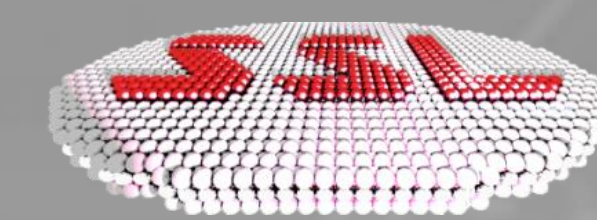


The exciting world of 2D Materials

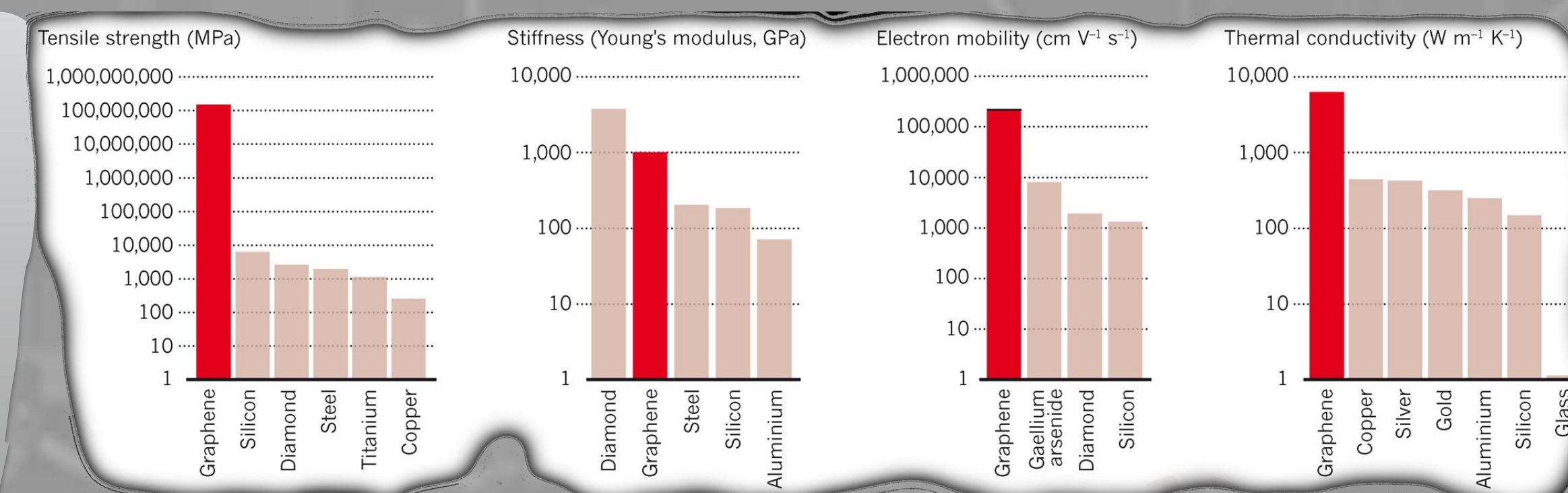
Joint efforts at the Surface Science Laboratory and SuperESCA beamline of Elettra



2D Materials are attracting considerable attention for their superlative physical and chemical properties. They consist of ultra-thin sheets exhibiting covalent in-plane bonding. Following the discovery of graphene, with its unique properties, entirely new synthetic 2D materials provide access to a greater range of properties through the choice of constituents elements and substrates.

