Supporting Information: Electron-Beam Manipulation of Silicon Dopants in Graphene

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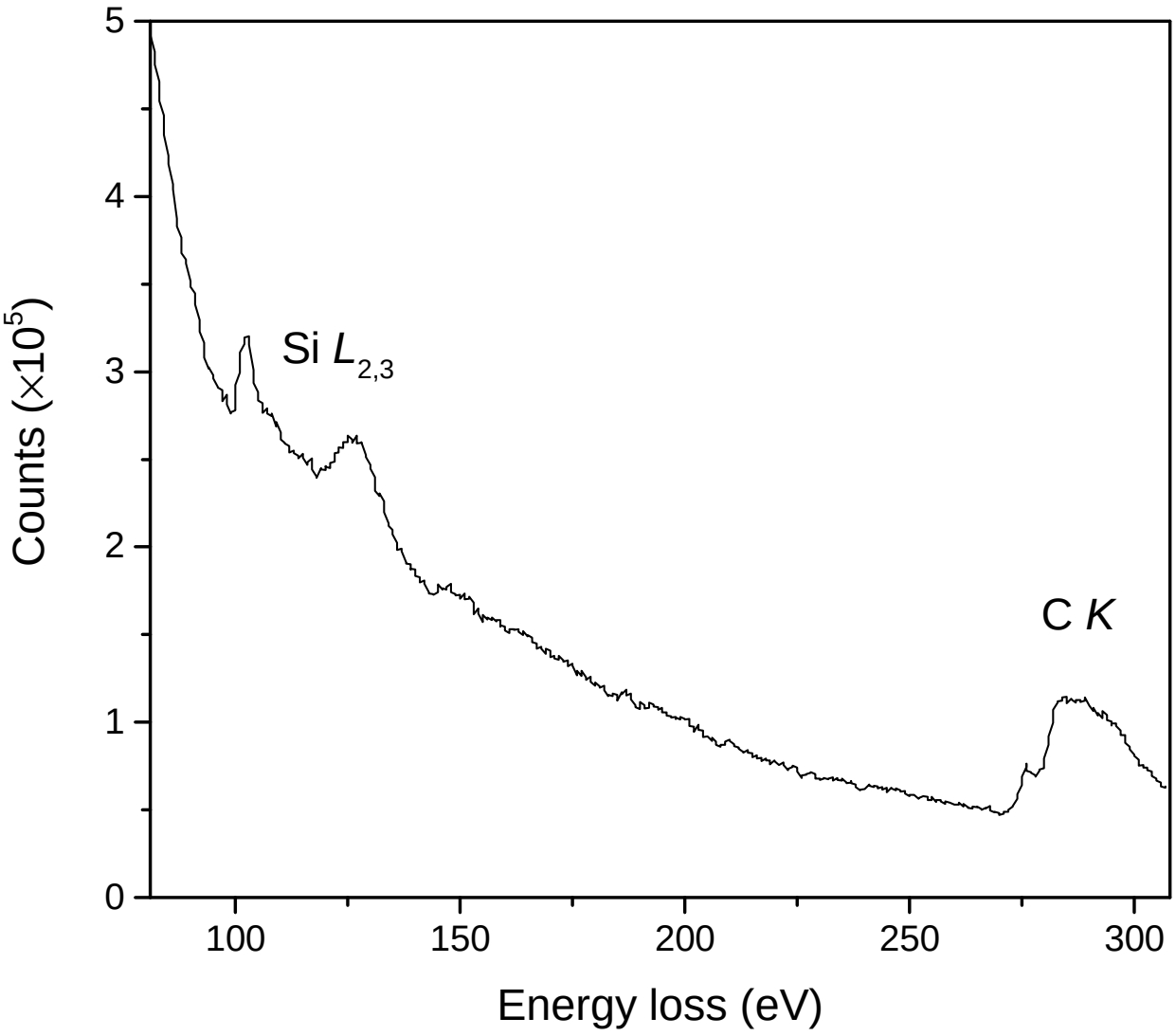

Figure S1: Electron energy loss spectrum measured at an acceleration voltage of 55 kV identifying a single Si impurity by its prominent $L_{2,3}$ response.

