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Epitaxial and Large Area Sb_2Te_3 Thin Films on Silicon by MOCVD

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Supplementary Information

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1. SEM Images

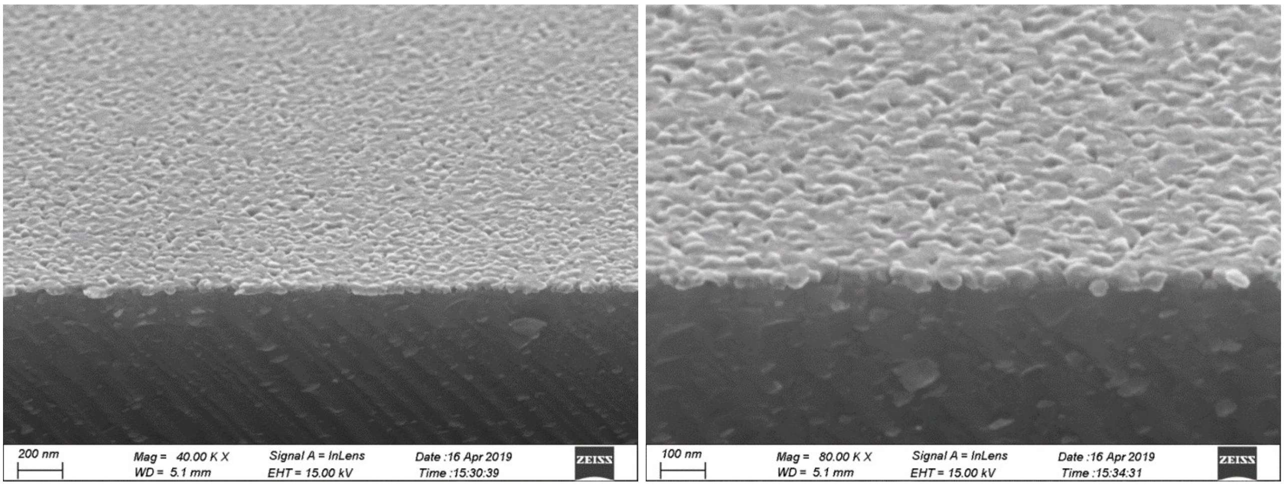

Figure S1. Tilted cross-section SEM images of Sb_2Te_3 - *As Deposited* (**1**) films.

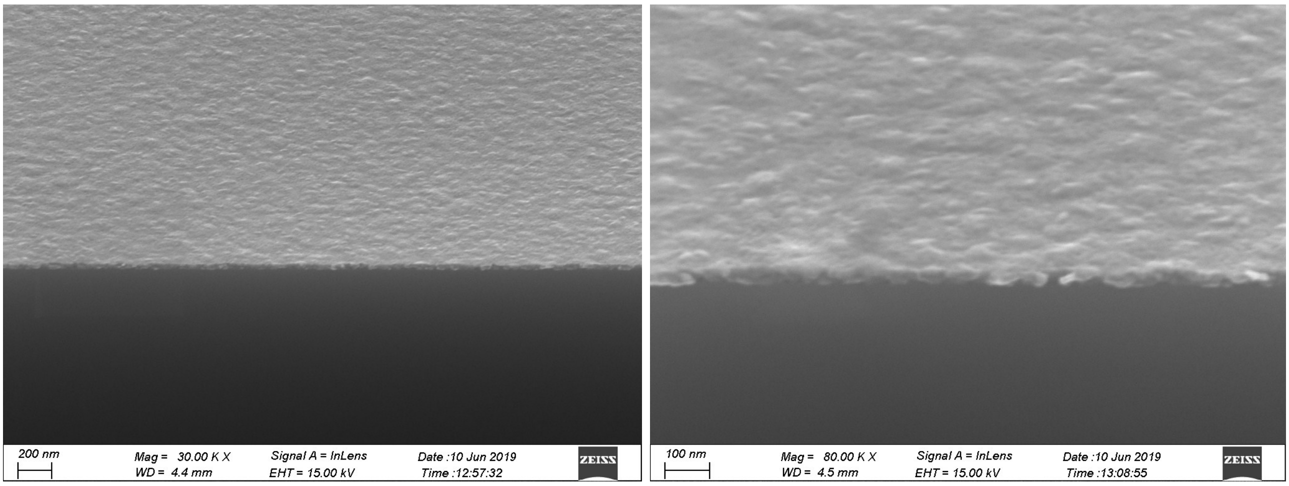

Figure S2. Tilted cross-section SEM images of Sb_2Te_3 - *Substrate Annealing* (**2**) films.