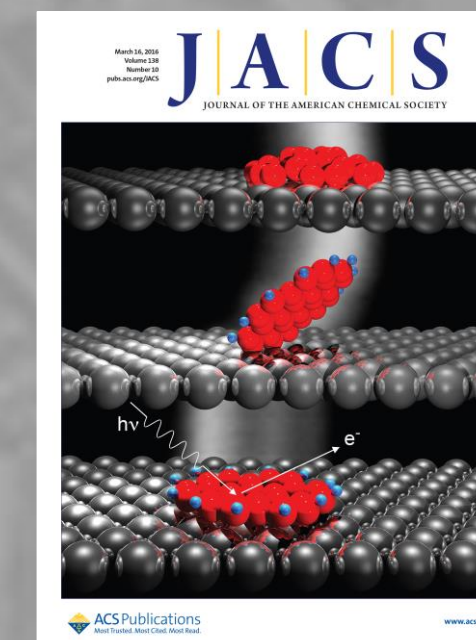
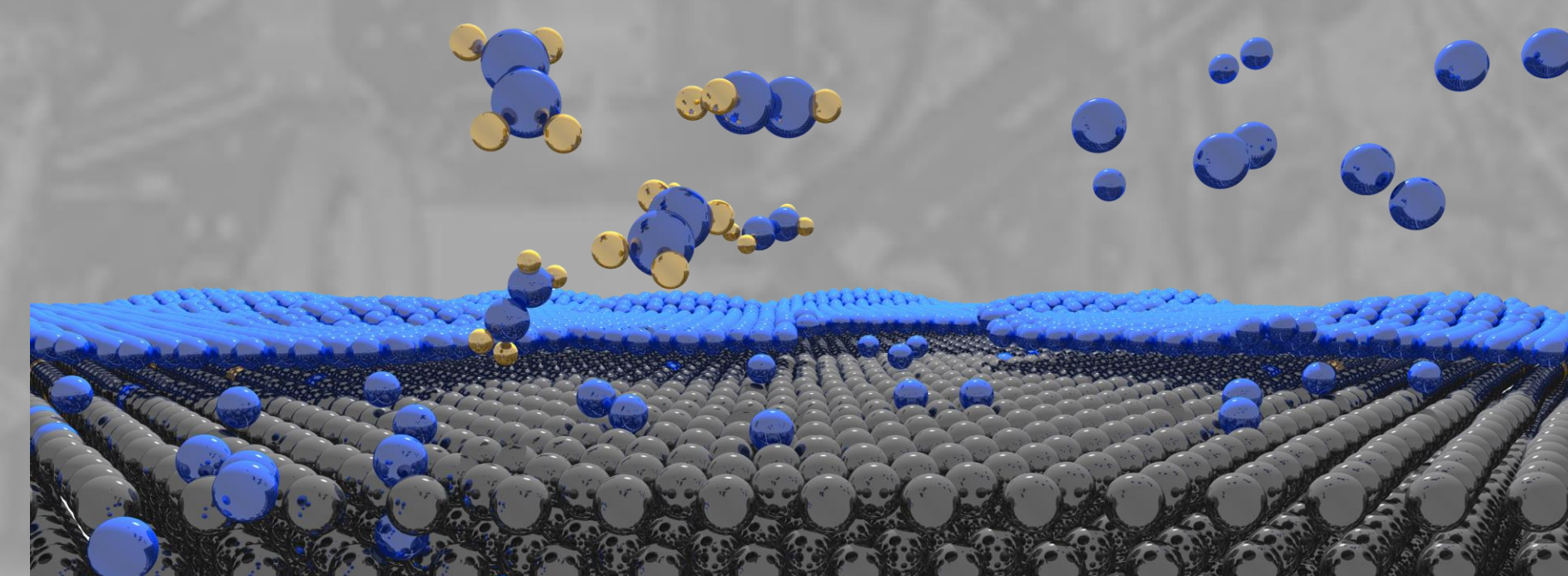
Since 2008 our teams are strongly involved in the study of different properties of these amazing materials.

