LOW FIELD MAGNETOTRANSPORT IN STRAINED Si-CAVITIES

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Magnetotransport measurements revealing signatures of ballistic transport effects in strained silicon cavities are presented. We will discuss magnetic focusing occurring at low magnetic fields and the presence of a negative magnetoresistance peak akin to the weak localization structures. Both effects have been intensively investigated in GaAs/AlGaAs systems but, to the best of our knowledge, this is the first observation in SiGe heterostructures [1]-[3].

The devices were fabricated by confining a high mobility Si/SiGe two dimensional electron gas in a bended nanowire geometry defined by electron-beam lithography and reactive ion etching. The cavities were obtained by the lateral displacement of a central 550-nm-long segment defined in the inner region of 2-µm-long and 250-nm-wide nanowires. Fig. 1 shows three scanning electron micrographs of devices with an increasing lateral displacement of the cavity. Since the cavity dimensions (~550 nm long and 250nm wide) are smaller than the mean free path (~1µm for the unconstrained 2D carriers), the transport in the cavities is expected to be ballistic. Due to sidewall depletion caused by the fabrication process the shift results in two constrictions connecting the central cavity with the other two segments of the wire and the outer mesa structure. These constrictions have an effective width smaller than the lithographic one and behave as quantum points contacts (QPC) connecting the cavity to the source and drain. The devices were completed defining a central metallic control gate aligned with the cavity.

The electrical characterization of the devices was performed in a dilution refrigerator by measuring the magnetoresistance in the 50mK-4.2K temperature range using standard AC low-frequency lock-in techniques. In Fig. 2 we report low field magnetoresistance curves measured at T=50mK in a four-terminal configuration ($R_{2,3}$, thicker line) and in a two-terminal configuration ($R_{1,4}$ thinner line). Refer to the inset in Fig. 2 for contact schematics. In both configurations the two most noteworthy features are the presence of a zero-field magnetoresistance peak akin to the weak localization (WL) structure and of an oscillatory structure at low fields, highlighted by arrows in Fig. 2.

We interpret the oscillatory structure in terms of magnetic focusing due to the commensurability between the ballistic trajectories of electrons in the cavity and the cavity geometry. These effects were mostly studied in ballistic cavities obtained by split-gate technique on GaAs/AlGaAs heterostructures [1],[2]. Concerning the zero-field negative magnetoresistance, we relate the sharp peak found in the two-terminal measurement to disorder-driven weak localization (WL) due to the 2DEG mesa region outside the cavity. On the other hand, the line-shape found in the four-terminal measurement, suggests an interpretation in terms of ballistic weak localization, an analogous of disorder driven WL predicted in ballistic cavities [4],[5] that has been the subject of a great interest [3],[6],[7]. Further investigations of the magnetoresistance features as a function of both the gate voltage and the temperatures well as the lateral displacement of the cavity will be presented and discussed.

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Figures:

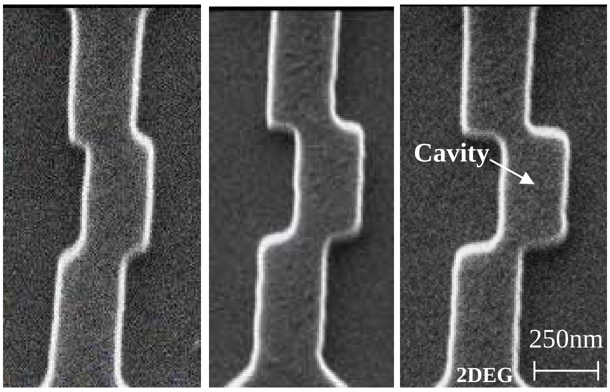

Fig. 1. Scanning electron micrographs of laterally displaced cavities fabricated by reactive ion etching of a Si/SiGe modulation doped heterostructure.

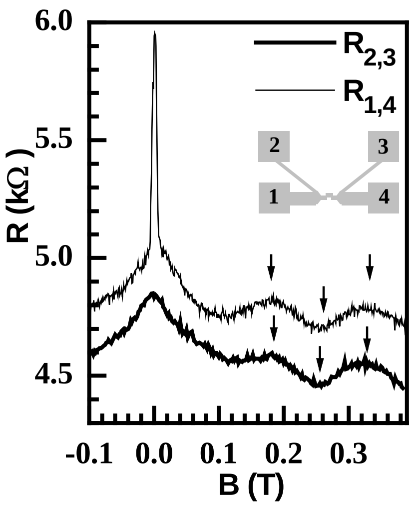

Fig. 2. Low-field magnetoresistance measured in a four-terminal configuration ($R_{2,3}$, thicker line) and in a two-terminal configuration ($R_{1,4}$ thinner line) at T=50mK. Electrical contacts scheme is reported in the inset.