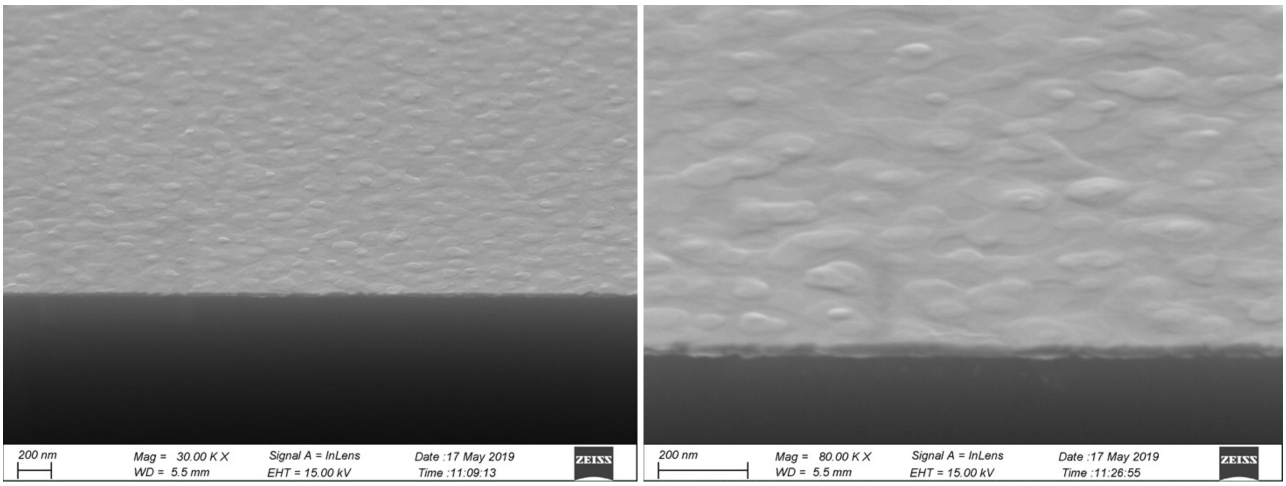

Figure S3. Tilted cross-section SEM images of Sb_2Te_3 - *Post-Growth Annealing* (**3**) films.

2. AFM Images

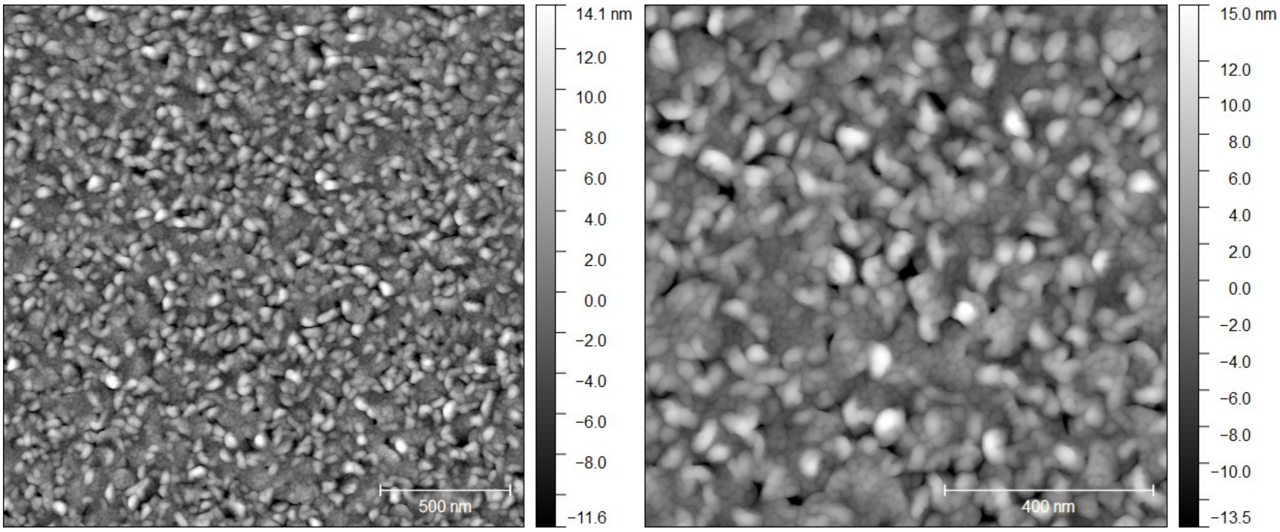

Figure S4. AFM images of Sb_2Te_3 - *As Deposited* (**1**) films.

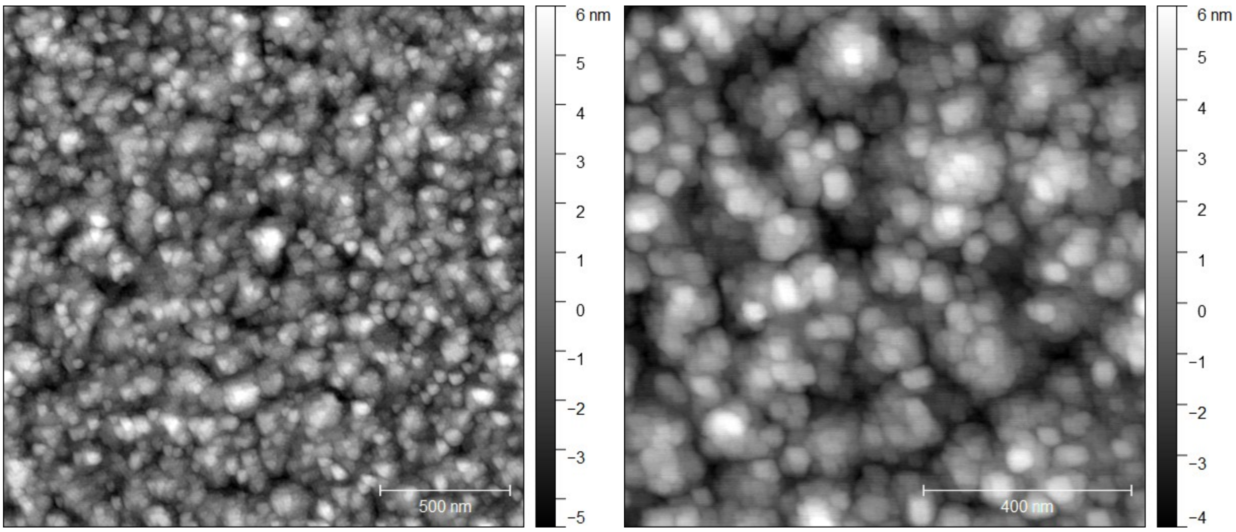

Figure S5. AFM images of Sb_2Te_3 - *Substrate Annealing* (**2**) films.