Graphene main characteristics



Growth mechanism

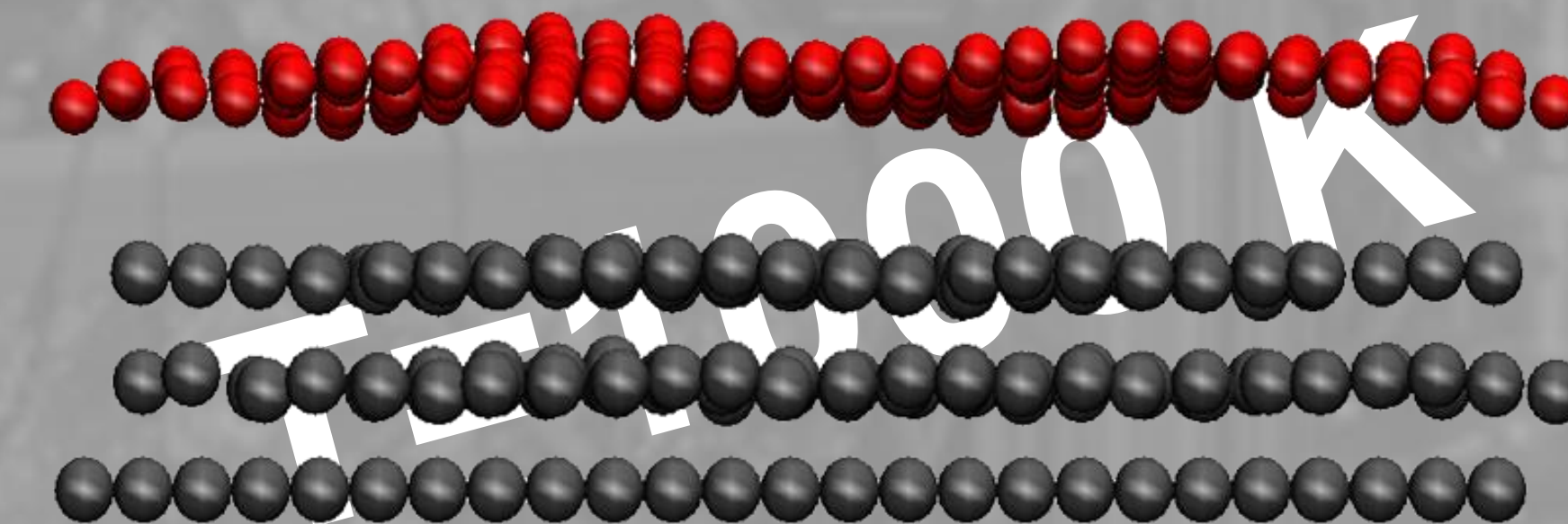
Improving the crystalline quality of epitaxially grown 2D materials is one of the main target to preserve the unique transport properties they present as free-standing materials. This can be achieved by studying the mechanism of growth at atomic level.



Physical Review Letters 103, 166101 (2009); Journal of the American Chemical Society 138, 3395 (2016)

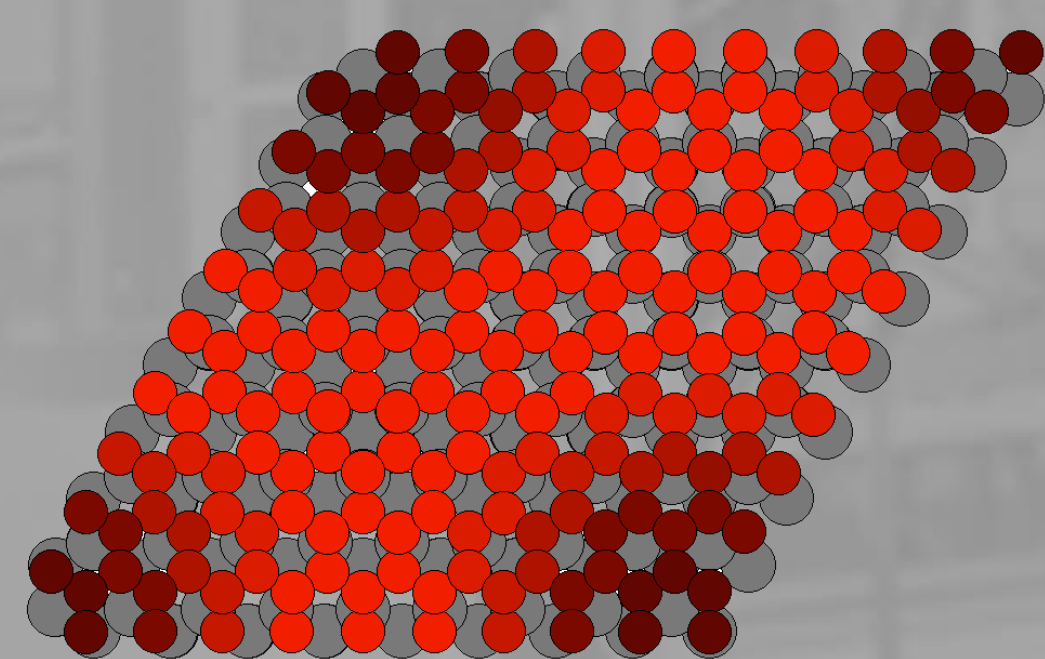
Thermal properties

Thermal expansion and stability largely influence the properties of 2D materials which could find applications in nanoscale heat dissipation devices. Graphene is among the few materials presenting a negative thermal expansion coefficient, which can however change when is supported on different substrates.