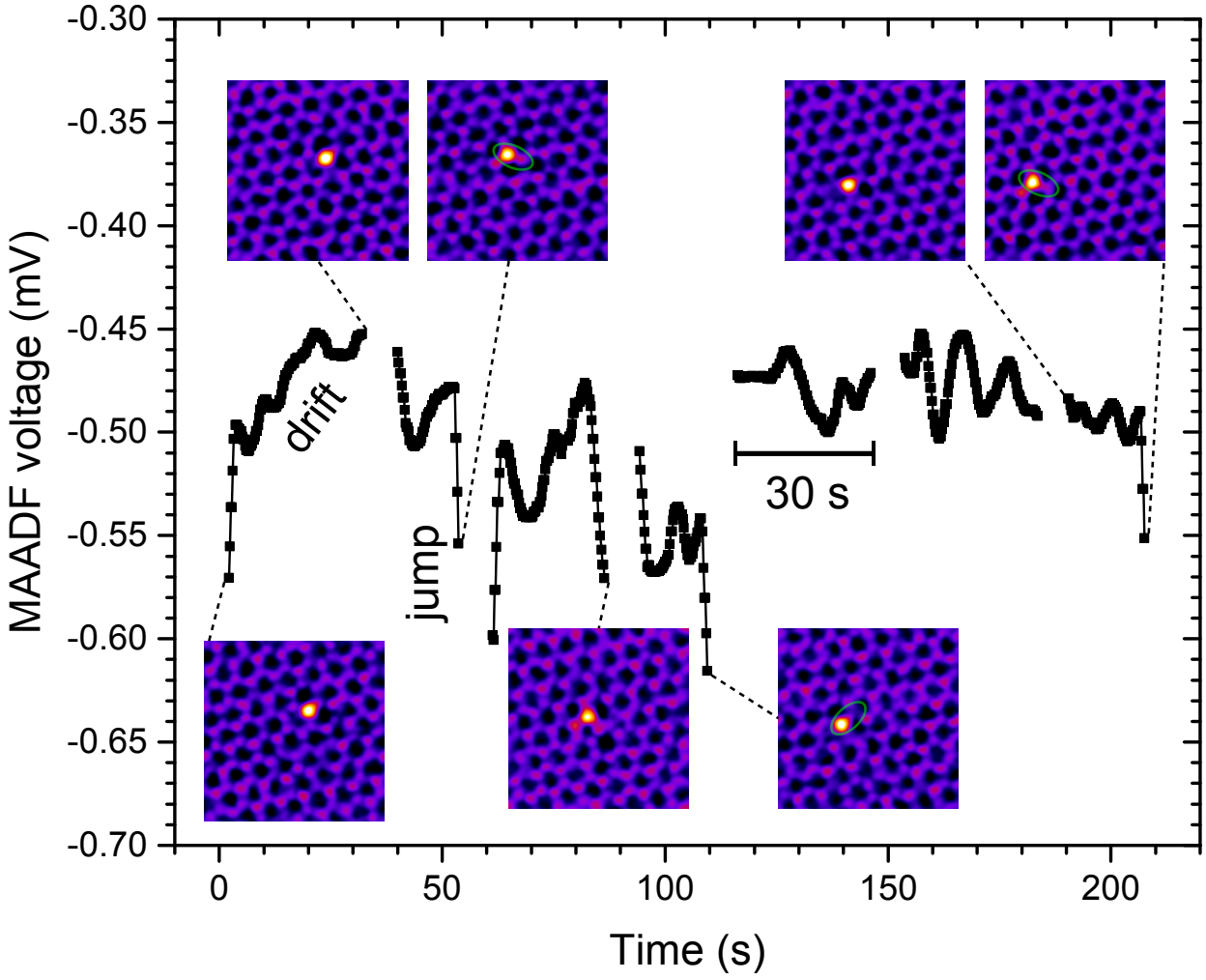

Figure S2: MAADF detector voltage read by a multimeter (each point averaged over 150 ms) and used to trigger new image frames. Jumps are detected as sudden drops in the voltage corresponding to greater scattering intensity due to the Si atom jumping under the beam, whereas gradual drift was accounted for by a 30 s timeout if no jump has been detected. The inset frames show Double Gaussian filtered MAADF images acquired between the feedback periods, with overlaid green ovals highlighting the Si jumps.