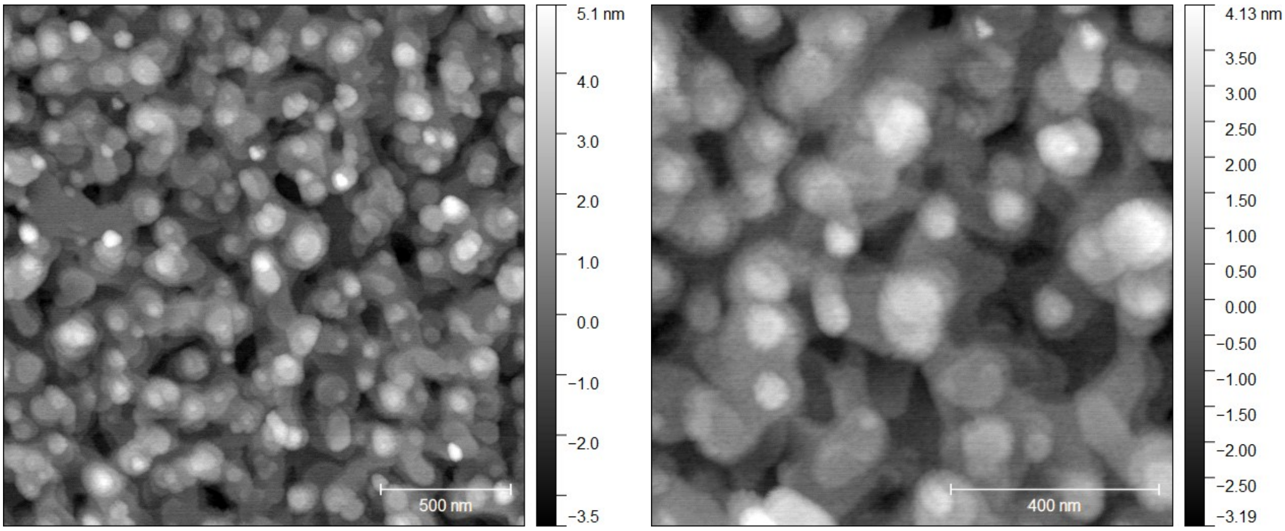

Figure S6. AFM images of Sb_2Te_3 - *Post-Growth Annealing* (**3**) films.

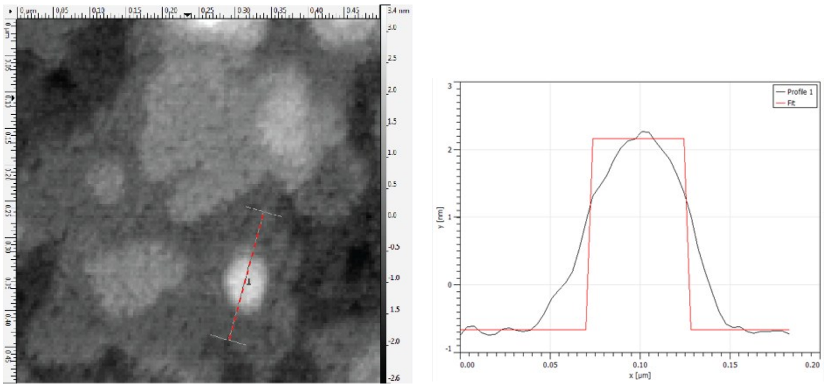

Figure S7. Selected surface profile of Sb_2Te_3 - *Post-Growth Annealing* (**3**); Step height: 3 nm.

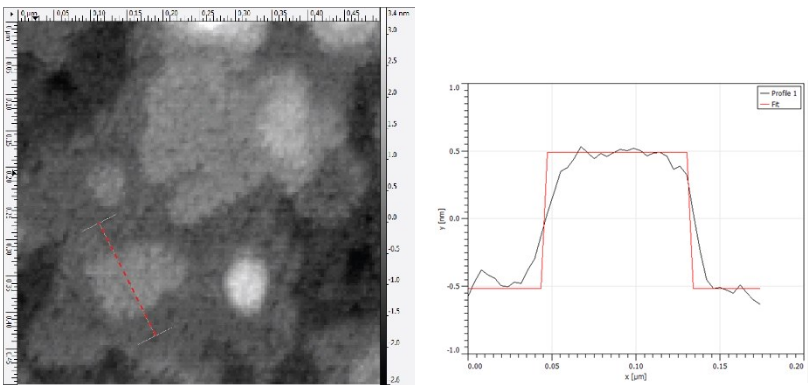

Figure S8. Selected surface profile of Sb_2Te_3 - *Post-Growth Annealing* (**3**); Step height: 1 nm.

