

Optical and chemical properties of As-Se and As-S-Se solution processed thin films, prepared via $As_{50}Se_{50}$ source solution modification – supporting information

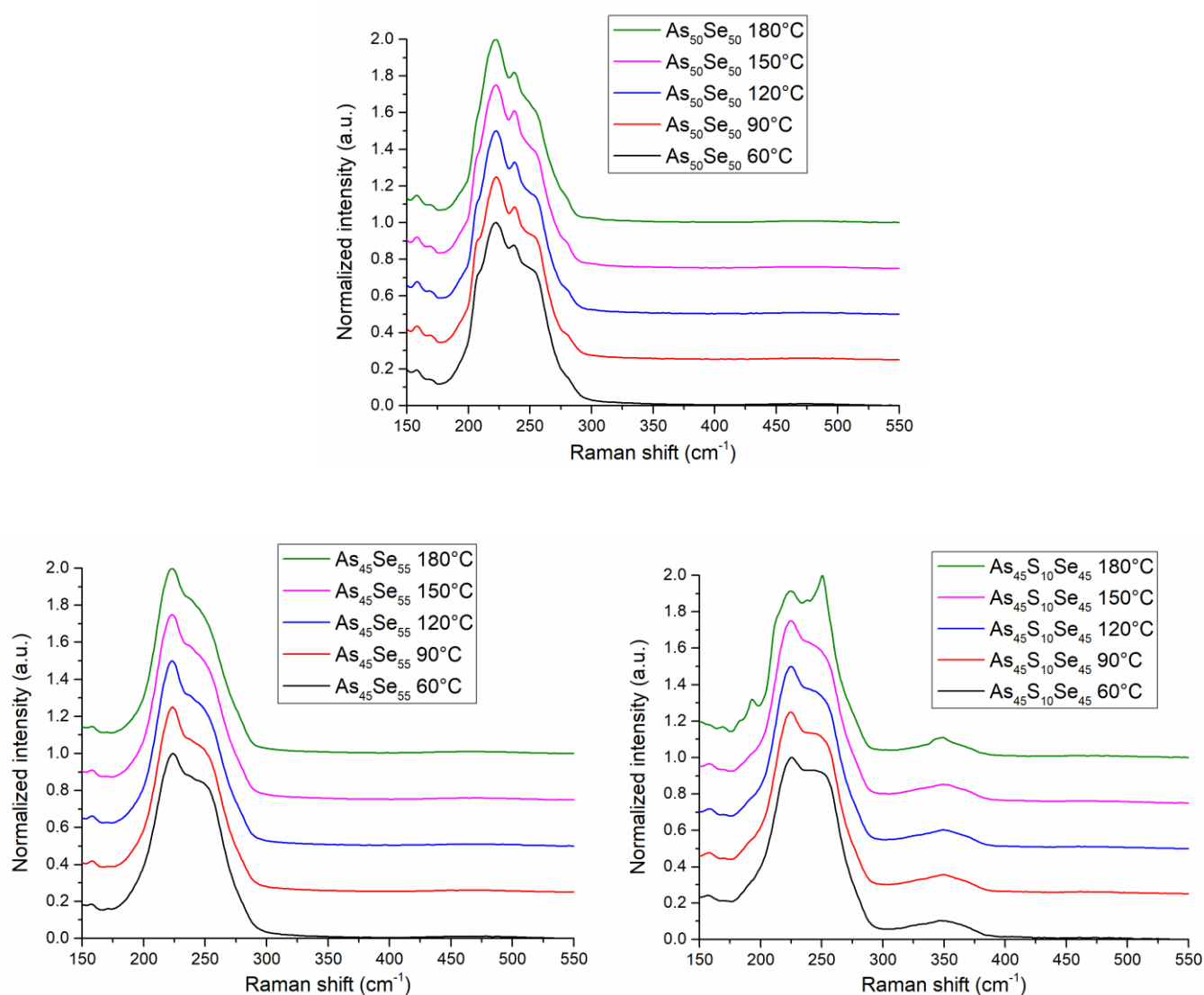
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Figure 1S. Raman spectra of all prepared thin film compositions at all annealing temperatures.



