Hydrogen Storage on Graphene: an STM study

S. Goler[1,2], C. Coletti[2], V. Tozzini[1], V. Piazza[2], T. Mashoff[2], M. Takamura[3], S. Tanabe[3], H. Hibino[3], F. Beltram[1,2], V. Pellegrini[1], and S. Heun[1]

[1] NEST, Istituto Nanoscienze – CNR and Scuola Normale Superiore, Piazza San Silvestro 12, 56127 Pisa, Italy
[2] Center for Nanotechnology Innovation @ NEST, Istituto Italiano di Tecnologia, Piazza San Silvestro 12, 56127 Pisa, Italy
[3] NTT Basic Research Laboratories, NTT Corporation, 3-1, Morinosato Wakamiya, Atsugi, Kanagawa 243-0198, Japan

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The realization of innovative hydrogen storage materials has worldwide strategic importance. In this context, graphene has recently attracted attention as a promising hydrogen storage medium. Indeed, graphene is lightweight, chemically stable, and exhibits attractive physico-chemical properties for hydrogen adsorption. Furthermore, the interaction between hydrogen and graphene can be controlled by chemical functionalization. However, experimental demonstrations of graphene-based hydrogen storage devices have yet to be reported.

The energetics of the chemisorption of hydrogen on graphene can be modified by the local curvature of the graphene sheet [1]. Based on scanning tunneling microscopy (STM) techniques, we report on site-selective adsorption of atomic hydrogen on convexly warped regions of monolayer graphene grown on SiC(0001). This system exhibits an intrinsic curvature owing to the interaction with the substrate [2]. We show that at low coverage hydrogen is found on convex areas of the graphene lattice. No hydrogen is detected on concave regions. These findings are in agreement with theoretical models which suggest that both binding energy and adsorption barrier can be tuned by controlling the local curvature of the graphene lattice [1]. This curvature-dependence combined with the known graphene flexibility may be exploited for storage and controlled release of hydrogen at room temperature.

Theoretical studies regarding metal atoms (e.g. Ti) deposited on graphene suggest that such materials can adsorb up to 8 wt% gravimetric density of hydrogen. We investigated the deposition of titanium on graphene and its potential for hydrogen storage. As shown in Fig. 1a, the titanium atoms form small islands (diameter ~ 10 nm). The Ti-covered graphene was exposed to molecular hydrogen (5 min at $1x10^{-7}$ mbar deuterium). The sample temperature was then increased up to 550ºC with a constant heating rate of 10 K/s while measuring the mass-sensitive desorption. The desorption spectra show two peaks at 210ºC and 290ºC (see Fig. 1b). Their intensity increases with increasing Ti coverage. Our data demonstrate the stability of hydrogen binding at room temperature and show that the hydrogen desorbes at moderate temperatures – both ideally matching technical requirements for hydrogen storage.

References:
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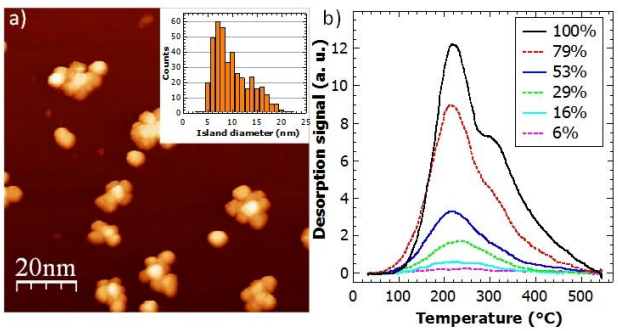

Fig. 1: a) 100 x 100 nm^2 UHV-STM image of a graphene surface with a titanium coverage of 16% (V = 2 V, I = 280 pA). The titanium atoms form small islands with a size distribution as shown in the inset. b) Desorption spectra measured for different coverages of titanium. The amount of stored hydrogen increases with Ti-coverage.