

Supplementary information: Cryo-Focused Ion Beam Induced Deposition of tungsten-carbon nanostructures using a thermoelectric plate

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Compositional characterization

As described in the main text, the compositional characterization of the samples was carried out by EDX in a SEM microscope. In SEM-EDX, the retrieved X-rays are not necessarily emitted from the material under study only, but from the interaction volume of the focused electron beam with the sample, which can extend to the substrate.

For the study at hand, since the K emission line of W is found at approximately 1.7 keV, it does require the usage of higher acceleration voltages for the focused electron beam to properly retrieve a significant amount of counts coming from that line. With Cryo-FIBID deposits showing an already reduced thickness, and the electron interaction volume unavoidably extending to the underlying SiO₂ layer in the substrate, the EDX quantification is thus performed taking into account substrate contributions (Table S1)

Ion dose	W (atomic %)	C (atomic %)	O (atomic %)	Si (atomic %)
10 $\mu\text{C}/\text{cm}^2$	3.7 ± 0.6	8.7 ± 0.8	61.6 ± 1.5	25.9 ± 1.9
50 $\mu\text{C}/\text{cm}^2$	9.0 ± 0.9	13.5 ± 0.7	55.1 ± 0.5	22.3 ± 1.4
100 $\mu\text{C}/\text{cm}^2$	11.0 ± 0.4	15.4 ± 0.7	53.0 ± 0.5	20.6 ± 0.7
200 $\mu\text{C}/\text{cm}^2$	13.1 ± 0.4	17.1 ± 1.8	50.7 ± 1.8	19.1 ± 1.0
500 $\mu\text{C}/\text{cm}^2$	14.6 ± 0.5	18.3 ± 1.9	49.3 ± 0.1	17.8 ± 1.6

Table S1. EDX quantification of the interaction volume with statistical uncertainty extracted from three independent samples.

Although a precise quantification of the metallic amount of W may not be obtained from this study only, it is possible to make an estimation by stoichiometrically subtracting the oxygen contribution to the analysis arising from the SiO₂ substrate, and normalizing the remaining contributions (Figure S1).

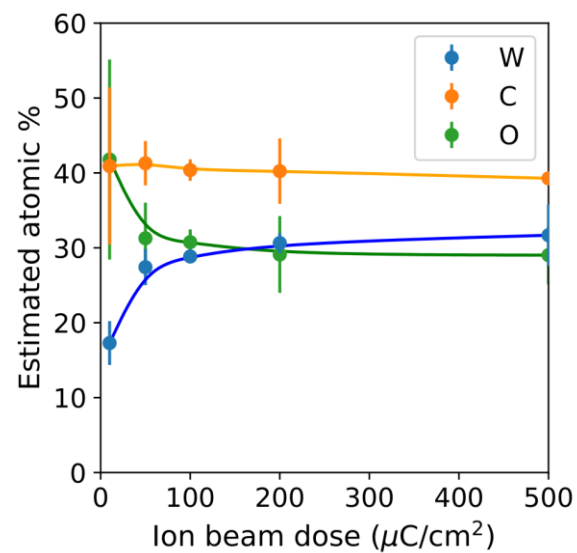


Figure S1. Estimated dependence of the composition with the ion dose, extracted from stoichiometric subtraction of substrate contribution. Solid lines are a guide for the eye. Error bars indicate the statistical deviation in the results from three sets of independent samples.