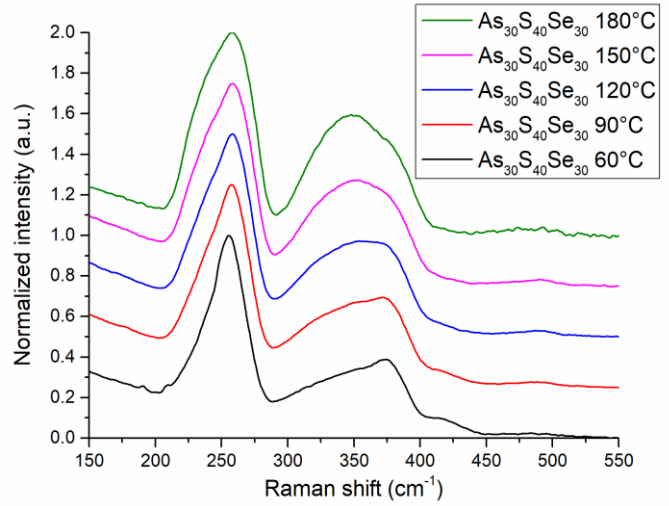
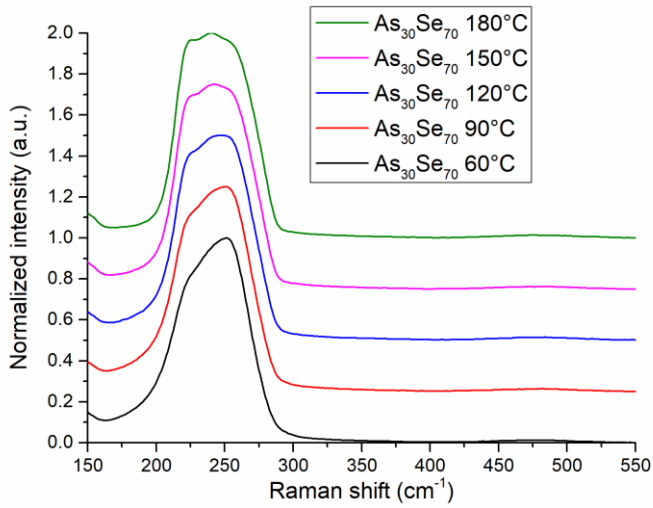
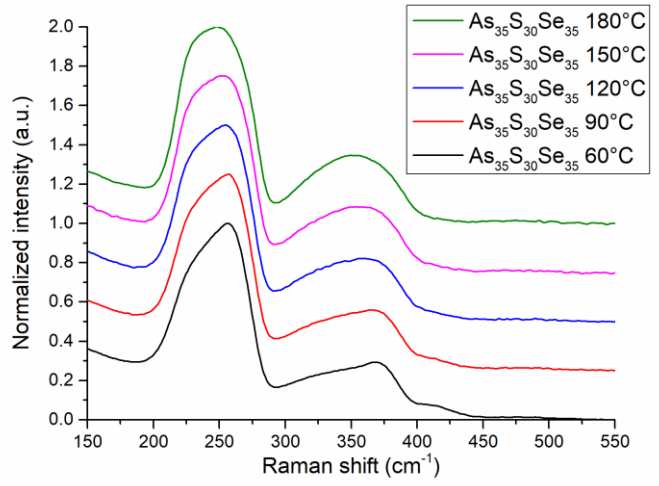
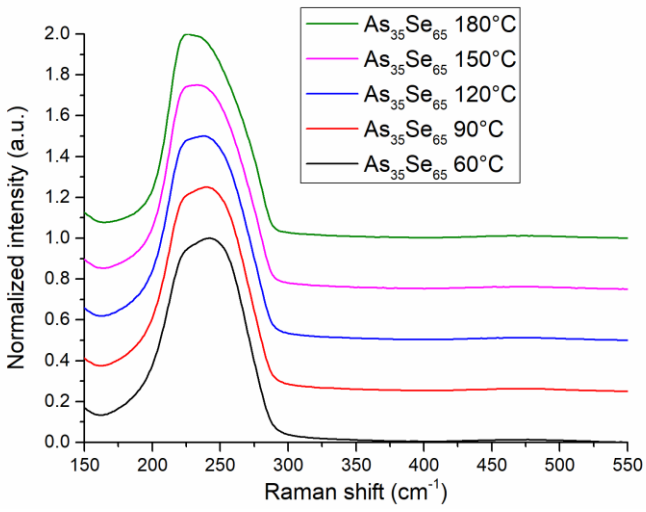
