Stuttgarter Physikalisches Kolloquium

Max-Planck-Institut für Festkörperforschung
Max-Planck-Institut für Intelligente Systeme
Fachbereich Physik, Universität Stuttgart

Ansprechpartner: Christian Ast
E-Mail: C.Ast@fkf.mpg.de
Telefon: 0711 - 689-5250

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Stuttgarter Max-Planck-Institute, Heisenbergstraße 1, 70569 Stuttgart-Büsnau

Squeezing the best out of graphene: graphene hybrid architectures

J. Smet
Max Planck Institute for Solid State Research

Abstract

Almost any superlative one can think of has been deployed to describe the physical properties of graphene. Among others, its electronic conductivity has been praised to surpass that of copper at room temperature. However, laboratory tests yield a more sobering, differentiated picture. While it has this potential, without appropriate measures, this gossamer, one-atom thick sheet of carbon does not even beat the lousy mobility at room temperature of charge carriers hosted in GaAs. All on its own it cannot accomplish much more than what already exists. A hybrid architecture is crucial to bring out the best of graphene. Encapsulation between inert, thicker layers of its close cousin hBN that serve as atomically flat surfaces, makes all the difference. It protects graphene from the dominant source of scattering it suffers from turning it into a marvelous and versatile testbed for basic research. The name of the game is called van der Waals stacking. It can be generalized to the large class of strictly 2D materials and offers unprecedented parameters to play with in order to tune electronic and other properties. It has led to a paradigm shift in the field of 2D condensed matter physics with truly bright prospects. This will be illustrated with two examples. One is a simple demonstration of the importance of the topology related Berry phase in condensed matter physics that can go straight into a textbook. A second more advanced example stems from the realm of quantum fractality. Combining graphene with other compounds outside of the family of 2D materials expands the 2D horizon even further and is at least equally rewarding. Here we explore an innovative device design in which local electrochemistry is married with machinery close to the heart of a low dimensional transport physicist to explore the virtues of bilayer graphene as an ionic conductor. Among the homogeneous mixed conductors, it turns out to be a true champion. This graphene/electrolyte hybrid architecture seems to pave the way for unusually potent experiments of on-chip ionic transport and electrochemistry studies.