Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Integration of 3D Nanographene into Mesoporous Germanium

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S1. Raman spectra for Gr-MP-Ge synthesized at different temperatures

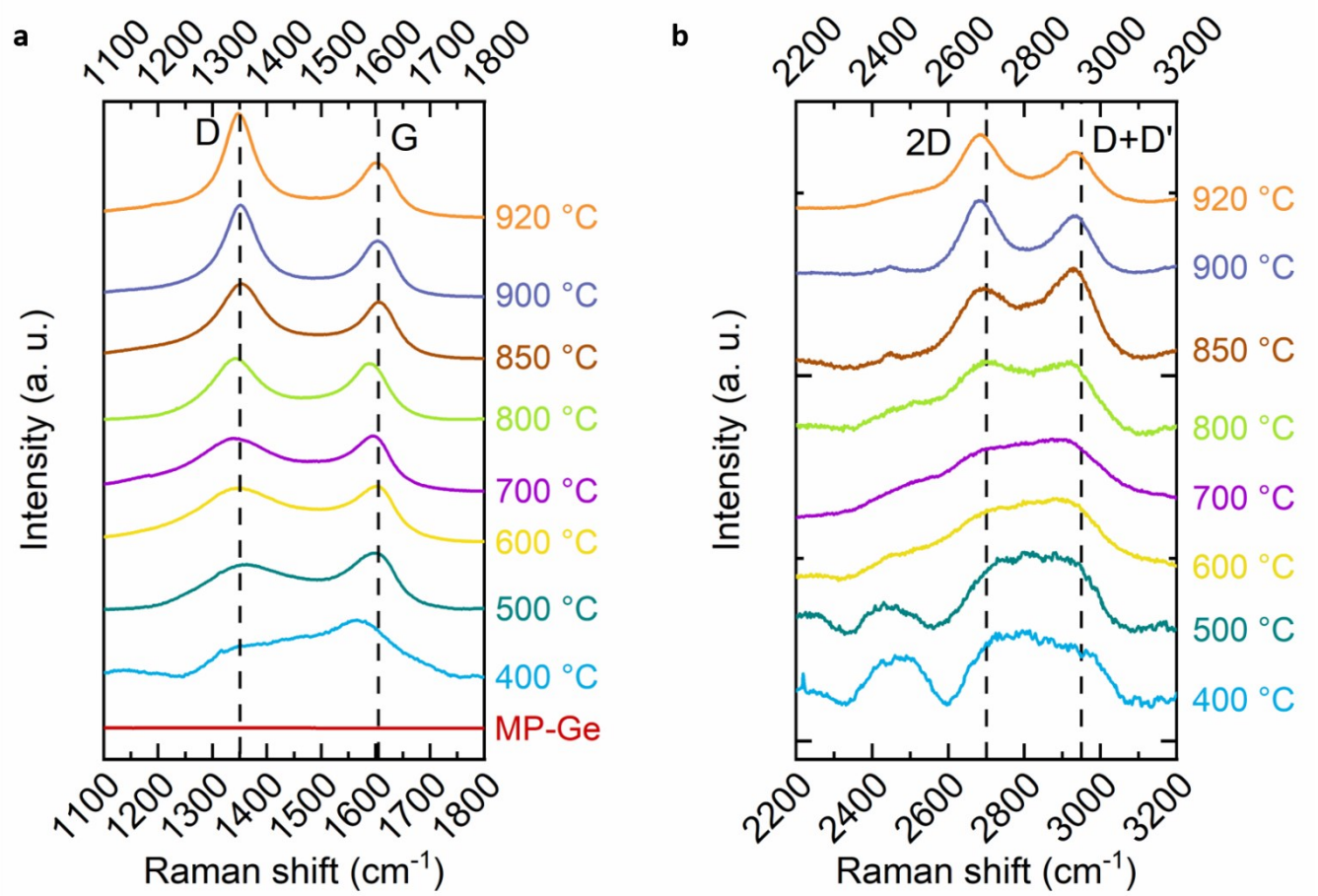


Figure S1 Normalized Raman spectra (λ_L = 532 nm) of mesoporous germanium (MP-Ge) and Graphene-Mesoporous Germanium (Gr-MP-Ge) at different carbonization temperatures related to the Graphene deposition (CVI). The red line at the bottom corresponds to the Raman spectrum of the MP-Ge sample that received no temperature treatment and no deposition of Graphene. Therefore, it is the reference sample for the study and no D-peak and G-peak were observed due to the absence of carbon. The temperature indicated on the graph is the carbonization temperature used. The peaks observed are related to the carbon deposition and not on the mesoporous structure of germanium.