3. TEM Images

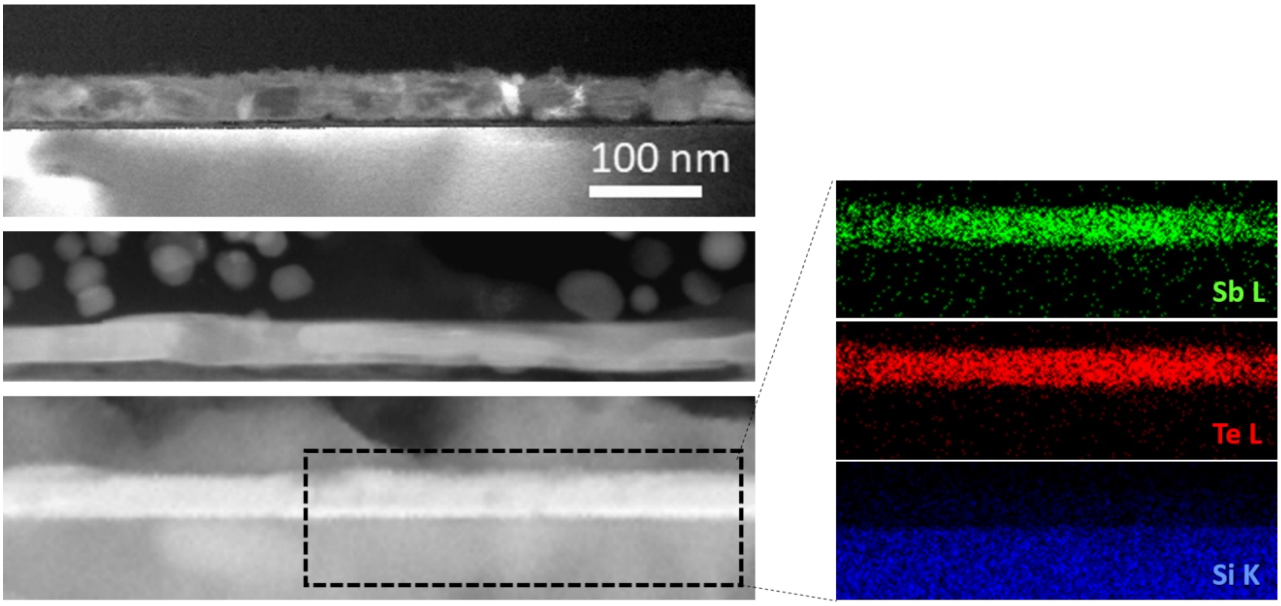

Figure S9. On the left, the STEM-HAADF images of the three different Sb_2Te_3 sample topology are reported for comparison: from the top, Sb_2Te_3 - *As Deposited* (**1**), Sb_2Te_3 - *Substrate Annealing* (**2**), and Sb_2Te_3 - *Post-Growth Annealing* (**3**). On the right, the EDX elemental maps obtained from the dashed square region of the sample Sb_2Te_3 - *Post-Growth Annealing* (**3**). Te and Sb are homogeneously distributed in the layer.

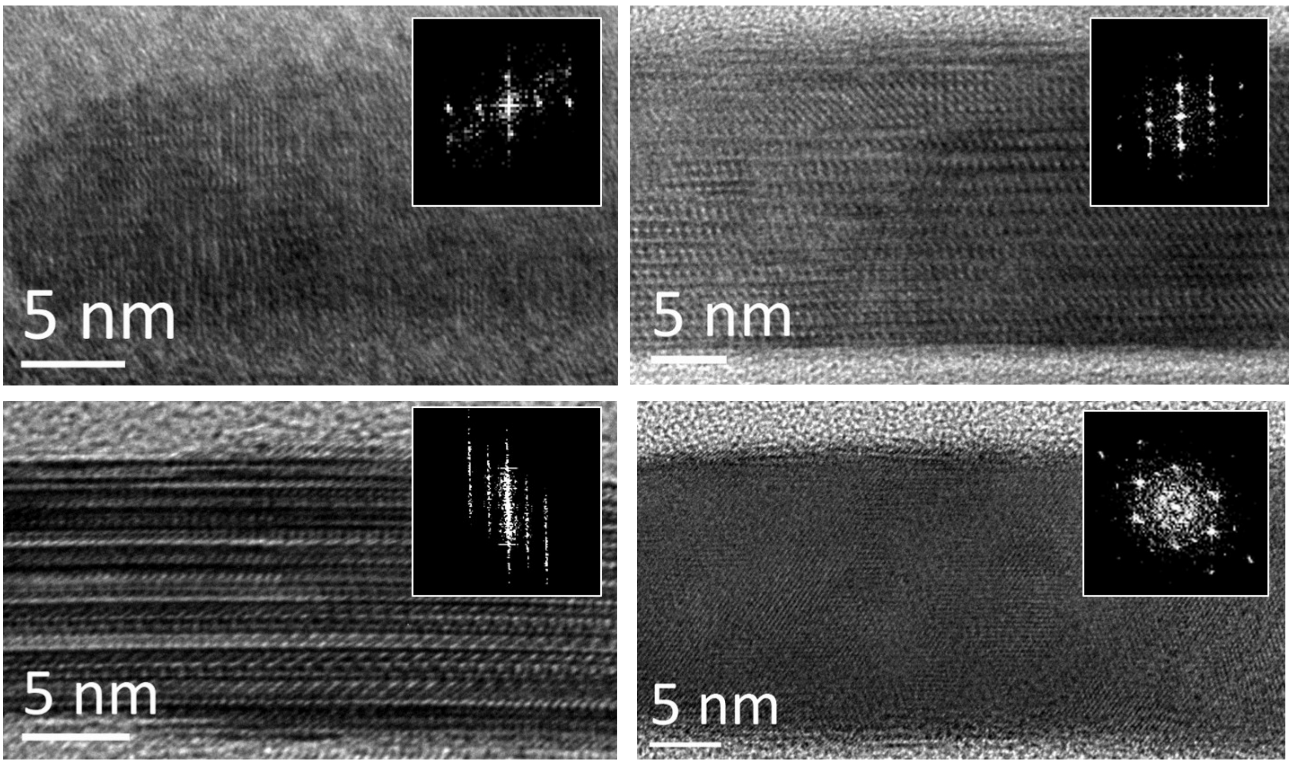

Figure S10. TEM images and related FFTs of Sb_2Te_3 - *Substrate Annealing* (**2**) films: examples of the variability in the crystallographic orientations of some different grains.

