MAR13-2012-020066

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Single-layer MoS_2 - electrical transport properties, devices and circuits[1]

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After quantum dots, nanotubes and nanowires, two-dimensional materials in the shape of sheets with atomic-scale thickness represent the newest addition to the diverse family of nanoscale materials. Single-layer molybdenum disulphide (MoS_2), a direct-gap semiconductor is a typical example of these new graphene-like materials that can be produced using the adhesive-tape based cleavage technique originally developed for graphene. The presence of a band gap in MoS_2 allowed us to fabricate transistors that can be turned off and operate with negligible leakage currents. Furthermore, our transistors can be used to build simple integrated circuits capable of performing logic operations and amplifying small signals. I will report here on our latest 2D MoS_2 transistors with improved performance due to enhanced electrostatic control, showing improved currents and transconductance as well as current saturation. We also record electrical breakdown of our devices and find that MoS_2 can support very high current densities, exceeding the current carrying capacity of copper by a factor of fifty. Furthermore, I will show optoelectronic devices incorporating MoS_2 with sensitivity that surpasses similar graphene devices by several orders of magnitude. Finally, I will present temperature-dependent electrical transport and mobility measurements that show clear mobility enhancement due to the suppression of the influence of charge impurities with the deposition of an HfO_2 capping layer.

[1]Financially supported by grants from Swiss National Science Foundation, EU-FP7, EU-ERC and Swiss Nanoscience Institute.