All the spectra are normalized compared to the G peak for figure S1a and compared to 2D peak for the figure S1b. The figure S1a presents the D and G peaks region (from 1100 to 1800 cm^{-1}) and the figure S1b is a zoom of the 2D region from 2200 cm^{-1} to 3200 cm^{-1}. The offsets of the spectra are used for clarity.

(A color version of this figure can be viewed online)

S2. SEM images for Graphene-Mesoporous Germanium nanomaterial

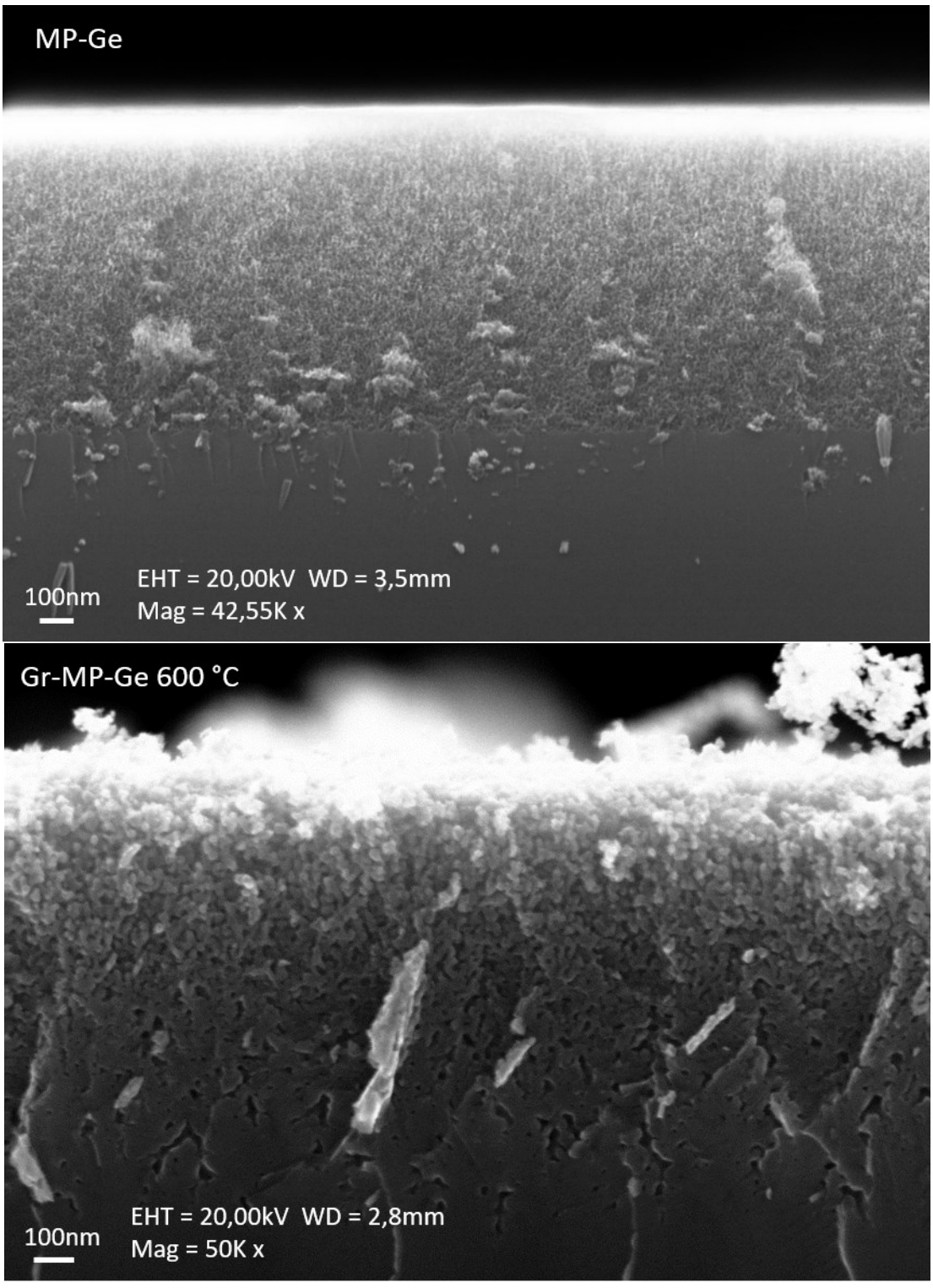


Figure S2 Cross-section SEM images for mesoporous germanium (MP-Ge) as prepared and Graphene-Mesoporous Germanium (Gr-MP-Ge) nanomaterial after carbonization treatment at 600 °C.

After carbonization treatment the mesoporous structure is modified with crystallite densified and thickness is reduced. However, the porous structure is maintained and lower temperature allows to reduce this effect.

S3. XPS spectra for C1s after different time of etching with Ar ions bombardment on Gr-MP-Ge 500 °C