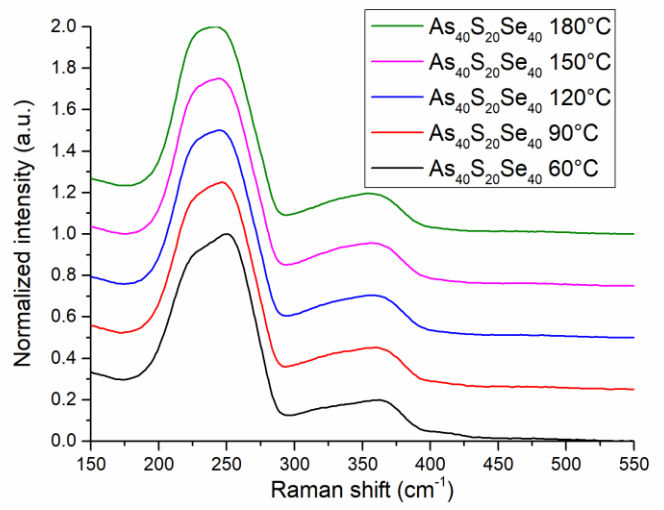
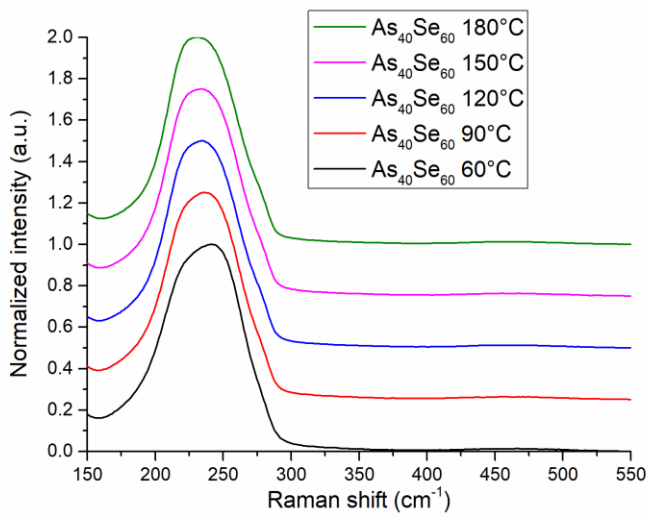
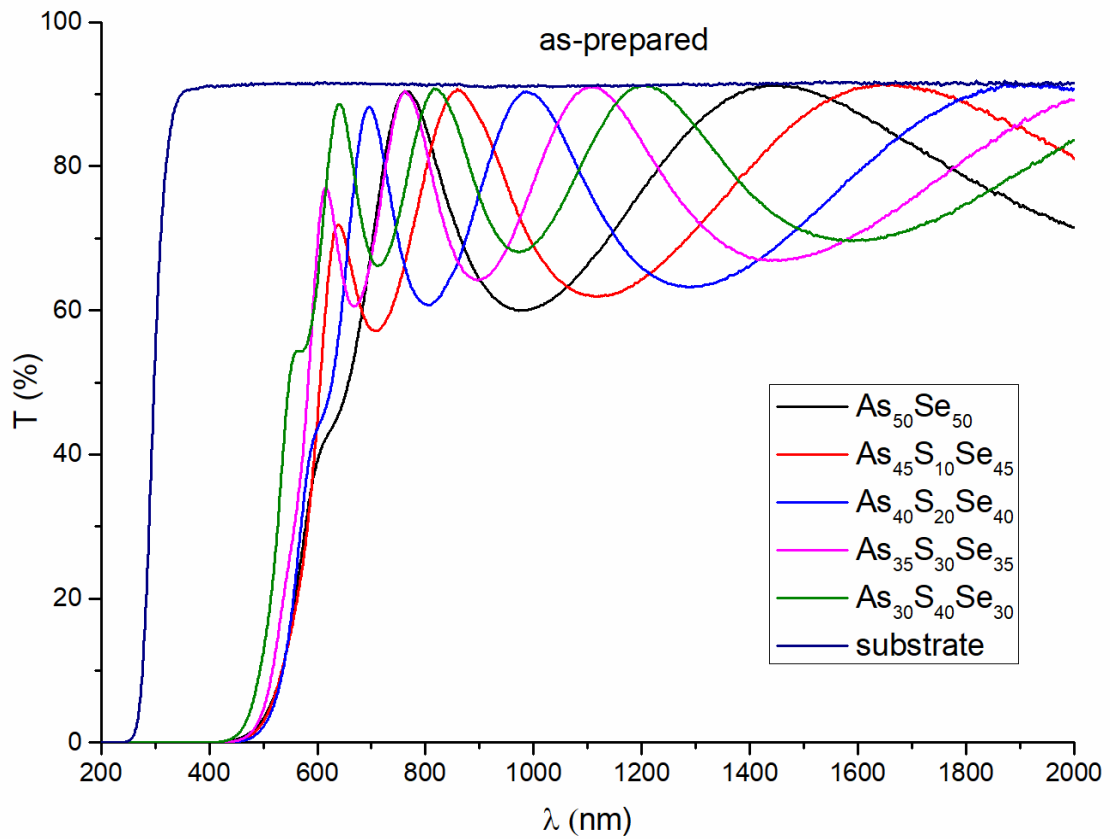
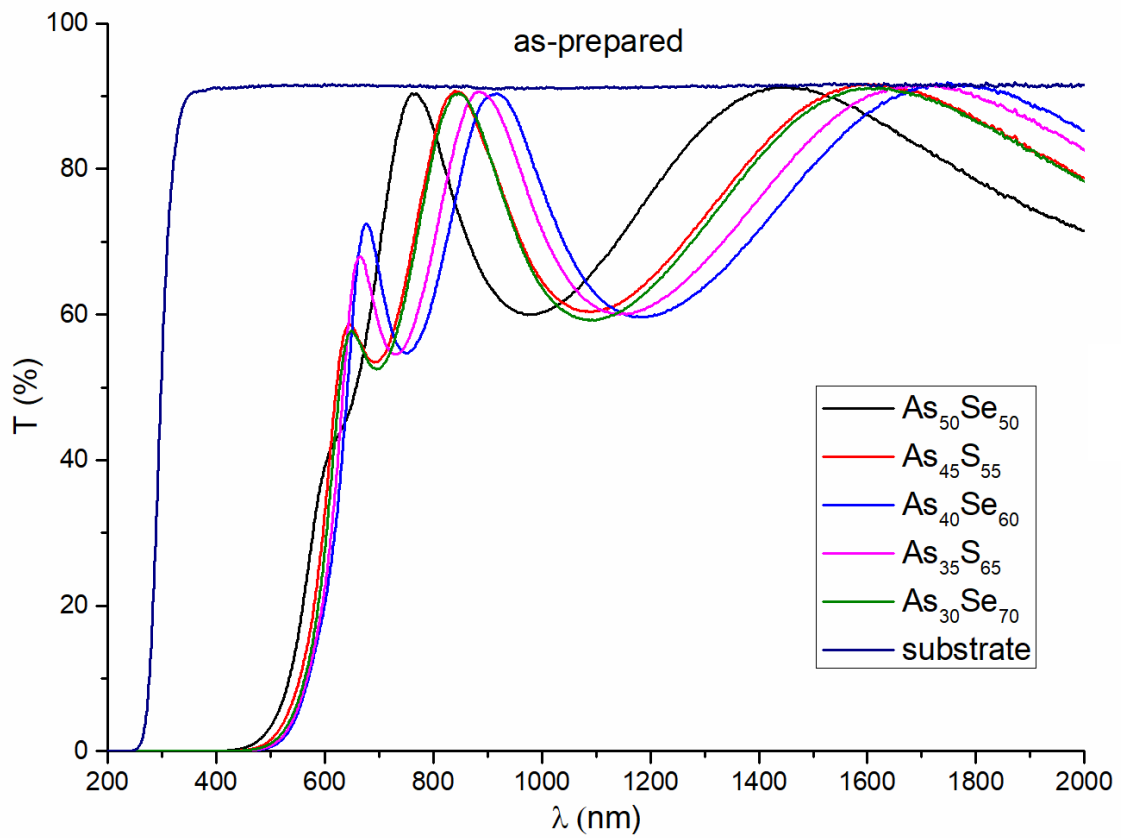


