Metal-Insulator transition in annealed MoS_2 devices

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Abstract

Single-layer MoS_2 has been widely studied due to its promising electronic and optoelectronic properties, which can be efficiently tuned by electrostatic doping in a transistor configuration [1]. To consider "real world" applications, a perfect understanding and control of the contacts and transport regime in the devices is required [2-3]. We present a systematic study of the transport characteristics of monolayer MoS_2 as a function of electron density and temperature. High quality MoS_2 flakes are grown by CVD on a Si/SiO_2 substrate, then plasma etched into the desired shape and contacted with Ti/Au by electron beam lithography (Fig. 1a). More than 10 devices were studied by electrical measurements after in-situ annealing at 600 K. The 2- and 4-probe resistance was systematically recorded as a function of temperature (up to 20 K), gate voltage and source-drain voltage. Vacuum annealing clearly improves the contact resistance, its ohmicity and increases the electron density. All samples show thermally activated and hopping transport at high and low temperatures, respectively. Mobility is limited by phonons at high temperature and by doping-dependent short/long range scatterers at low temperature, with mobilities at low temperature on the order of 200 cm^2/Vs. Some devices have even demonstrated a metal-insulator transition (MIT) at carrier densities around $2x10^{12}cm^{-2}$ (Fig. 1b) without the need for top-gating, with the transition occurring at a conductivity close to 1.42 e^2/h [4,5]. The origin of the MIT transition, whether it is the Mott or Anderson transition, is discussed along with a finite size scaling analysis. A detailed analysis with different models fitting these results [5,6] will be presented to clearly elucidate the dominant transport mechanism for each doping and temperature range.

References

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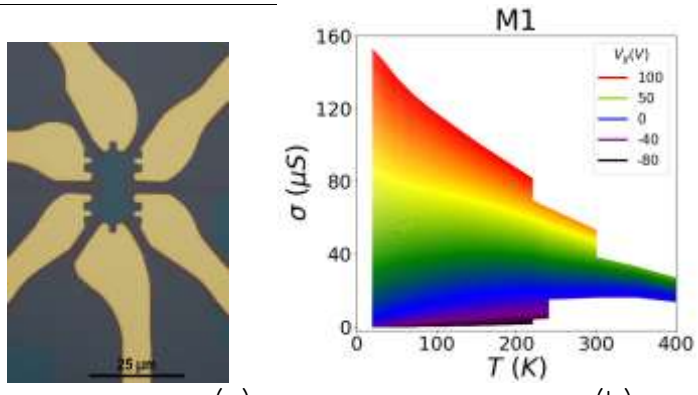
Figures



(a) (b)

Figure 1: (a) Optical picture of a monolayer MoS_2 Hall bar (M1). (b) Four-probe conductivity of a device showing a MIT around V_g=45V.