Flat band and Lifshitz transition in long-range-ordered supergraphene obtained by Erbium Intercalation

Ahmad Zaarour[1]
V. Malesys[1], J. Teyssandier[1], M. Cranney[1], E. Denys[1], J. L. Bubendorff[1], A. Florentin[1], L. Josien[1], F. Vonau[1], D. Aubel[1], A. Ouerghi[2], E. Otero[4], C. Bena[3], and L. Simon[1].
[1]*Université de Haute-Alsace, CNRS, Institut de Science des Matériaux de Mulhouse UMR 7361, 3Bis rue Alfred Werner, 68093 Mulhouse, France and Université de Strasbourg (UniStra), F-67081 Strasbourg, France.*
Laurent.simon@uha.fr

We present a groundbreaking study showcasing the emergence of heavily electron-doped graphene, achieved solely through Erbium atom intercalation [1]. Utilizing Scanning Tunneling Microscopy (STM), we unveil a novel long-range ordered hexagonal supergraphene structure (Fig. 1a). Analysis via ARPES reveals remarkable features: a robust linear dispersion near K points with a remarkable Dirac point energy shift 1.72 eV below the Fermi level (Fig. 1b), marking the highest reported doping level to date, along with a wide flat band around the M point (Fig. 1c). Our Fermi surface measurements definitively confirm the Lifshitz transition attainment, with an electron density of $5.1\pm0.8\times10^{14}$ cm^2 (Fig. 1d). XPS investigations demonstrate the free-standing nature of Er atoms between the graphene layer and substrate, preserving their metallic character. XAS and XMCD measurement realized at Deimos line in Soleil synchrotron, reveal the presence of non-oxidized individual Er atoms, notably Er3+. Through Tight-Binding calculations, we propose a theoretical model where diluted ordered Erbium atoms act as impurities under the graphene and induce a local-density-of-states perturbation, as for a kekulé order, which is typically observed near the Dirac point [2]. Furthermore, we also discuss the possible impacts of spin-orbit coupling on Fermi surface topology and the flattening of the band around M at Lifshitz transition.

References

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Figures

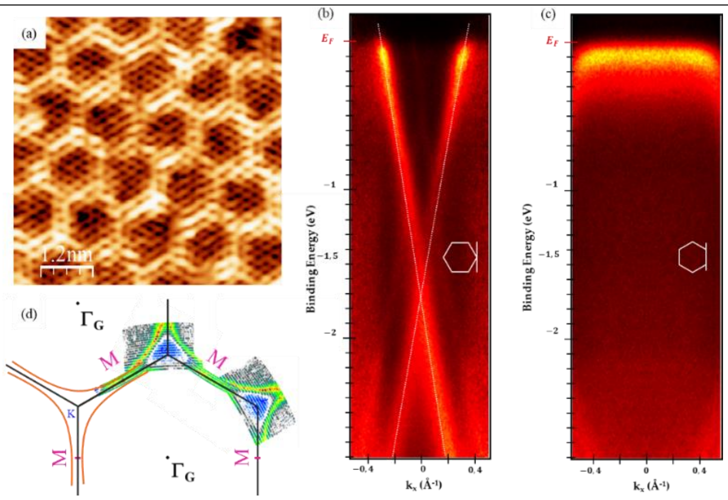

Figure 1: (a) Topographic STM image of the (5.75 × 5.75) R19°-G superstructure; 6×6 nm^2. ARPES measurements of the dispersion band around K point in **(b)** and around M point in **(c)**. **(d)** Fermi surface of the system.