CMD30 FisMat2023 - Submission - View

Abstract title: Hydrogen absorption in a novel three-dimensional graphene structure: Towards hydrogen storage applications

Submitting author: Stefano Veronesi

Affiliation: NEST, Istituto Nanoscienze - CNR and Scuola Normale Superiore

Affiliation Address: Piazza S. Silvestro, 12 56127 Pisa

Country: Italy

Other authors and affiliations: Aureliano Macili (1), Ylea Vlamidis (1, 2), Emanuele Pompei (1), Georg Pfusterschmied (3), Markus Leitgeb (3), Ulrich Schmid (3), Stefan Heun (1) (1) NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Piazza S. Silvestro 12, 56127 Pisa, Italy (2) Department of Physical Science; Earth and Environment; University of Siena; via Roma 56; Siena; 53100 Italy (3) Institute of Sensor and Actuator Systems; TU Wien; Vienna; 1040; Austria

Abstract

The reduction of fossil fuel consumption relying on renewable energies cannot be done without consideration of their intermittency and needs thus some form of energy storage to manage it [1]. Hydrogen is considered one of the most appealing forms of energy storage. Graphene-based materials suitable for hydrogen storage must feature a high surface-to-volume ratio, in order to accomplish the requirements of real-world applications [2]. We explored the use of a novel three-dimensional graphene structure, which allows circumventing the limitations of the 2D nature of graphene and allows its application in hydrogen absorption. Here we report an investigation of deuterium-bonding on monolayer graphene conformally grown via the epitaxial growth method on the (0001) face of a porousified 4H-SiC wafer [3]. Deuterium absorption is studied via Thermal Desorption Spectroscopy (TDS), exposing the samples to either atomic (D) or molecular (D_2) deuterium. Both hydrogen chemisorption and physisorption, and the morphology of the structure are investigated and related to their effect on hydrogen absorption [4]. In particular, we demonstrate that the three-dimensional graphene structures chemically bind atomic deuterium when exposed to D_2. This is the first report of such an event in un-functionalized graphene-based materials and implies the presence of a catalytic splitting mechanism. Moreover, we show that the three-dimensional dendritic structure of the material temporarily retains the desorbed molecules and causes a delayed emission. The capability of chemisorbing atoms after a catalytic splitting of deuterium, in conjunction with its large surface-to-volume ratio, make this material a promising substrate for hydrogen storage devices. In a further experiment, we for the first time succeeded to obtain the diffusion of metal nanoparticles inside the pores down to the bottom of the porous layer. Thus, the investigation of metal functionalization of this three-dimensional structure is underway. [1] J. W. Ager and A. A. Lapkin, Science 2018, **360**, 707–708.[2] M. Mohan et al., Energy Storage 2019, **1**, e35.[3] S. Veronesi et al., Carbon 2022, **189**, 210–218.[4] A. Macili et al., Applied Surface Science 2023, **615**, 156375.