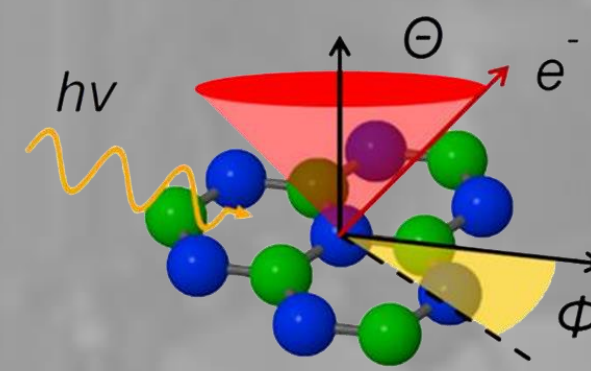


Physical Review Letters 106, 135501 (2011); Physical Review Letters 106, 216101 (2011)

Geometric structure



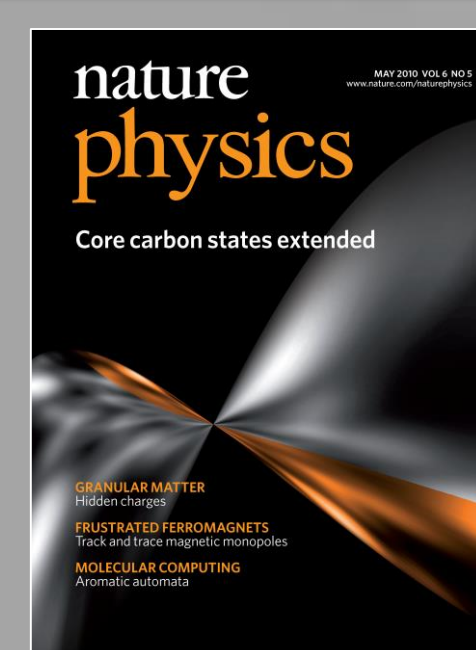
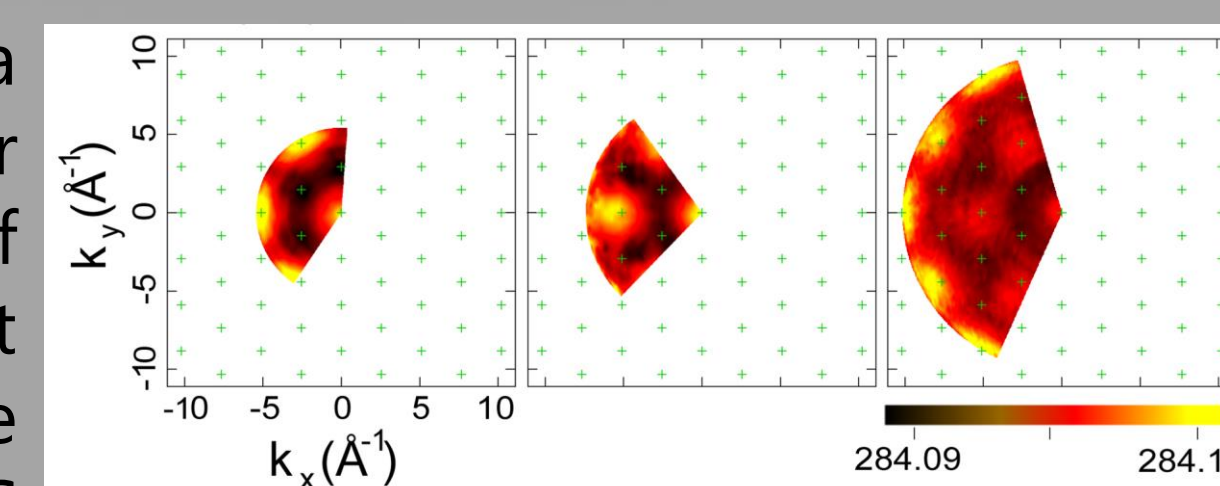
When supported on most of the metal and oxide surface 2D shows a strongly modified atomic structure. In stead of being flat they can be corrugated. This can modified their electronic structure and their adsorption properties. The knowledge of the exact position of each atoms of the large units cell in the 3D space a fundamental pre-requisite of a deep understand of all other properties.