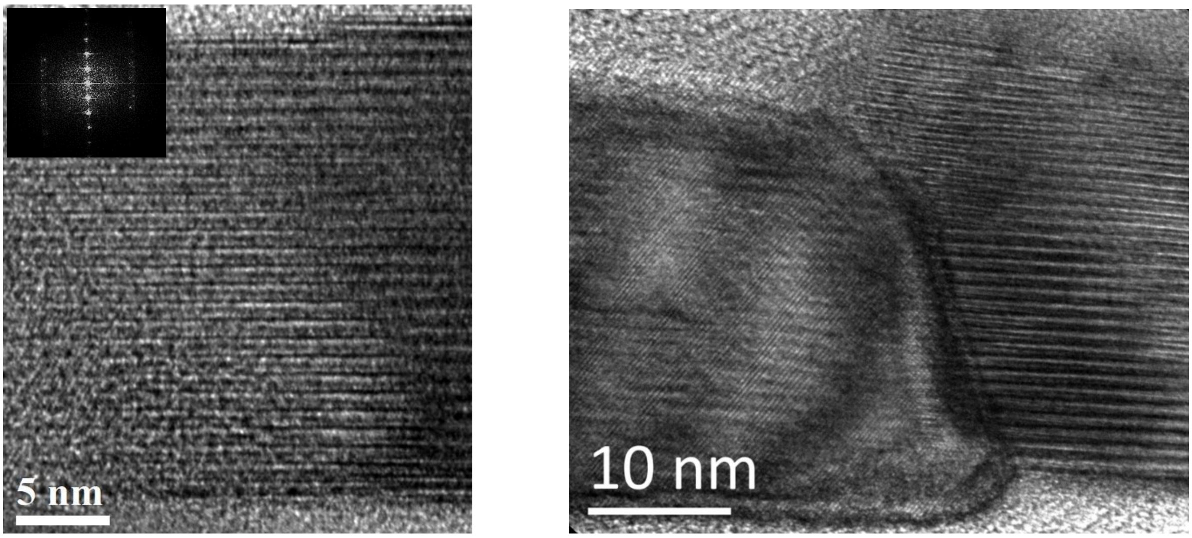

Figure S11. High resolution TEM images of Sb_2Te_3 - *Post-Growth Annealing* (**3**) film. Left: the quintuple stack of the Sb_2Te_3 rhombohedral crystalline structure (R -3m space group); the stacking period, measured from the FFT in the inset, is 1 nm. Right: the boundary between two grains.

4. TXRF Spectra

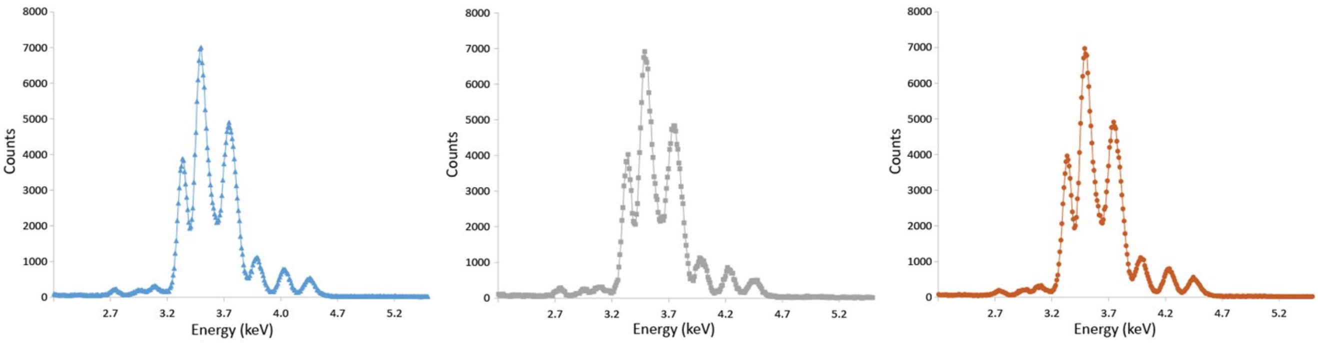

Figure S12. TXRF Spectra of Sb_2Te_3 - *As Deposited* (**1**) (blue, left), Sb_2Te_3 - *Substrate Annealing* (**2**) (grey, middle), and of Sb_2Te_3 - *Post-Growth Annealing* (**3**) (red, right).

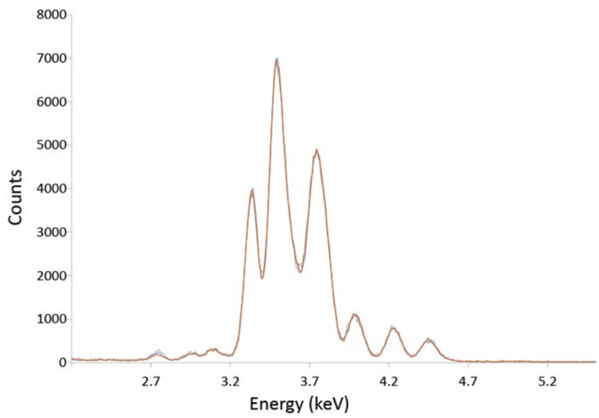

Figure S13. Overlap of the TXRF Spectra shown in Figure S12 indicating the same elemental composition in **1**, **2**, **3**.

