**Recent advances in epitaxial graphene on SiC(0001)**

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The growth of epitaxial graphene (EG) on SiC surfaces is a promising approach for the development of graphene-based electronic devices [1]. The field has recently been boosted by improved growth procedures which allow wafer scale growth of EG on SiC(0001) [2,3]. The growth of EG on SiC(0001) in Ar atmosphere [2] leads to a significantly improved film morphology and homogeneity. In addition, the carrier mobility increases compared to graphene films formed in an UHV environment. Despite these improvements several issues still remain. In the present talk I will summarize resent studies on EG on SiC, which address a number of these issues.

One fundamental question is whether the substrate can influence the graphene layer in a way such that the symmetry between the two sub-lattices is broken. This would lead to the appearance of a band gap as was suggested [4] although arguments were presented against a gap opening [5]. An interesting test would be if the anomalous quantum Hall effect of graphene can be observed in EG on SiC(0001). The improved properties of EG grown in Ar allow such measurements [6,7] as demonstrated in fig. 1. This seems to indicate, that the substrate does not induce a breaking of the AB symmetry in EG on SiC(0001).

In pristine EG on SiC(0001) the carrier concentration is very high, typically $1\times10^{13}$ $cm^{-2}$, which is detrimental for the carrier mobility. The latter reaches only values of close to 1000 $cm^2/Vs$ at Room temperature and 2300 $cm^2/Vs$ at He temperature. These values are much lower than what is observed in exfoliated graphene on a substrate [11] where values of 20000 $cm^2/Vs$ are frequently measured at He temperature. Using adsorption of organic molecules such as tetrafluoro-tetracyanoquinodimethane (F4-TCN) it is possible to reduce the carrier concentration in EG considerably [6,8]. For samples with an electron concentration of about $1\times10^{11}$ $cm^{-2}$ a mobility of 29000 $cm^2/Vs$ is observed [6] at 4.2 K, a value which compares well with the observations for exfoliated graphene on $SiO_2$ substrates [11].

Finally, we investigate the properties of quasi-freestanding graphene layers obtained by decoupling the covalently bound buffer layer from the substrate by hydrogen intercalation [9,10]. Annealing of samples covered only by the $(6\sqrt{3}\times6\sqrt{3})$ reconstruction in a hydrogen atmosphere breaks the bonds between the SiC(0001) substrate and the chemisorbed graphene layer, which turns into a physisorbed layer with pi-band typical of graphene [see Fig. 2(a)]. The Si-atoms of the substrate surface are saturated by hydrogen leading to a sharp Si-H stretch mode signal as shown in Fig. 2(b). The quasi-freestanding graphene layer is p-type doped with a concentration of $\sim6\times10^{12}$ $cm^{-2}$.Mobility values of up to 3100 $cm^2/Vs$ at room temperature have been observed. In contrast to EG on the buffer layer a very small temperature dependence is observed for quasi-freestanding epitaxial graphene.

## References

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**Figures**

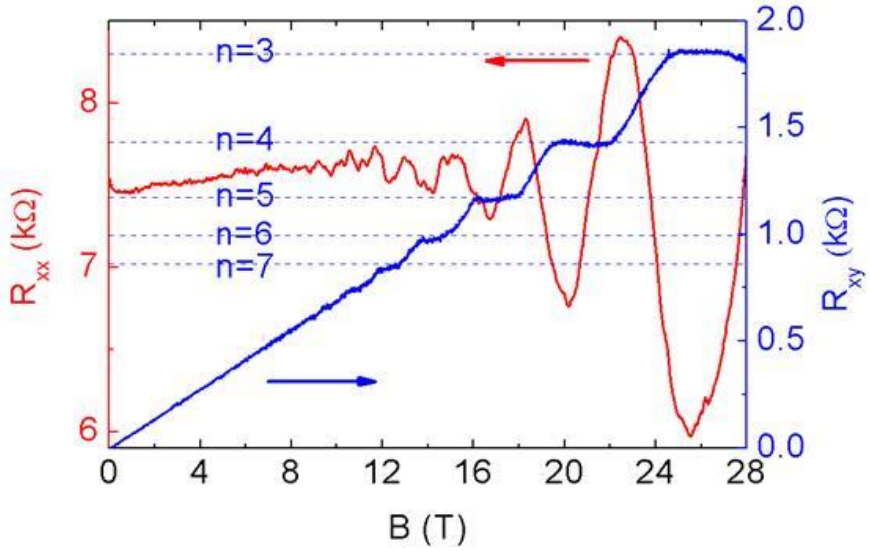


*Fig. 1. Resistance $R_{xx}$ and Hall resistance $R_{xy}$ at T=4.2 K from a sample of single-sheet graphene with $n=8.9\times10^{12}$ $cm^{-2}$ and $\mu=2300$ $cm^2/Vs$. Hall plateaus and the positions of extrema can be identified with the unconventional Landau-level structure of single-layer graphene. From [6].*

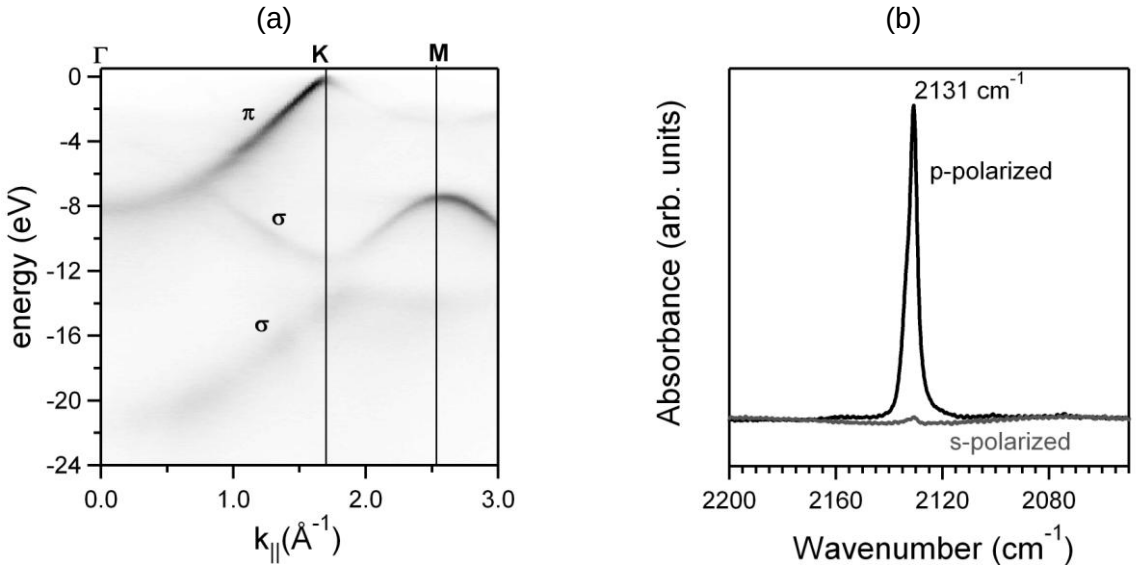


*Fig. 2. Quasi-free standing graphene obtained by intercalation of hydrogen underneath the (6√3×6√3) reconstruction (buffer layer): (a) band structure along ΓKM direction. (b) FTIR spectrum of the Si-H stretch mode. From [10].*