of Texas at Austin, FAN ZHANG, The University of Texas at Dallas, QIAN NIU, The University of Texas at Austin, JI FENG, Peking University — A topological insulator is a novel state of quantum matter, characterized by symmetry-protected Dirac interfacial states within its bulk gap. Tremendous effort has been invested into the search for topological insulators. To date, the discovery of topological insulators has been largely limited to natural crystalline solids. Therefore, it is highly desirable to tailor-make various topological states of matter by design, starting with but a few accessible materials or elements. Here, we establish that valley-dependent dimerization of Dirac surface states can be exploited to induce topological quantum phase transitions, in a binary superlattice bearing symmetry-unrelated interfacial Dirac states. This mechanism leads to a rich phase diagram and allows for rational design of strong topological insulators, weak topological insulators, and topological crystalline insulators. Our ab initio simulations further demonstrate this mechanism in [111] and [110] superlattices of calcium and tin tellurides. While our results reveal a remarkable phase diagram for the binary superlattice, the mechanism is a general route to design various topological states.

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