5. XP Spectra

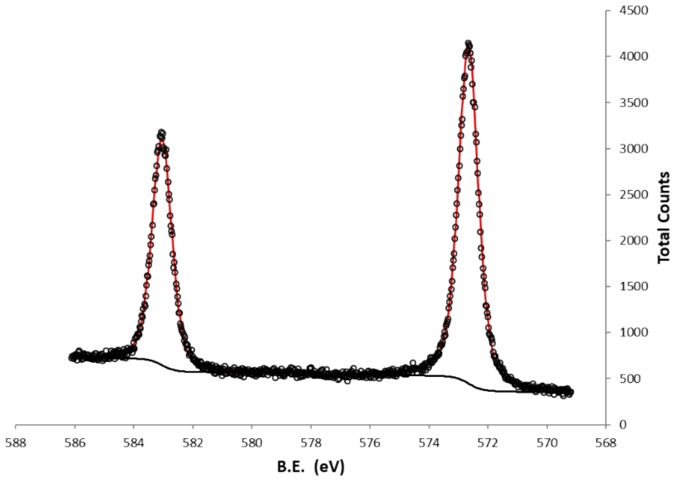

Figure S14. Te 3*d* XPS of Sb_2Te_3 - *As Deposited* (**1**). Te 3$d_{5/2}$: 572.6 eV (Δ = 10.4 eV).

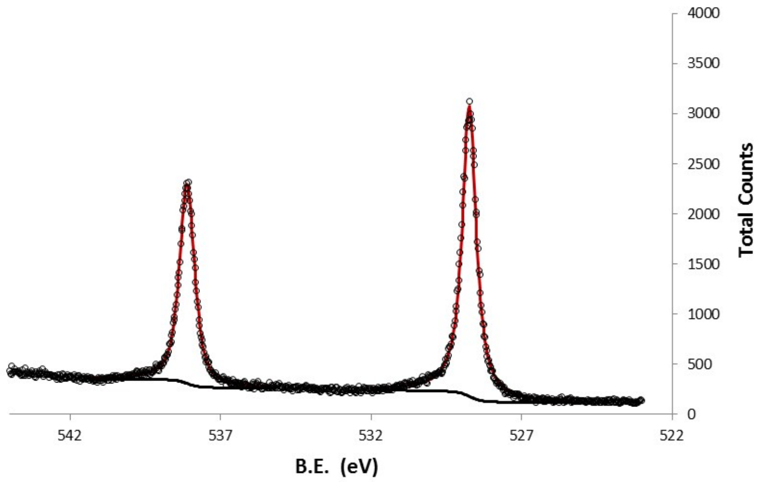

Figure S15. Sb 3*d* XPS of Sb_2Te_3 - *As Deposited* (**1**). Sb 3$d_{5/2}$: 529.0 eV (Δ = 9.35 eV).

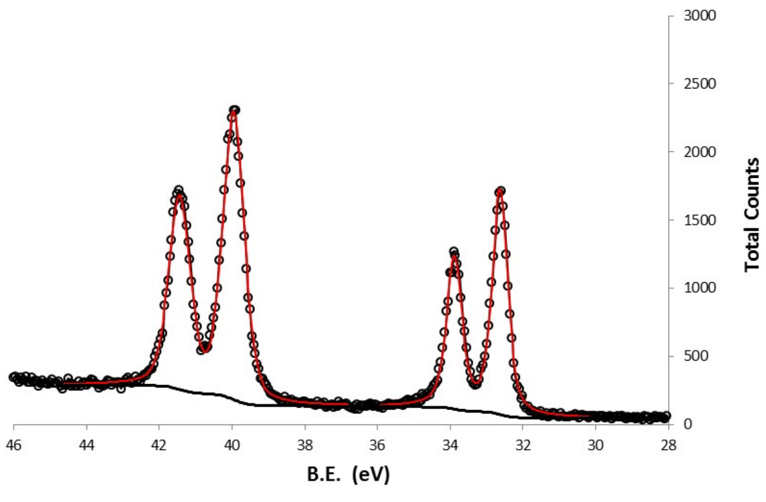

Figure S16. Te and Sb 4*d* XPS of Sb_2Te_3 - *As Deposited* (**1**). Te 4$d_{5/2}$: 40.2 eV (Δ = 1.5 eV); Sb 4$d_{5/2}$: 32.9 eV, (Δ = 1.2 eV).

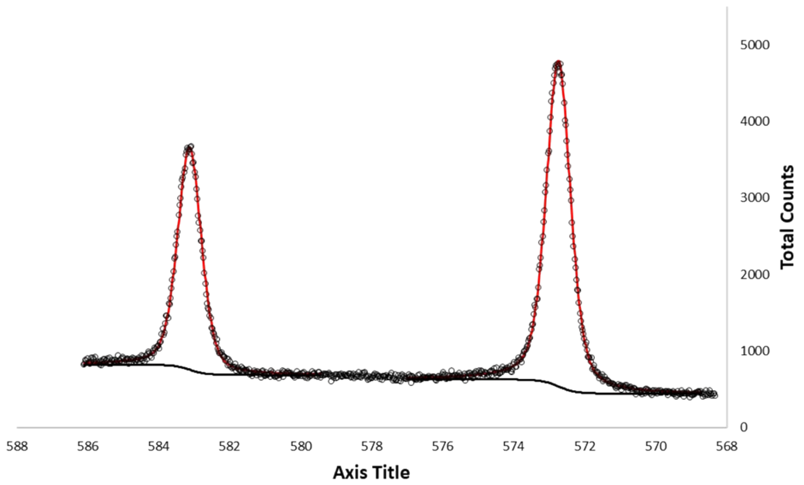

Figure S17. Te 3*d* XPS of Sb_2Te_3 - *Substrate Annealing* (**3**). Te 3$d_{5/2}$: 572.7 eV (Δ = 10.4 eV).