Physical Review Letters 106, 135501 (2011); ACS Nano 3, 9551 (2012); ACS Nano 8, 12063 (2014)

Electronic structure

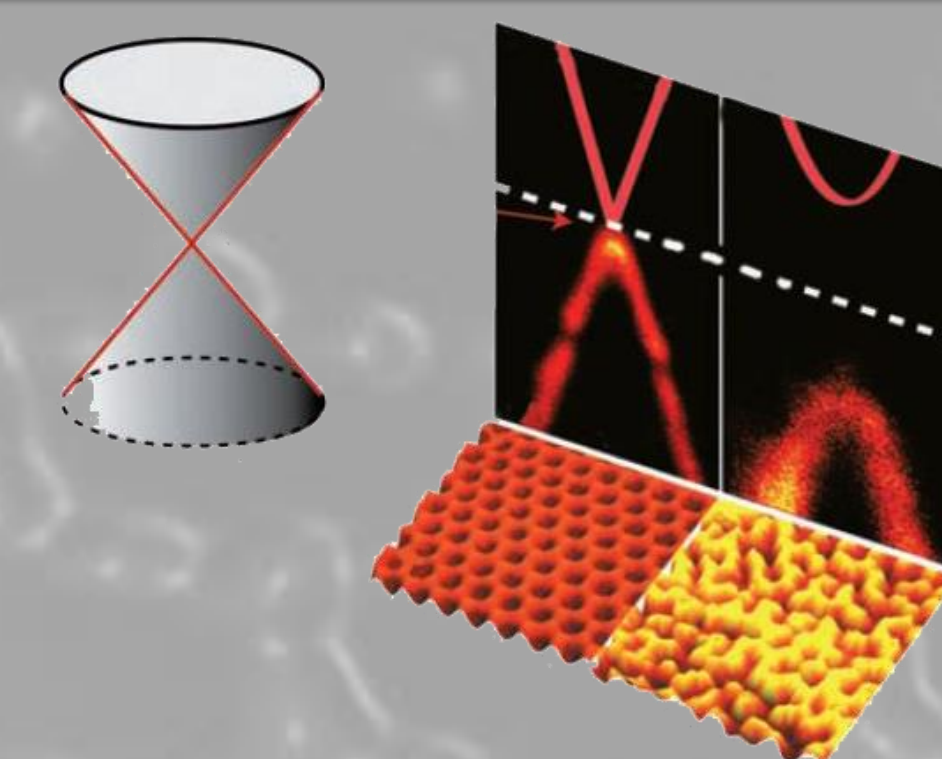
In several 2D materials charge carriers behave like Dirac fermions, i.e. as relativistic massless particles, with a ballistic charge transport, turning into ideal materials for nanoelectronics circuit fabrication. The uniqueness of electronic structure is reflected not only in valence, but also in core electrons. Band formation and considerable band dispersion has been observed also in the case of C 1s electrons of epitaxial graphene.



Nature Physics 6, 345 (2010)

