Electronic Supplementary Material

In-situ observations of novel single-atom thick 2D tin membranes embedded in graphene

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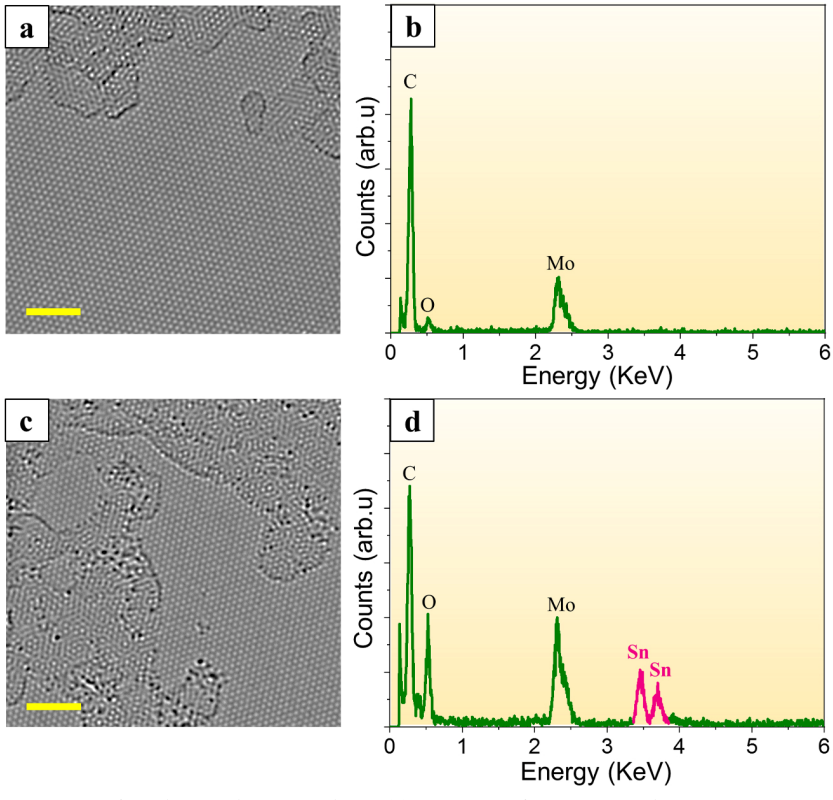

Figure S1 Analytical characterization of Sn deposited over graphene. (a) Overview of TEM image showing no Sn atoms on the pristine transferred graphene. (b) Overview of EDX analysis showing no Sn signal (The Mo signal is from the TEM grid). (c) Overview of TEM image showing Sn atoms decorated on the graphene (d) EDX spectrum showing clear Sn signal (red peak). All scale bars are 2 nm.

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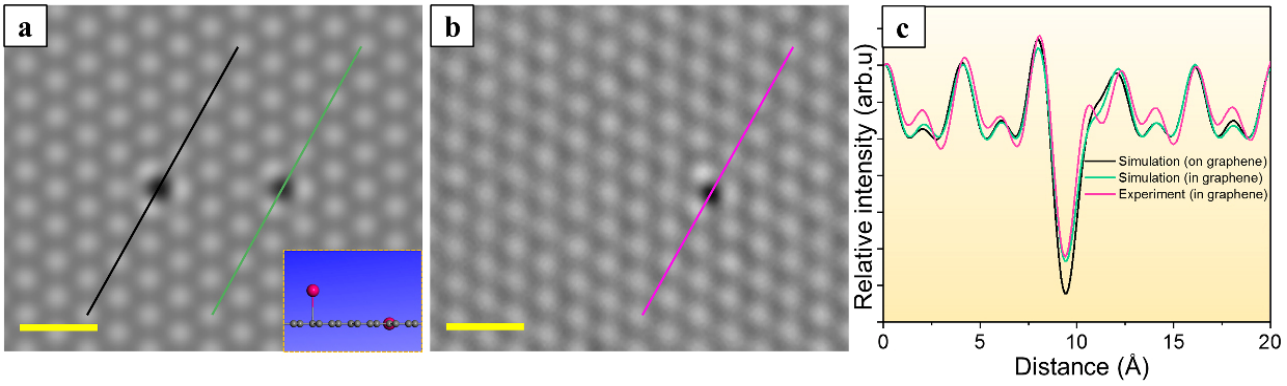

Figure S2 Relative intensity analysis for one atom on and in graphene. (a) Image simulation for atom on (left atom) and in (right atom) graphene, inset: side-view stick-and-ball model for the one-atom configuration. (b) Experimental TEM image for one Sn atom in graphene defect. (c) Comparison of the normalized relative contrast intensity profiles across Sn atom in the defect between the simulations and experiment. All scale bars are 5 Å.