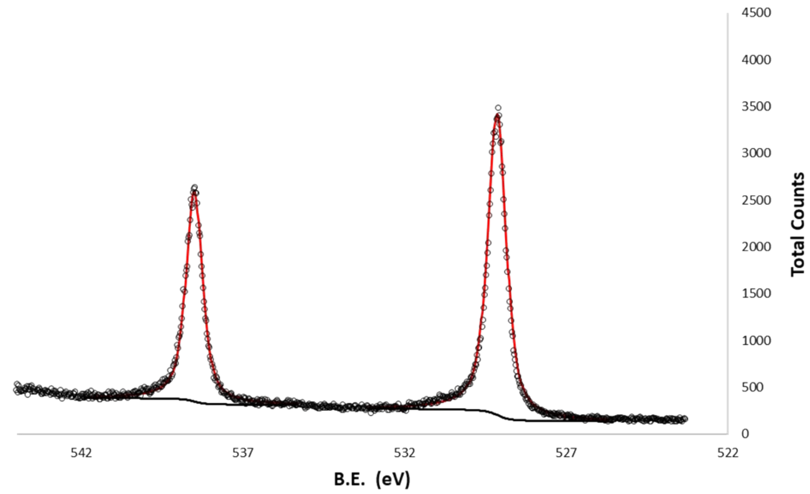

Figure S18. Sb 3*d* XPS of Sb_2Te_3 - *Substrate Annealing* (**3**). Sb 3$d_{5/2}$: 529.1 eV (Δ = 9.4 eV).

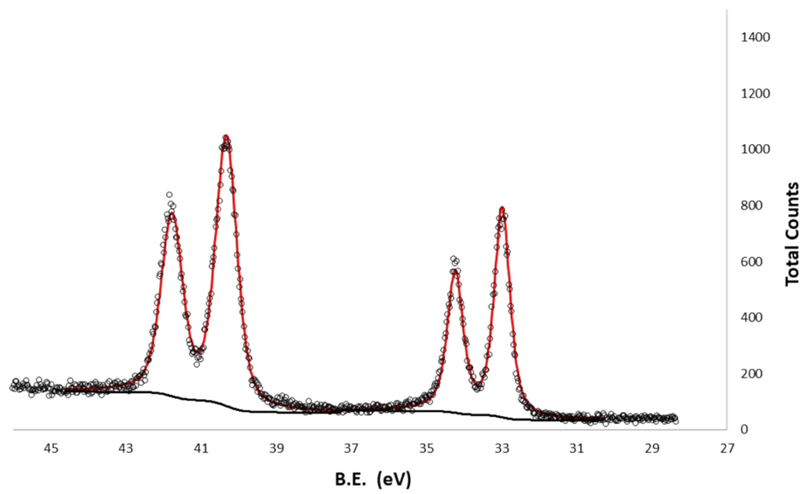

Figure S19. Te and Sb *4*d XPS of Sb_2Te_3 - *Substrate Annealing* (**3**). Te 4$d_{5/2}$: 40.3 eV (Δ = 1.5 eV); Sb 4$d_{5/2}$: 33.0 eV, (Δ = 1.3 eV).

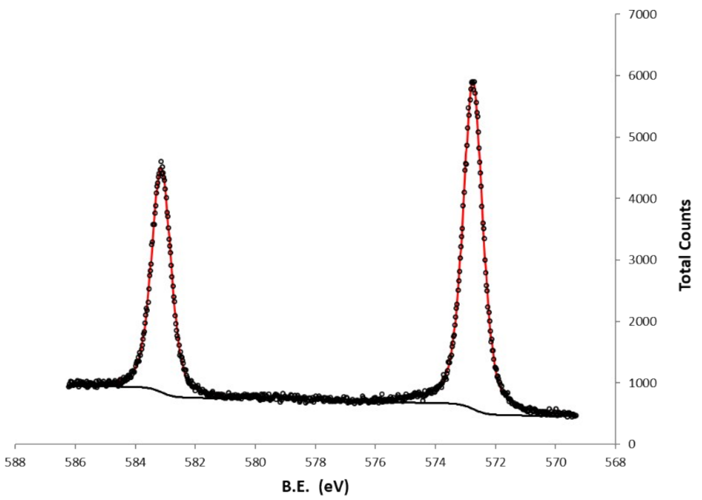

Figure S20. Te 3*d* XPS of Sb_2Te_3 - *Post-Growth Annealing* (**3**). Te 3$d_{5/2}$: 572.7 eV (Δ = 10.4 eV).

