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Misfit layer compounds as ultra-tunable field effect transistors: from charge transfer control to emergent superconductivity

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Misfit layer compounds are heterostructures composed of bilayer rocksalts stacked with few layers transition metal dichalcogenides. They host Ising superconductivity, charge density waves and good thermoelectricity. The design of misfits emergent properties is, however, hindered by the lack of a global understanding of the electronic transfer among the constituents. Here, by performing first principles calculations, we unveil the mechanism controlling the charge transfer and demonstrate that rocksalt bilayers are always donor and dichalcogenides acceptors. We show that misfits behave as a periodic arrangement of ultra-tunable field effect transistors where chargings as large as $\approx 5 \times 10^{14}$ $e^{-}cm^{-2}$ can be reached and controlled efficiently by the La-Pb alloying in the rocksalt. Finally, we identify a strategy to design emergent superconductivity and demonstrate its applicability in $(LaSe)_{1.27}(SnSe_2)_2$. Our work paves the way to the synthesis and design of misfit compounds with tailored properties.

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