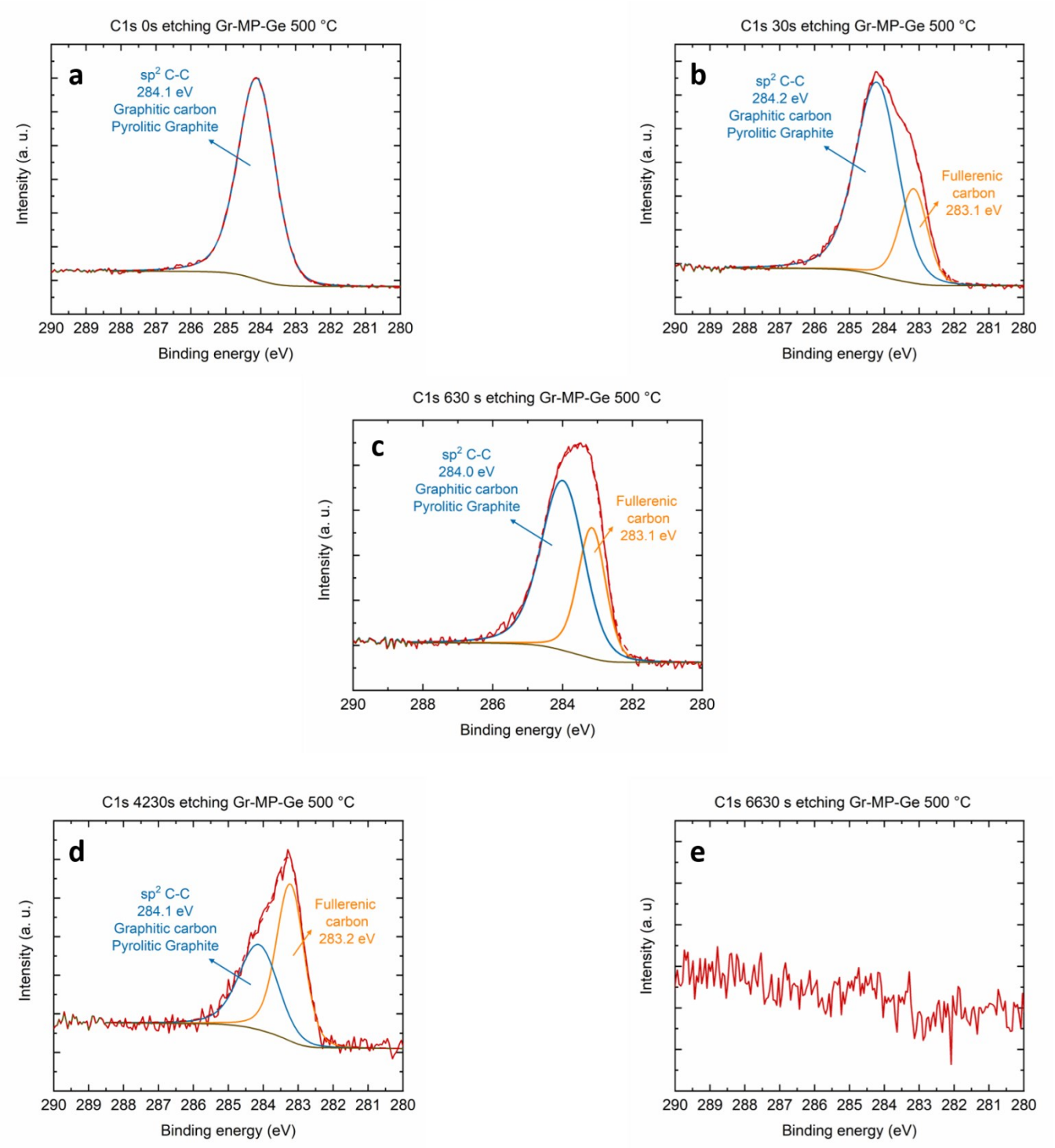


Figure S3 High-resolution XPS scans for carbon C1s at different etching time for Gr-MP-Ge sample treated at 500 °C, the etching time is calculated adding the previous time, for instance, 630 s it is first 30 s etching and then 600 s. Red line represents experimental data, dash red line the fit and colored lines the deconvoluted peaks.

(A color version of this figure can be viewed online)

