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Room Temperature Silicene Field-Effect Transistors[1]

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Silicene, a buckled Si analogue of graphene, holds significant promise for future electronics beyond traditional CMOS. In our predefined experiments via encapsulated delamination with native electrodes approach, silicene devices exhibit an ambipolar charge transport behavior, corroborating theories on Dirac band in Ag-free silicene. Monolayer silicene device has extracted field-effect mobility within the theoretical expectation and ON/OFF ratio greater than monolayer graphene, while multilayer silicene devices show decreased mobility and gate modulation. Air-stability of silicene devices depends on the number of layers of silicene and intrinsic material structure determined by growth temperature. Few or multi-layer silicene devices maintain their ambipolar behavior for days in contrast to minutes time scale for monolayer counterparts under similar conditions. Multilayer silicene grown at different temperatures below 300°C possess different intrinsic structures and yield different electrical property and air-stability. This work suggests a practical prospect to enable more air-stable silicene devices with layer and growth condition control, which can be leveraged for other air-sensitive 2D materials. In addition, we describe quantum and classical transistor device concepts based on silicene and related buckled materials that exploit the 2D topological insulating phenomenon. The transistor device physics offer the potential for ballistic transport that is robust against scattering and can be employed for both charge and spin transport.

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