Table 1S. Composition of prepared thin films at all annealing temperatures.

T [°C]	As [at. %]	Se [at. %]
As₅₀Se₅₀		
60	48.4 ± 0.1	51.6 ± 0.1
90	48.4 ± 0.2	51.6 ± 0.2
120	48.5 ± 0.1	51.5 ± 0.1
150	48.3 ± 0.1	51.7 ± 0.1
180	47.8 ± 0.2	52.2 ± 0.2
As₄₅Se₅₅		
60	43.3 ± 0.1	56.7 ± 0.1
90	43.3 ± 0.1	56.7 ± 0.1
120	43.3 ± 0.1	56.7 ± 0.1
150	43.2 ± 0.2	56.8 ± 0.2
180	42.8 ± 0.2	57.2 ± 0.2
As₄₀Se₆₀		
60	38.8 ± 0.2	61.2 ± 0.2
90	38.6 ± 0.2	61.4 ± 0.2
120	38.5 ± 0.2	61.5 ± 0.2
150	38.4 ± 0.1	61.6 ± 0.1
180	38.9 ± 0.2	61.1 ± 0.2
As₃₅Se₆₅		
60	33.8 ± 0.1	66.2 ± 0.1
90	34.1 ± 0.2	65.9 ± 0.2
120	33.8 ± 0.1	66.2 ± 0.1
150	33.9 ± 0.1	66.1 ± 0.1
180	34.2 ± 0.3	65.8 ± 0.3
As₃₀Se₇₀		
60	29.0 ± 0.1	71.0 ± 0.1
90	28.9 ± 0.1	71.1 ± 0.1
120	28.9 ± 0.1	71.1 ± 0.1
150	29.0 ± 0.2	71.0 ± 0.2
180	29.4 ± 0.2	70.6 ± 0.2

T	As [at. %]	S [at. %]	Se [at. %]
As₄₅S₁₀Se₄₅			
60	43.0 ± 0.2	10.9 ± 0.2	46.1 ± 0.1
90	42.9 ± 0.1	11.0 ± 0.3	46.1 ± 0.3
120	43.3 ± 0.2	10.5 ± 0.2	46.2 ± 0.1
150	43.0 ± 0.2	10.0 ± 0.2	47.0 ± 0.1
180	42.6 ± 0.4	8.2 ± 0.3	49.2 ± 0.2
As₄₀S₂₀Se₄₀			
60	38.1 ± 0.3	21.9 ± 0.4	40.0 ± 0.3
90	38.2 ± 0.3	21.6 ± 0.4	40.2 ± 0.2
120	37.9 ± 0.3	22.3 ± 0.4	39.8 ± 0.2
150	37.6 ± 0.2	22.6 ± 0.5	39.8 ± 0.3
180	38.2 ± 0.2	19.6 ± 0.3	42.2 ± 0.2
As₃₅S₃₀Se₃₅			
60	33.2 ± 0.1	32.1 ± 0.2	34.7 ± 0.1
90	33.3 ± 0.3	31.8 ± 0.4	34.8 ± 0.3
120	33.4 ± 0.2	31.6 ± 0.3	35.1 ± 0.1
150	33.4 ± 0.2	30.4 ± 0.4	36.2 ± 0.2
180	34.1 ± 0.1	28.3 ± 0.2	37.6 ± 0.2
As₃₀S₄₀Se₃₀			
60	28.7 ± 0.3	42.4 ± 0.6	28.8 ± 0.4
90	28.8 ± 0.1	42.2 ± 0.2	29.0 ± 0.2
120	28.9 ± 0.2	41.2 ± 0.5	29.9 ± 0.3
150	28.5 ± 0.2	38.4 ± 0.3	33.1 ± 0.2
180	29.5 ± 0.2	38.9 ± 0.2	31.6 ± 0.1

Figure 2S. UV-VIS-NIR spectra of as-prepared thin films and thin films annealed at 150°C.