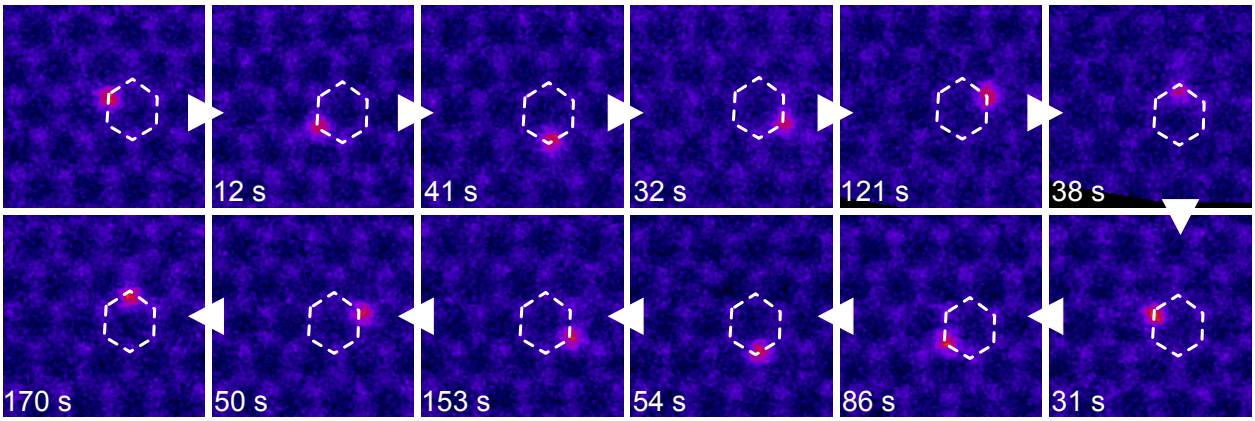

Figure S3: Consecutive STEM/MAADF frames recorded at 55 kV of a Si impurity manipulated around a graphene hexagon. The inset numbers indicate the number of seconds of spot irradiation between frames. (A Double Gaussian filtered, cropped and reordered version of this data appears as the TOC Figure of the main article.)

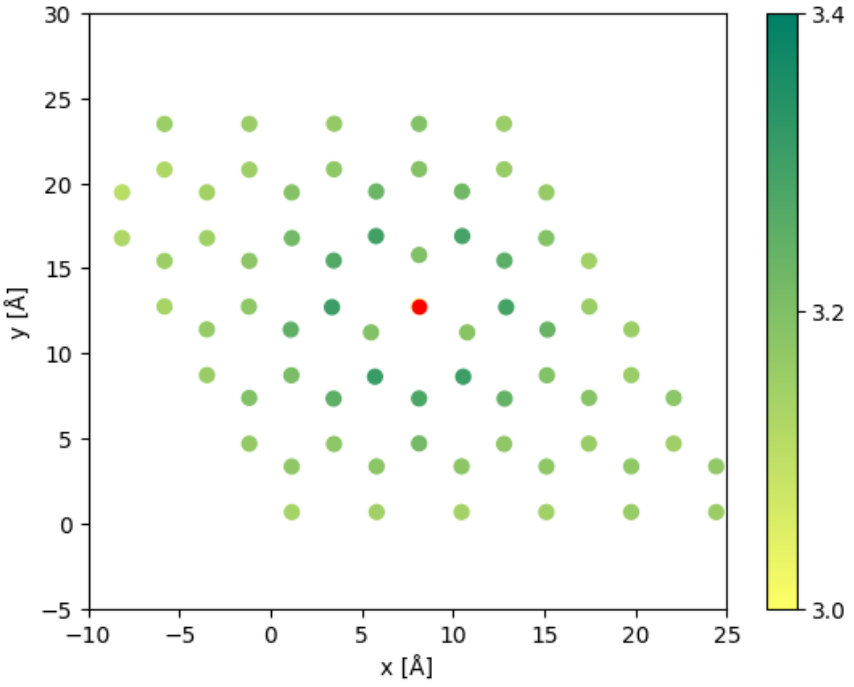

Figure S4: Calculated out-of-plane mean-square velocity for a single Si impurity in graphene, shown as the red dot. Colors of the remaining dots indicate the out-of-plane velocity in units of 10^5 m^2/s^2 on the carbon atoms with the maximum calculated velocity on the next-nearest neighbor carbon atoms to the Si impurity.