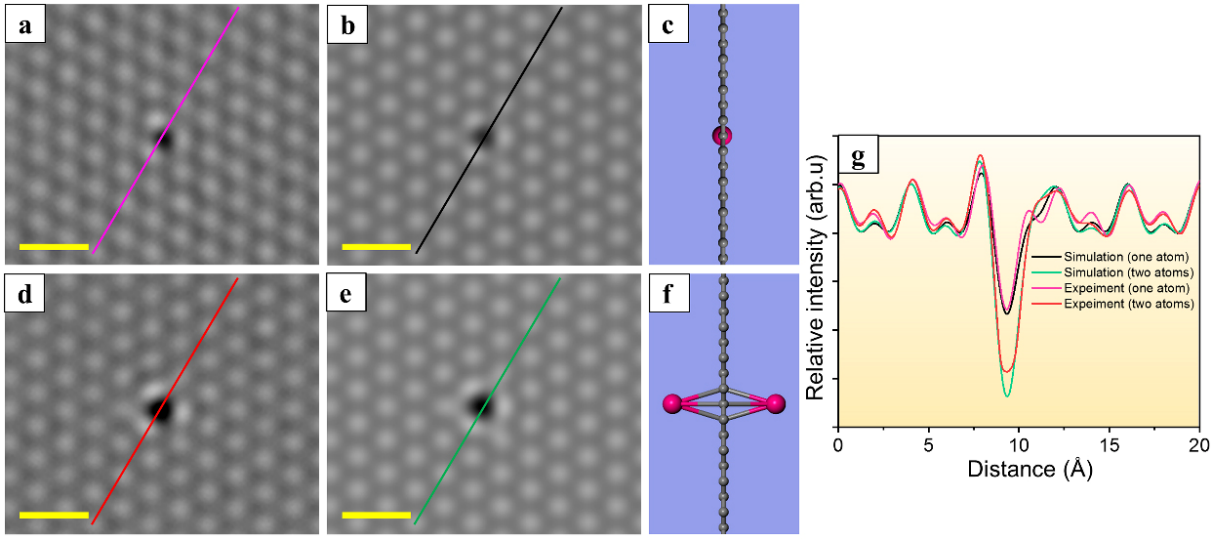

Figure S3 Relative intensity analysis for one atom and two atoms (one atom up and one atom down) embedded in graphene. (a–c) Experimental TEM image, image simulation and cross-section view of stick-and ball model for one Sn atom in graphene defect. (d–f) Experimental TEM image, image simulation and cross-section view of stick-and ball model for two Sn atoms in graphene defect. (g) Comparison of the normalized relative contrast intensity profiles across one and two Sn atoms in the defect between simulations and experiments. All scale bars are 5 Å.

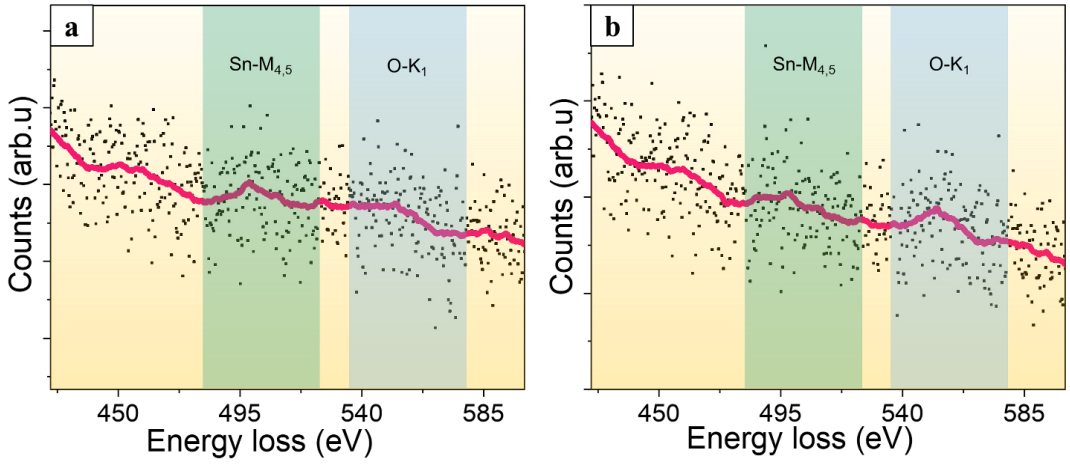

Figure S4 EELS core-level spectra acquired from two Sn cluster regions in graphene confirming the presence of Sn.