S4. Modeling for different temperatures with C atoms precursors

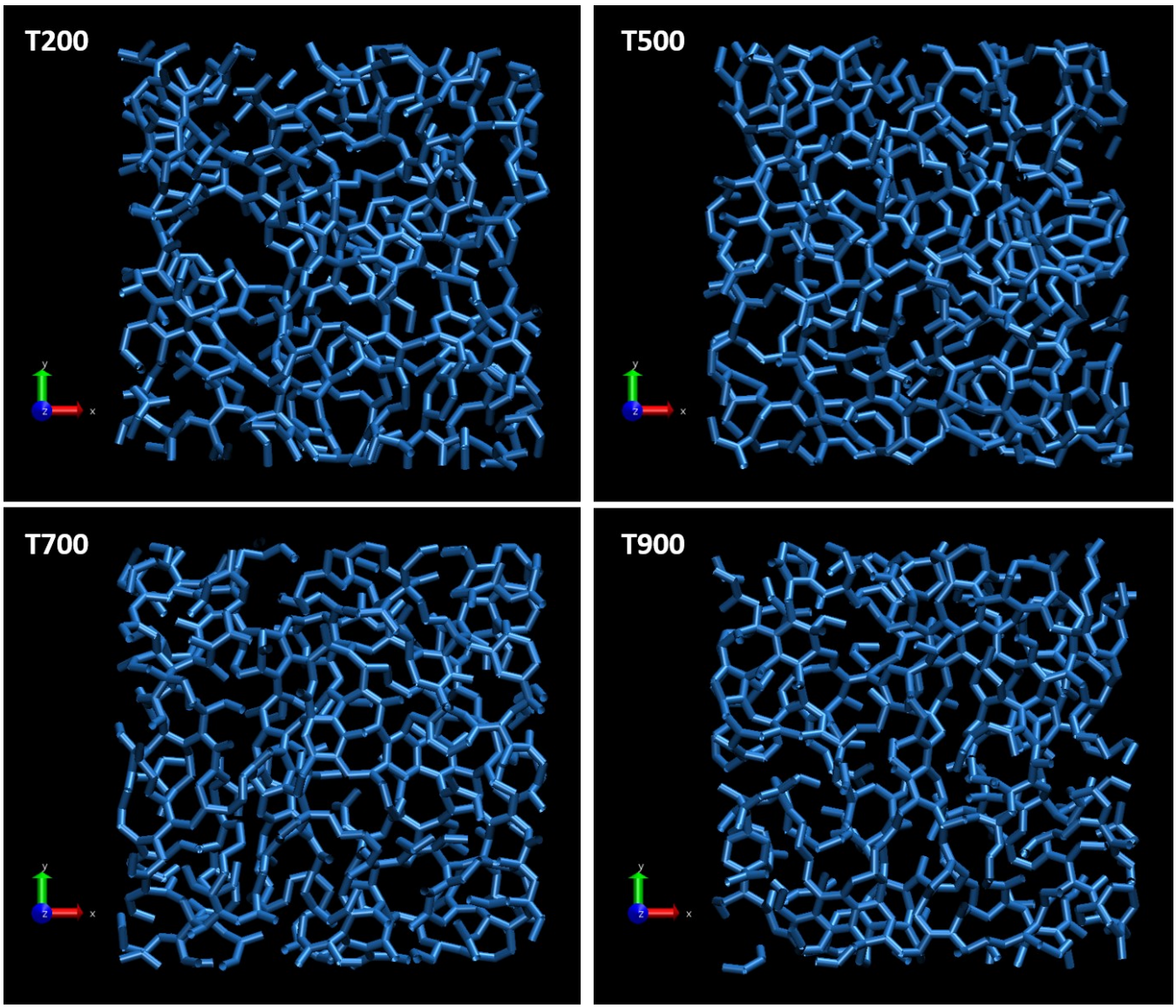


Figure S4 Snapshot for the top view for Molecular Dynamic Modeling for C atoms precursors at 200, 500, 700 and 900 °C for the growth on germanium substrate

Germanium substrate is not represented for further clarity; thus, only carbon-carbon bonds are represented.

(A color version of this figure can be viewed online, blue ticks are C-C bonds)

Molecular Dynamic Modeling with carbon atoms as precursors show graphene growth on germanium substrate. Only bonding between carbon is observed. Germanium and carbon have not covalent bonding each other.