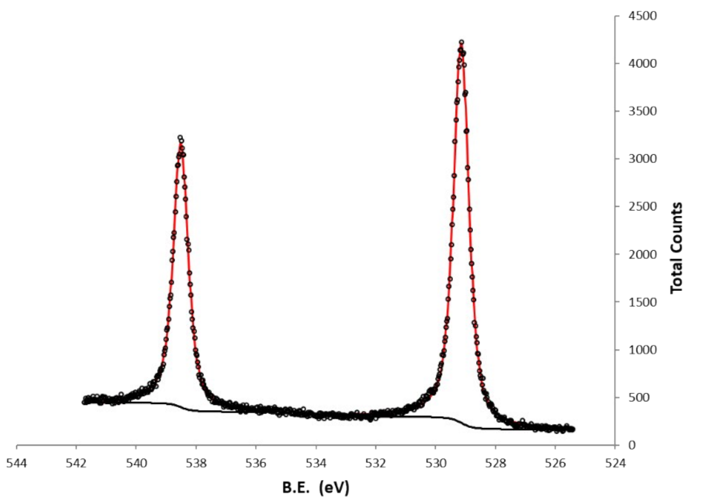

Figure S21. Sb 3*d* XPS of Sb_2Te_3 - *Post-Growth Annealing* (**3**). Sb 3$d_{5/2}$: 529.1 eV (Δ = 9.35 eV).

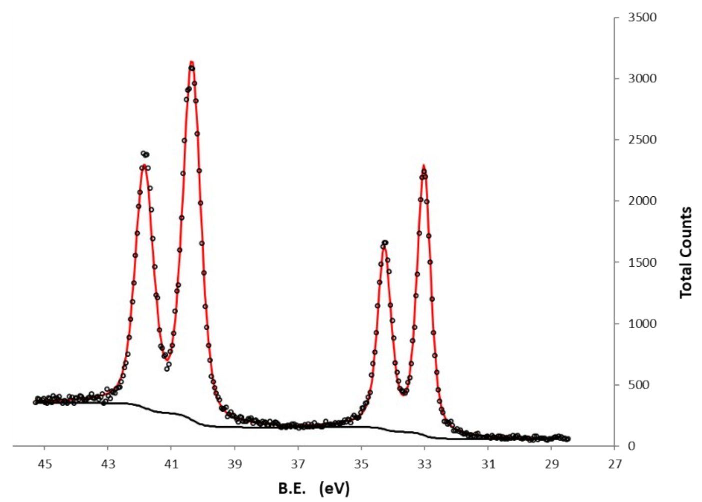

Figure S22. Te and Sb *4*d XPS of Sb_2Te_3 - *Post-Growth Annealing* (**3**). Te 4$d_{5/2}$: 40.3 eV (Δ = 1.5 eV); Sb 4$d_{5/2}$: 33.0 eV, (Δ = 1.2 eV).

6. XRR Measurements

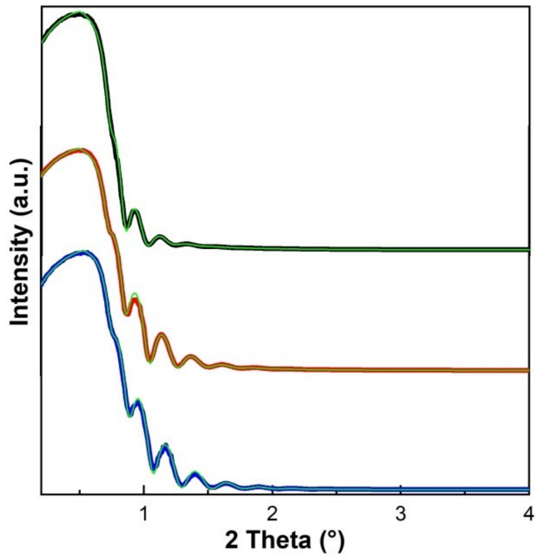

Figure S23. XRR measurements of Sb_2Te_3 - *As Deposited* (**1**) (black, top), Sb_2Te_3 - *Substrate Annealing* (**2**) (red, middle), and of Sb_2Te_3 - *Post-Growth Annealing* (**3**) (blue, bottom).

	Thickness (nm)	**Electronic density (e/A^3)**	**Roughness (nm)**
Sb_2Te_3 - As Deposited	33.7	1.75	3.1
Sb_2Te_3 - Substrate Annealing	32.5	1.68	2.0
Sb_2Te_3 - Post-Growth Annealing	32.0	1.80	1.5

Table S1. Thickness (nm), Electron density (e/A^3), and Roughness (nm) of Sb_2Te_3 - *As Deposited* (**1**), Sb_2Te_3 - *Substrate Annealing* (**2**), and of Sb_2Te_3 - *Post-Growth Annealing* (**3**) extracted from XRR measurements.

7. XRD Measurements

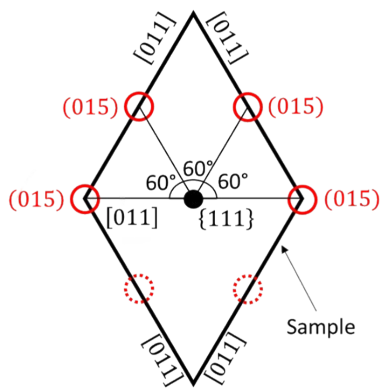

Figure S24. Schematic representation of the sample and the Sb_2Te_3 015 reflections. The solid black circle indicates the Si(111) out-of-plane orientation of the substrate. The position of the reflections from the Sb_2Te_3 (015) planes (red circles) with respect the [011] planes of the Si{111} substrate forms an angle of 60 °. The latter condition can be easily associated to a single family of Sb_2Te_3 hexagonal crystalline structures with a fixed orientation in the film plane.