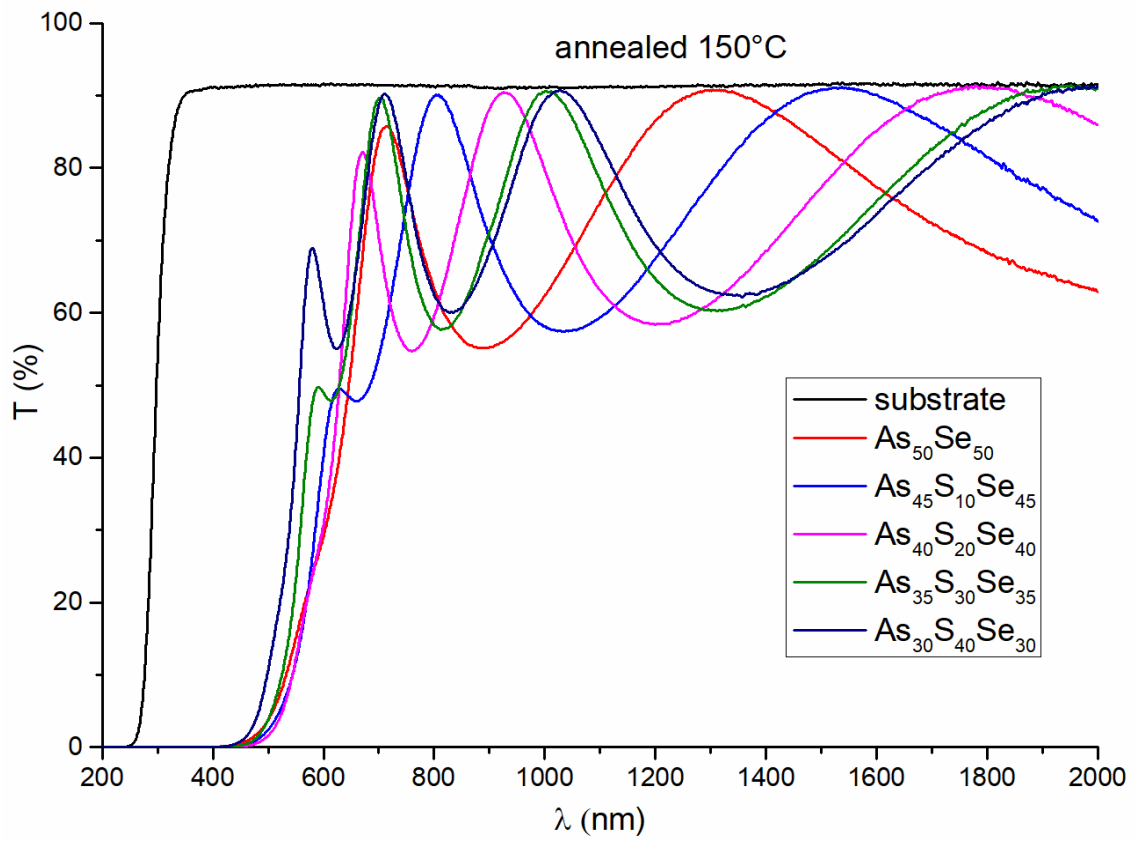
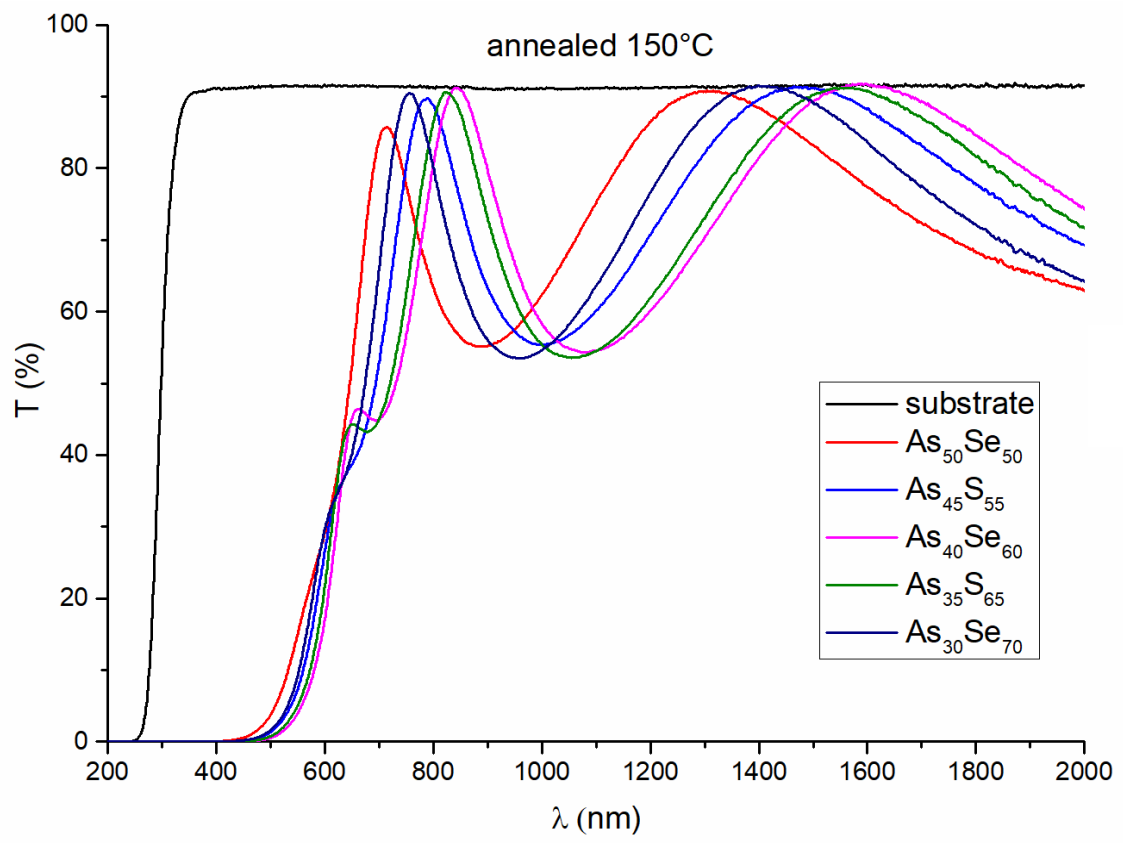
