Graphene-Si CMOS oscillators

Graphene field-effect transistors (GFETs) offer a possibility of exploiting unique physical properties of graphene in realizing novel electronic circuits. However, graphene circuits often lack the voltage swing and switchability of Si complementary metal-oxide-semiconductor (CMOS) circuits, which are the main building block of modern electronics. Here we introduce graphene in Si CMOS circuits to exploit favorable electronic properties of both technologies and realize a new class of simple oscillators using only a GFET, Si CMOS D latch, and timing RC circuit. The operation of the two types of realized oscillators is based on the ambipolarity of graphene, i.e., the symmetry of the transfer curve of GFETs around the Dirac point. The ambipolarity of graphene also allowed to turn the oscillators into pulse-width modulators (with a duty cycle ratio ~1:4) and voltage-controlled oscillators (with a frequency ratio ~1:8) without any circuit modifications. The oscillation frequency was in the range from 4 kHz to 4 MHz and limited only by the external circuit connections, rather than components themselves. The demonstrated graphene-Si CMOS hybrid circuits pave the way to the more widespread adoption of graphene in electronics.

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