S5. Modeling for different temperatures with C_2H radical precursors

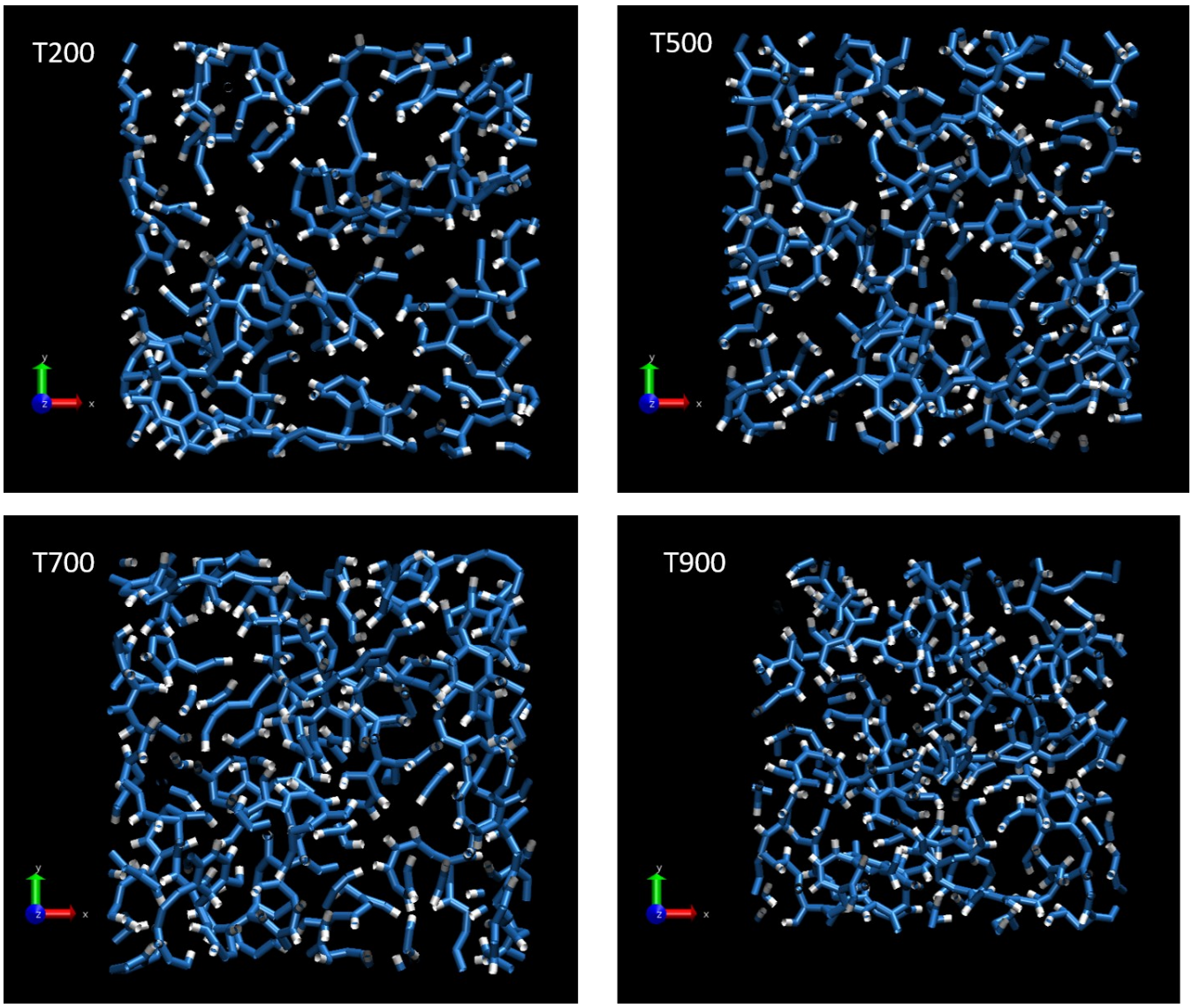
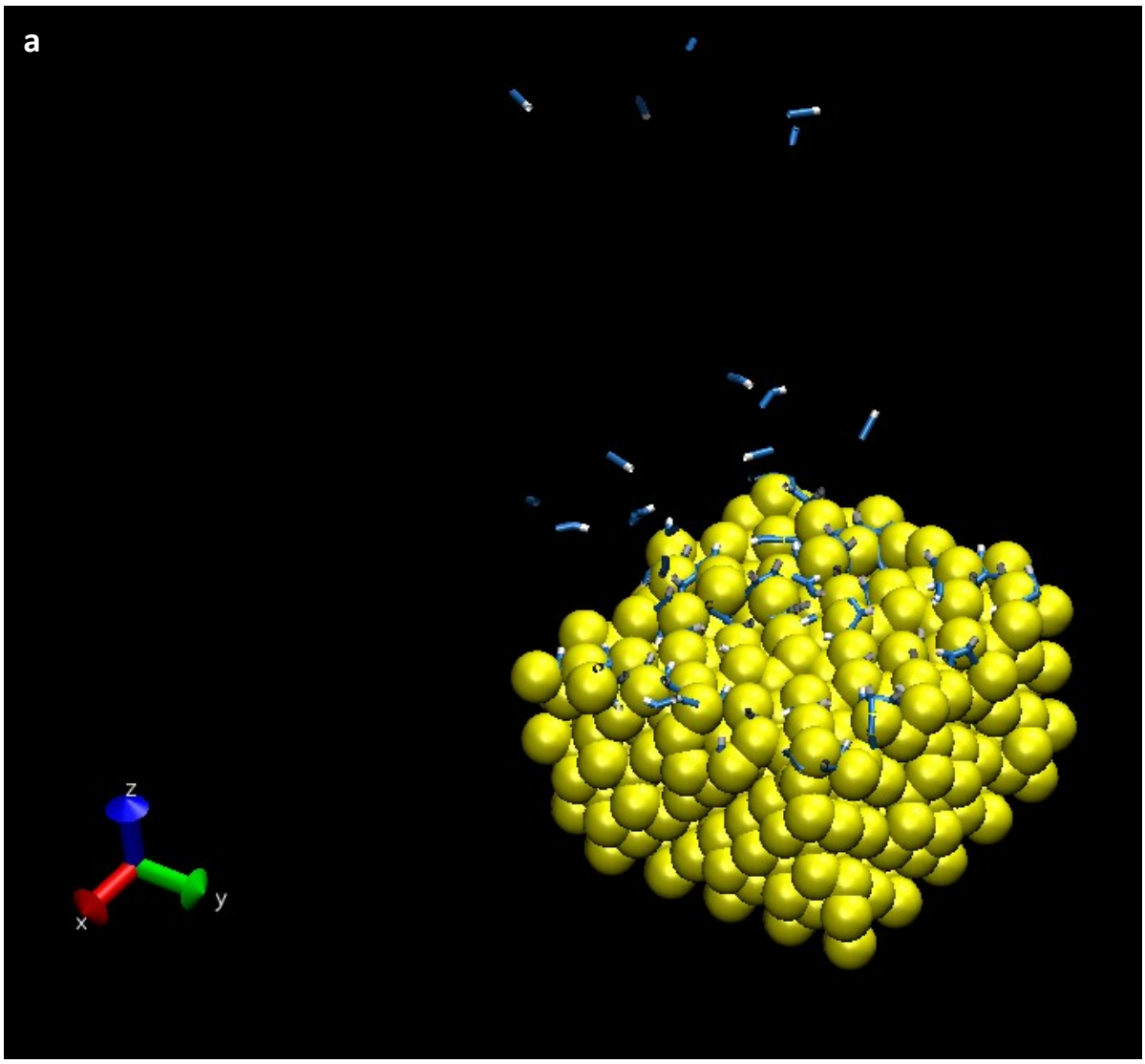


Figure S5 Snapshot for the top view for Molecular Dynamic Modeling for C_2H radical precursors at 200, 500, 700 and 900 °C for the growth on germanium substrate

Germanium substrate is not represented for further clarity; thus, only carbon-carbon and hydrogen-carbon bonds are represented.