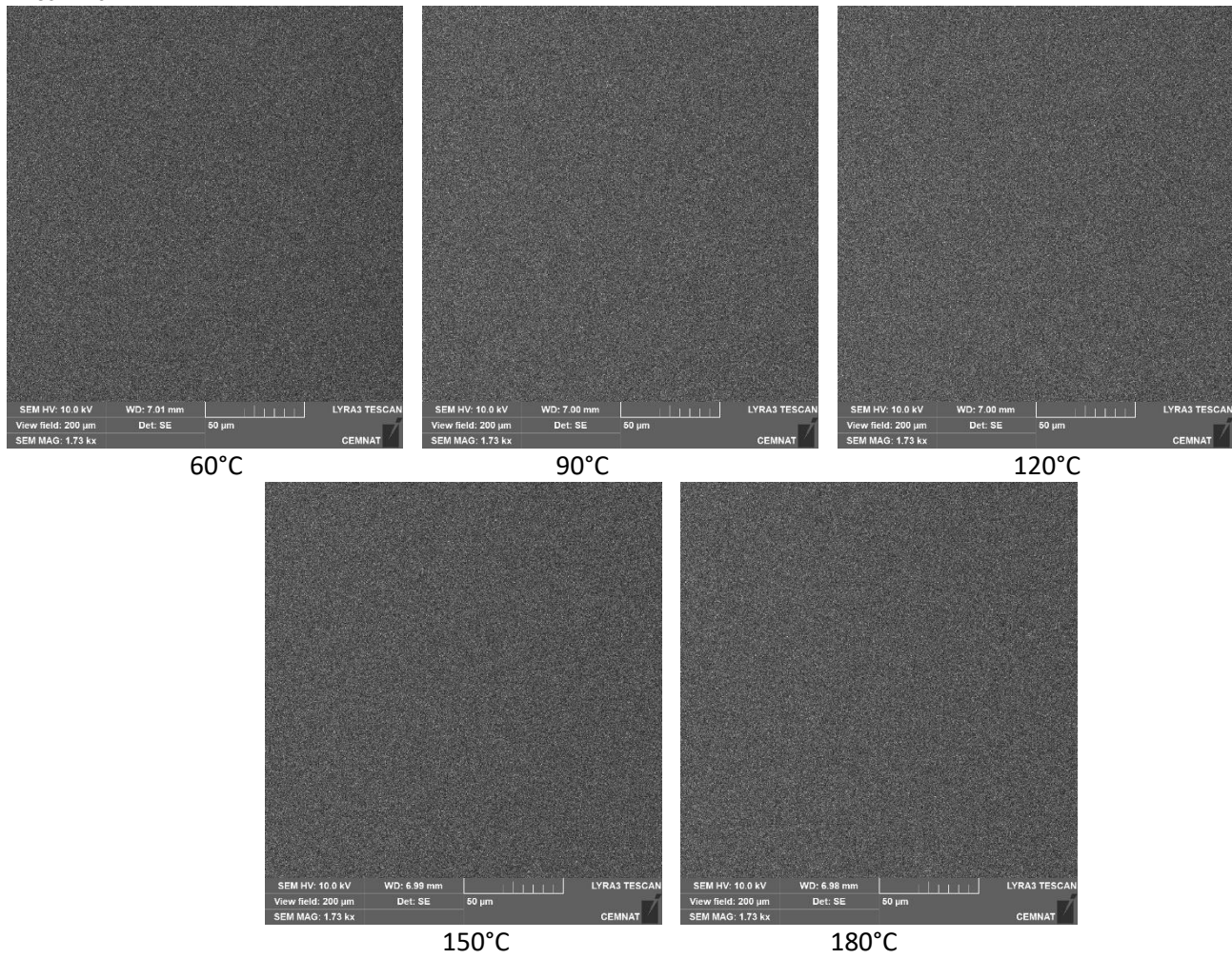
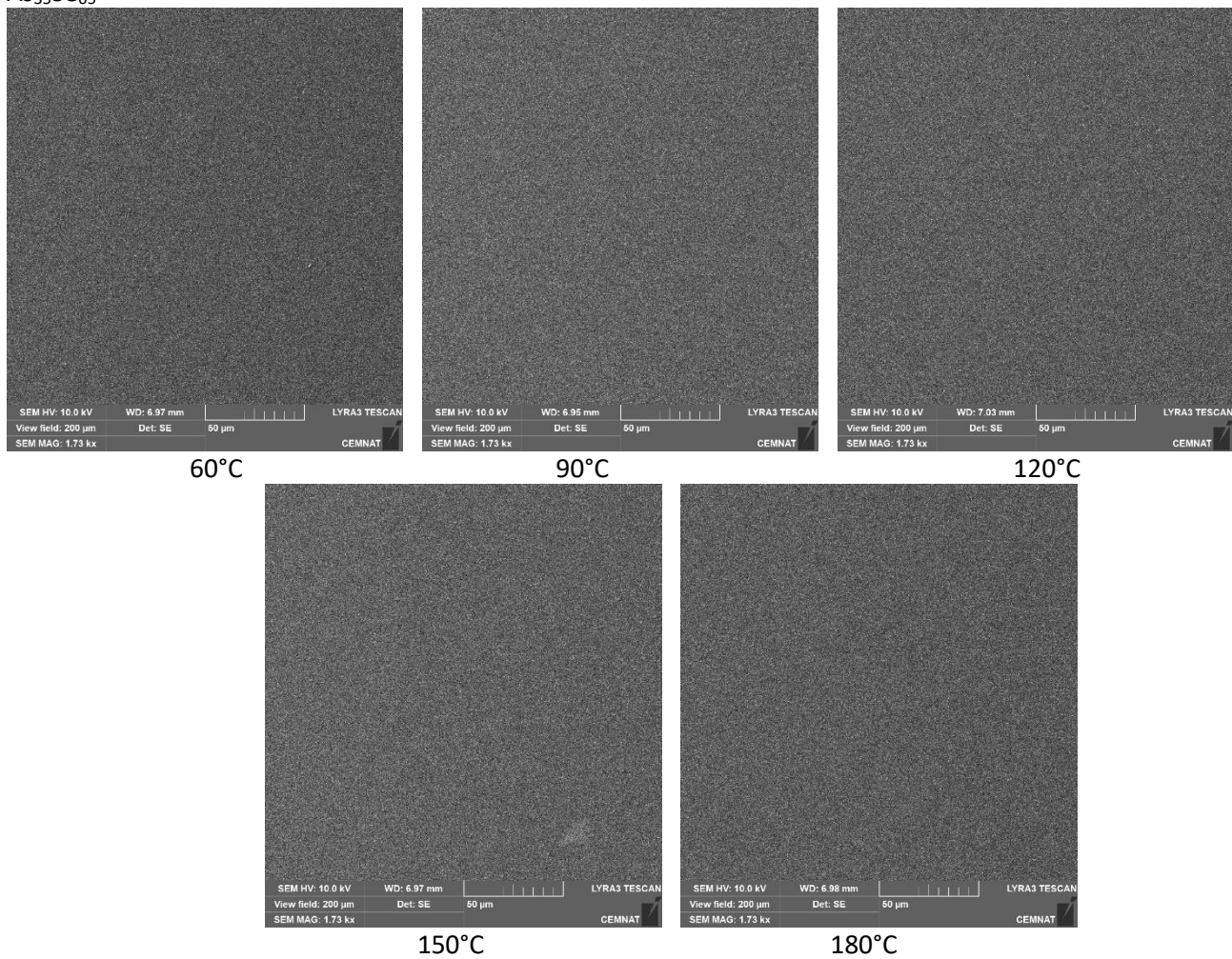