Functionalization

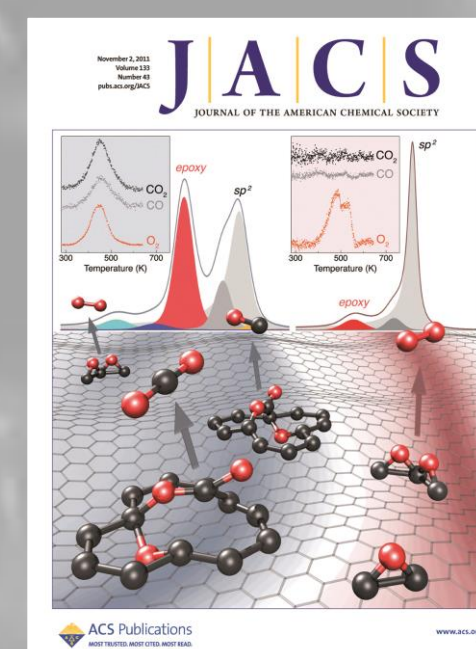
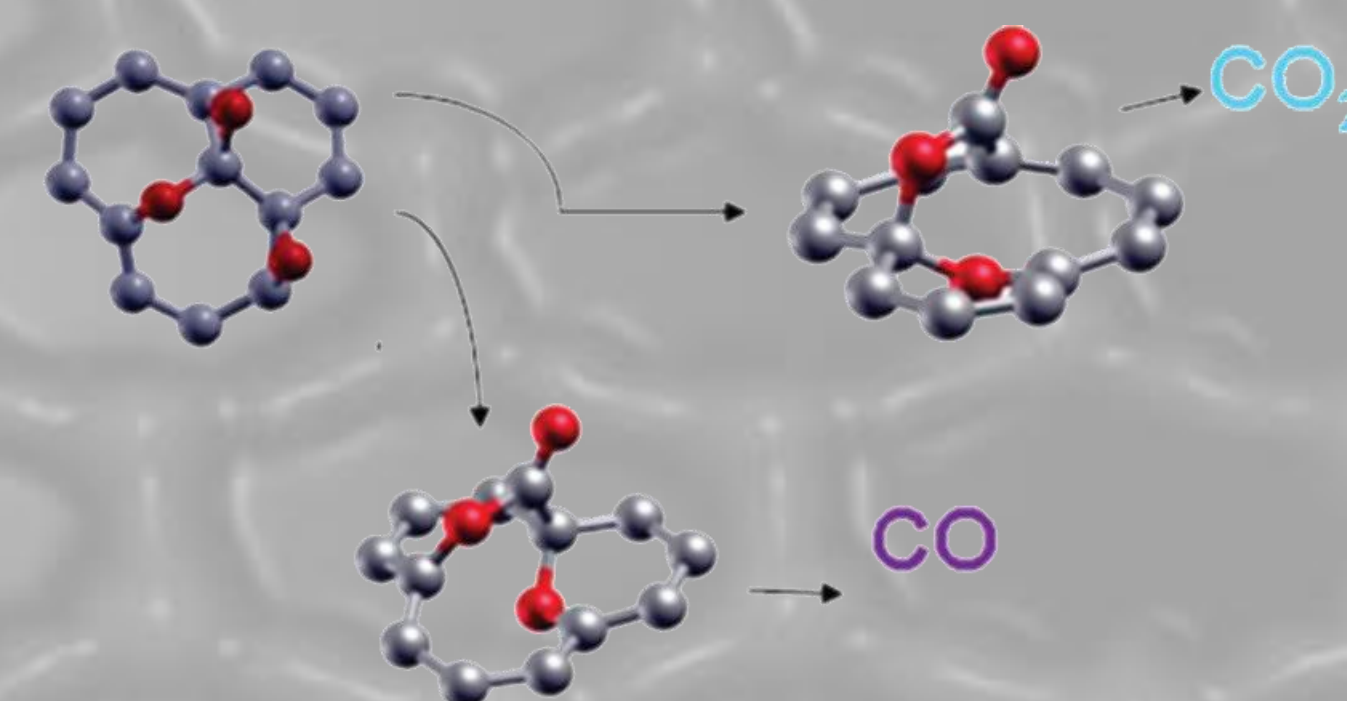
In some cases 2D materials lack, however, an energetic band gap around the Fermi level as in semiconductor materials, which is essential for controlling the conductivity by electronic means. A band-gap opening can be induced by the patterned adsorption of atomic species, through a process of chemical functionalization. Functionalization, with different goals, can be achieved also via atomic clusters deposition.