(A color version of this figure can be viewed online, blue ticks are C-C bonds and blue-white ticks are C-H bonds)

S6. Molecular dynamic modeling with C_2H_2 and H_2 precursors at 500 °C



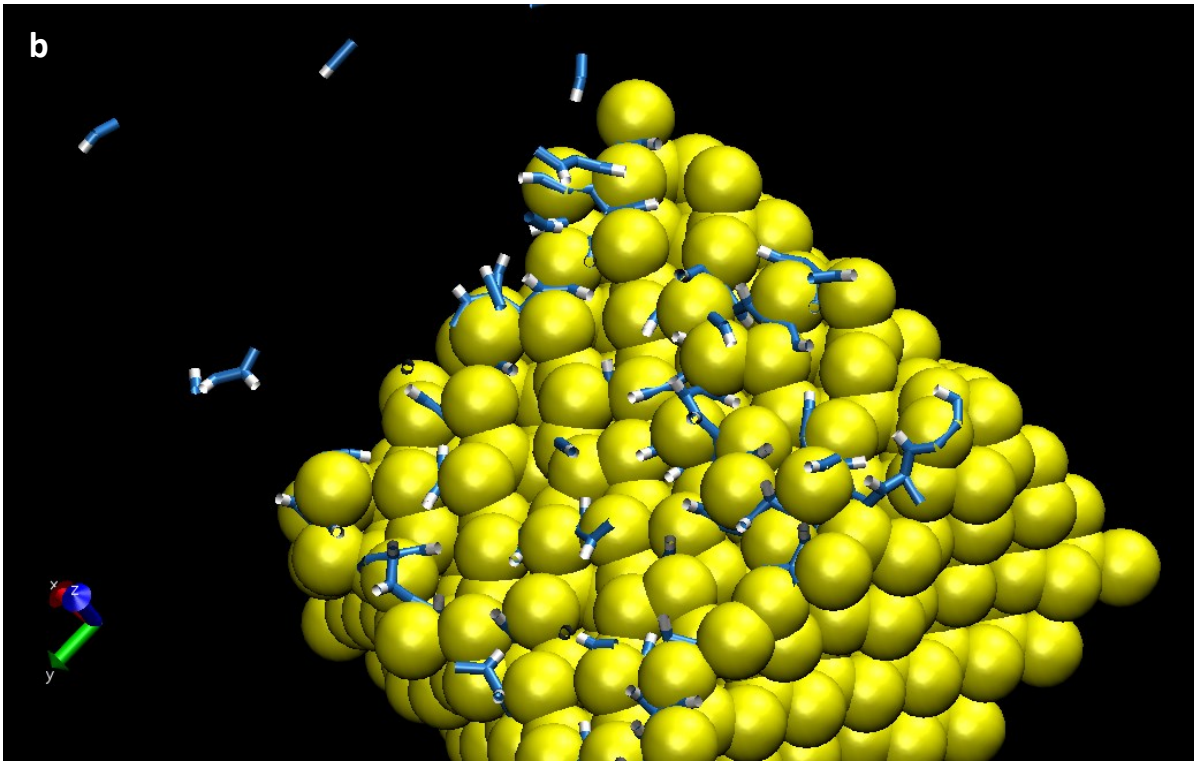


Figure S6 Snapshots for the top view for Molecular Dynamic Modeling for C_2H_2 and H_2 precursors at 500 °C for the growth on germanium substrate presenting C_2H radicals in vapor phase, larger molecules are present adsorbed on the surface of germanium.

(A color version of this figure can be viewed online, yellow spheres represents germanium substrate, blue ticks are C-C bonds and blue-white ticks are C-H bonds)