Figure 3S. SEM scans of all studied thin film compositions at all annealing temperatures – Scan view field 200 μm , accelerating voltage 10 kV.

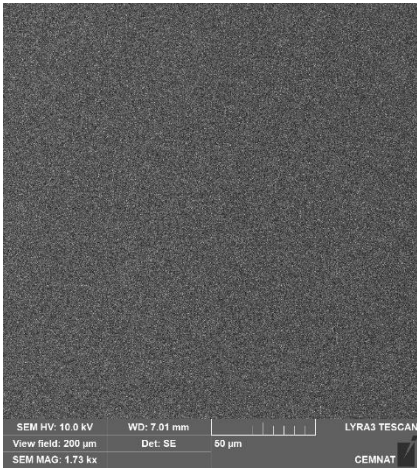
$\text{As}_{30}\text{Se}_{70}$



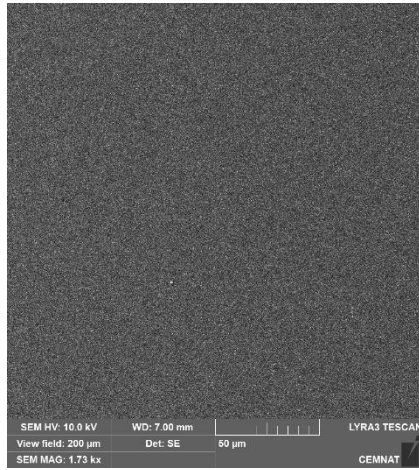
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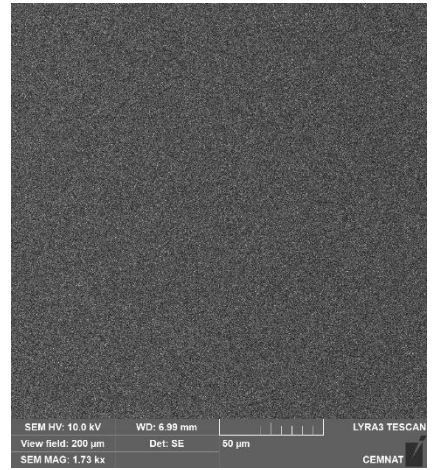
As₄₀Se₆₀