Nature Materials 9, 315 (2010); ACS Nano 6, 3034 (2012); ACS Nano 7, 3823 (2013)

Chemical reactivity

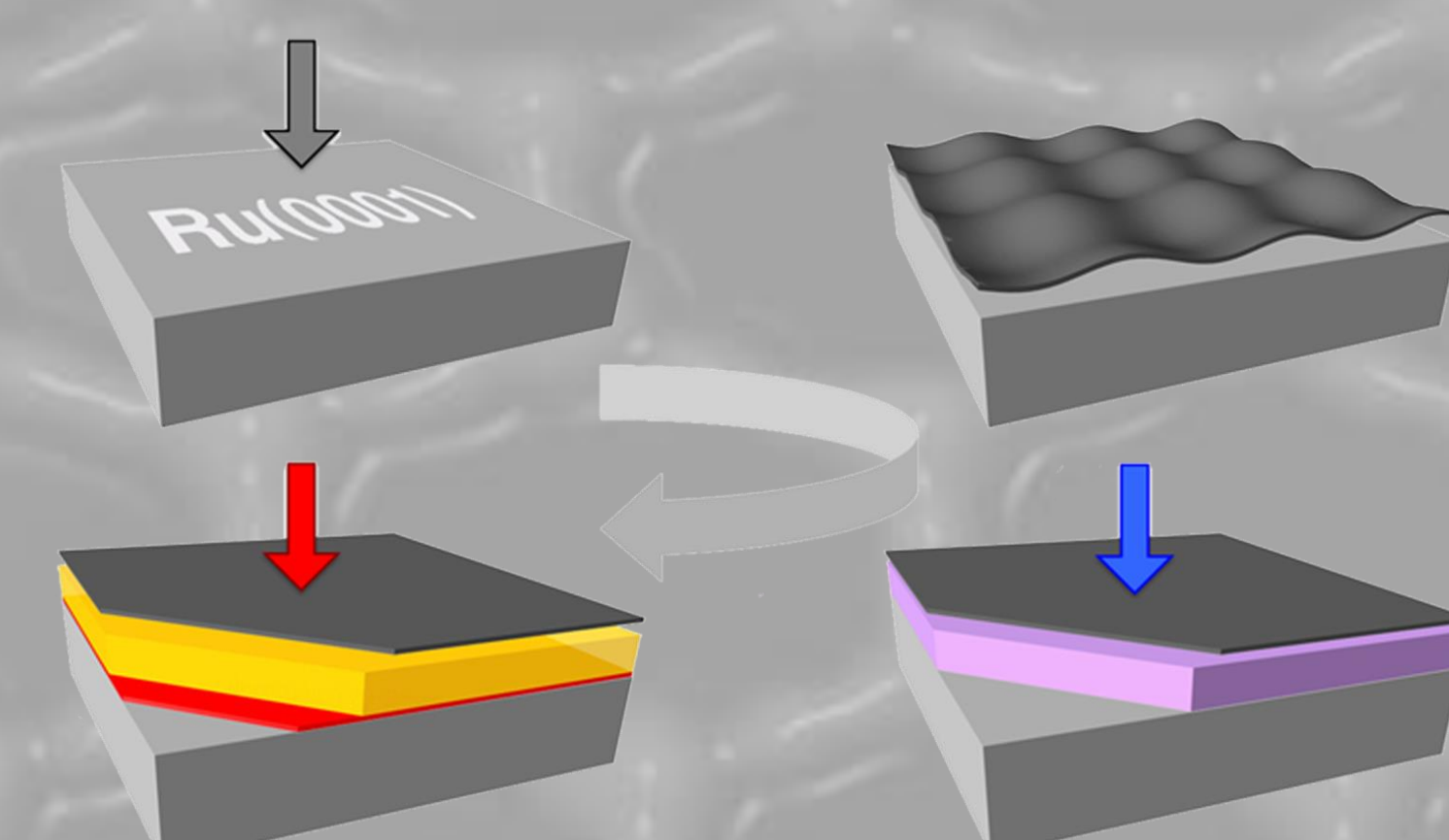
Defect formation in the two-dimensional network during chemical processes compromises the charge carrier mobility in the materials. Understanding the mechanisms of the thermal reactions is essential for defining alternative routes able to limit the density of defects.



Journal of the American Chemical Society 133, 17315 (2011)

Novel interfaces

New architectures formed by 2D materials interfaces (2D-metals, 2D-semiconductors, 2D-oxides, 2D-2D heterostructures) can be adopted in a large range of technological applications from nanoelectronics to energy storage.



Nano Letters 12, 4503 (2012); ACS Nano 6, 9511 (2012); Nature Communications 5, 5062 (2014)

Take a flight on graphene

YouTube



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