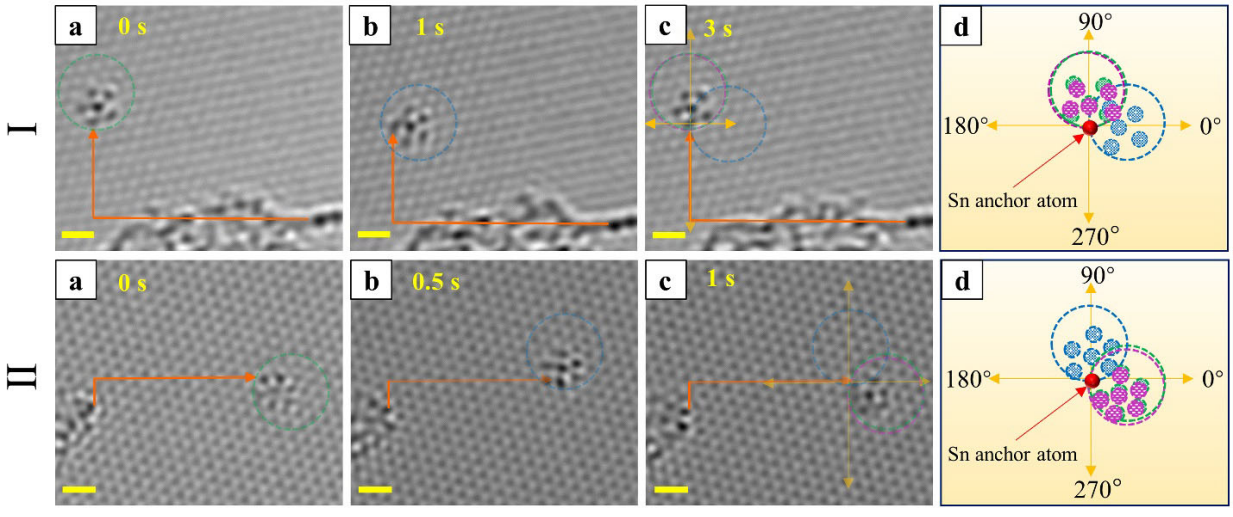

Figure S5 Dynamic behaviour of anchored planar star cluster on graphene. I (a–d), II (a–d) Sequences of HRTEM images show the flip/rotate activities. All scale bars are 5 Å.

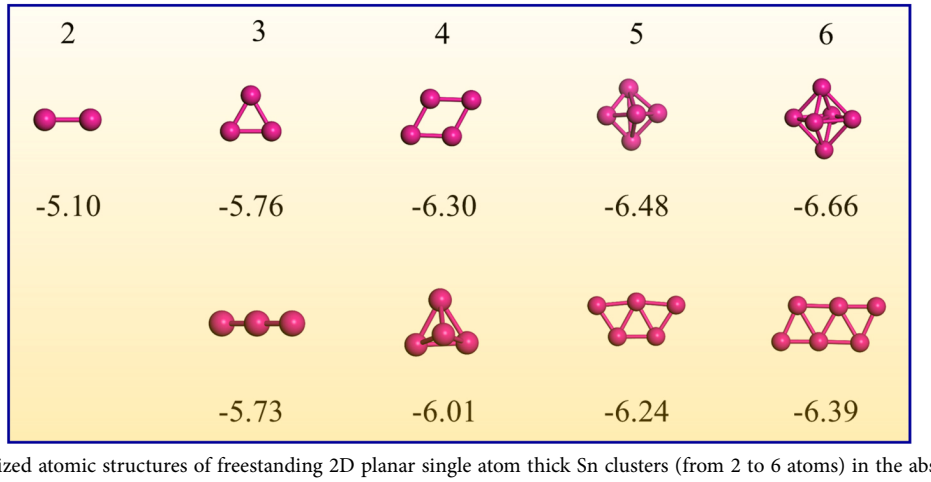

Figure S6 The optimized atomic structures of freestanding 2D planar single atom thick Sn clusters (from 2 to 6 atoms) in the absence of the graphene matrix. The numbers represent the corresponding cohesive energy in the units of eV per atom. The cohesive energy is obtained by a formula $E_{cohesive} = (E_{cluster} - E_{atom} \times n)/n$, where $E_{cluster}$ and E_{atom} are the total energy of Sn clusters and Sn atom, respectively.