Flip-chip gating for studying quantum Hall states in pristine ultra-high mobility 2DEGs

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Electrostatic gating is a necessity for controlling and probing semiconductor systems. With interest in ultra-high mobility semiconductors and more fragile low-dimensional systems, preserving qualities such as charge carrier mobility is key to enabling future research. One innovative method for preserving pristine materials is to employ a mechanical assembly to gate two-dimensional electron gases (2DEGs) in GaAs/AlGaAs wafers. In this flip-chip device, metallic gates are deposited via lithography onto a separate sapphire substrate that is mechanically held on to the semiconductor of interest (Fig. 1 c.-e). The enables control of the current in a 2DEG via field effect for quantum interference measurements.

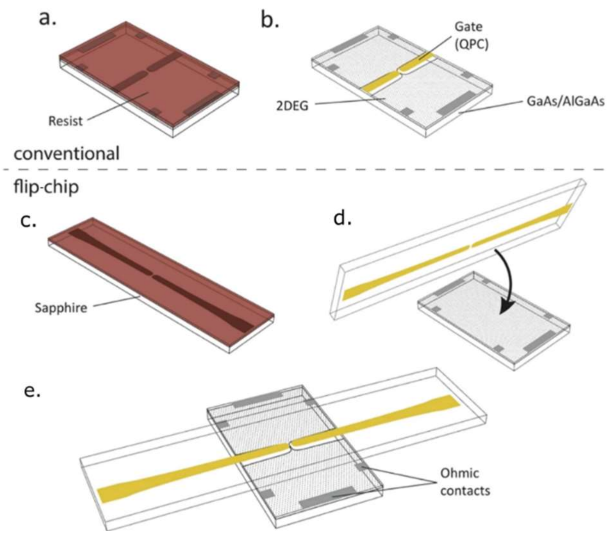

Fig 1. Conventional lithography methods deposit metal directly on the semiconductor surface (a.,b.). In contrast, a flip-chip device utilizes sapphire as the substrate for the gates preserving pristine semiconductor materials from direct lithography and enables reuse and reconfiguration (c.-e.) [2].

Flip-chips offer a number of advantages, namely that they facilitate the reuse of semiconductor wafers in the case of gate malfunction or allow for movement of the gates should the original placement fall on a low-quality region of the material of interest [1]. Secondly, flip-chips avoid any contamination or mobility-degradation from chemicals or cleaning processes involved in traditional lithography. Thirdly, by avoiding direct deposition of materials on the wafers we avoid strain on the GaAs crystal due to disparities in thermal contraction as the device is cooled to milli Kelvins. Finally, we avoid charge traps by replacing traditional dielectric materials, such as oxides, between the semiconductor and the gates with a vacuum in a flip-chip device. By preserving the high mobility of 2DEGs, our flip-chip devices enable further study of fragile quantum Hall states. In this paper we will present results on gating a 2DEG with mobility as high as 25×10^6 cm^2/Vs and will discuss further progress in making Fabry-Perot interferometer designs for the fractional quantum Hall regime.

References

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