Fractional quantum Hall state preserving gates

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Metallic (Schottky) gates are widely used to tune the carrier density in mesoscopic and nanoelectronic AlGaAs/GaAs two-dimensional electron gas (2DEG) based devices. However, such gates have detrimental effects on the fractional quantum Hall states. In this work, we try to find the origin of this annihilation of the fractional states, and thus find a recipe for gates that preserves them. Studying a series of gated Hallbar devices made from high mobility 2DEG with varying thicknesses of the gate metal layer in Schottky gates and of the dielectric layer (HfO_2) in metal-insulator (MI) gates, we find a reduction of the low temperature carrier mobility for increasing gate metal thickness and/or decreasing dielectric thickness. Furthermore, the MI gate devices show several fractional Hall states, suggesting a strain-related increase of the disorder in the 2DEG leading to the destruction of the fractional quantum Hall states in the Schottky gated devices. To further investigate this, we implement a novel periodic gate structure which, via the study of commensurability oscillations[1], allows us to verify the presence of the strain and evaluate its role.

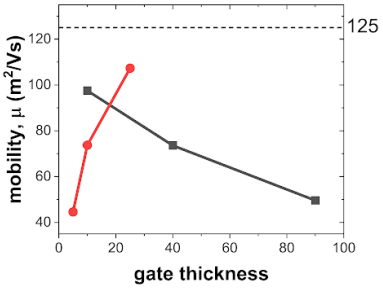

Fig.1. Mobility variation with thickness of metal (black) in Schottky and dielectric (red) in MI gated devices

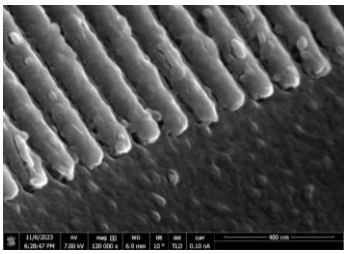

Fig.2. Scanning electron microscope image of periodic Schottky gates

References

[1] D. Kamburov, M.A. Mueed, I. Jo, Y. Liu, M. Shayegan, L.N. Pfeiffer, K.W. West, K.W. Baldwin, J.J.D. Lee, and R. Winkler, Phys. Rev. B **90**, 23, 235108 (2014)