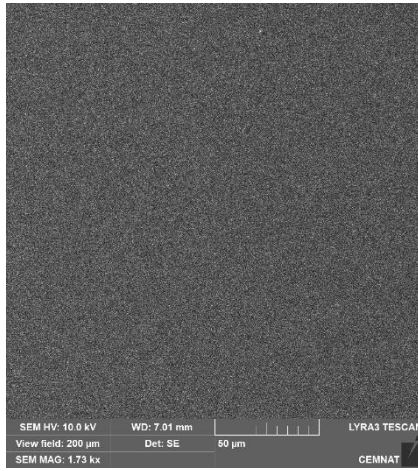
60°C



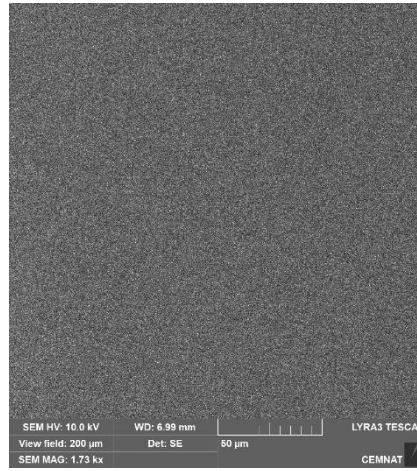
90°C



120°C

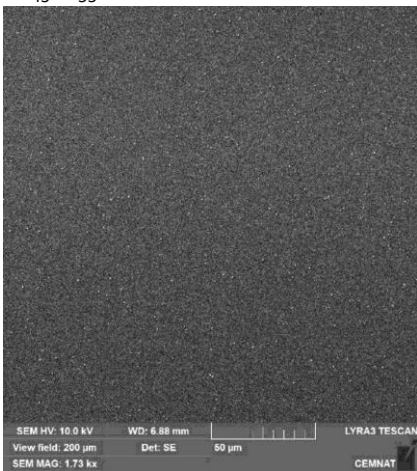


150°C

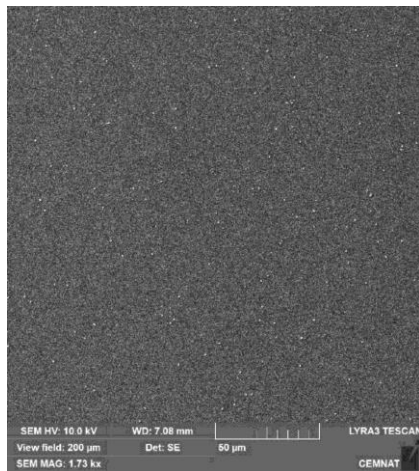


180°C

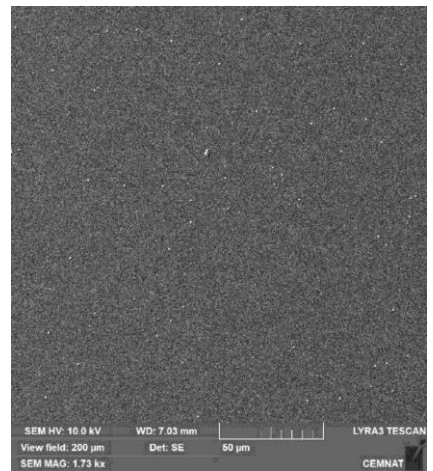
As₄₅Se₅₅



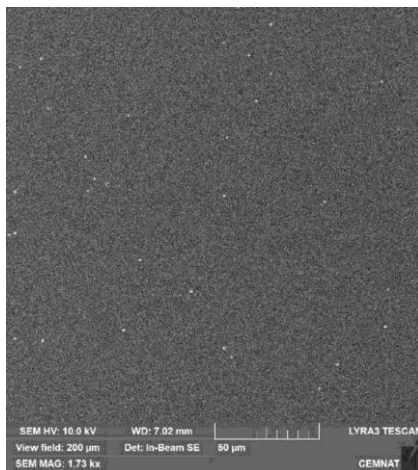
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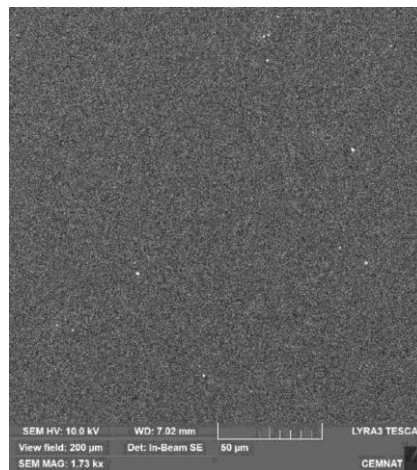
90°C



120°C

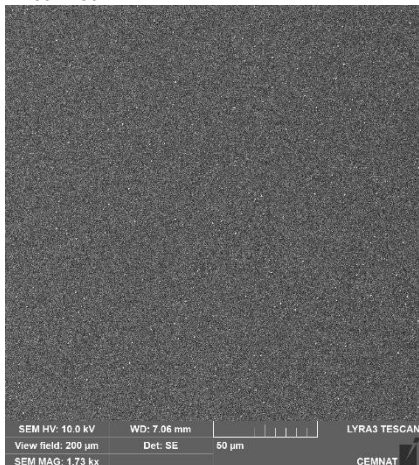


150°C

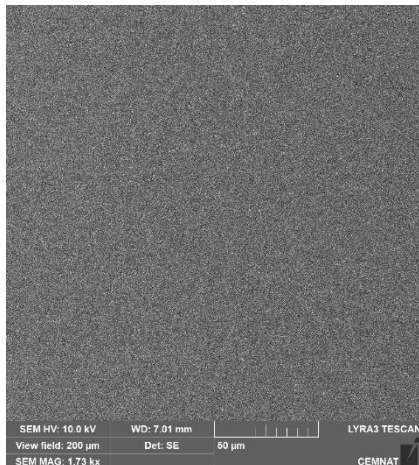


180°C

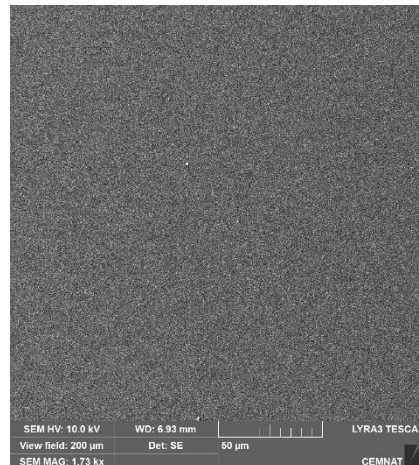
As₅₀Se₅₀



60°C



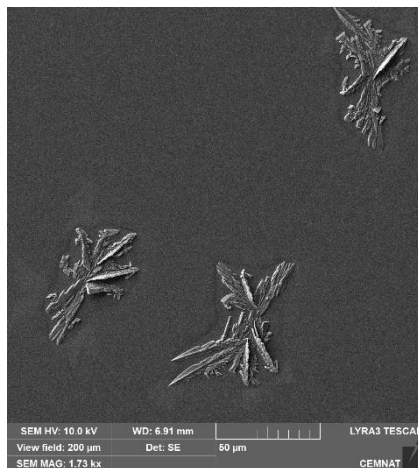
90°C



120°C

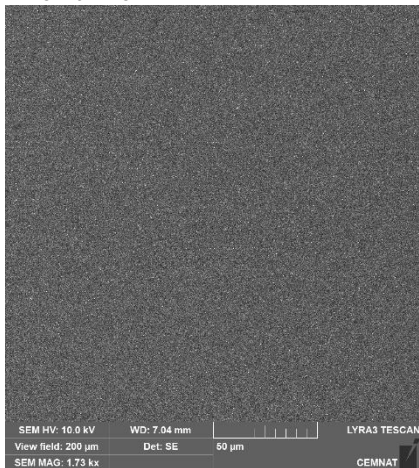


150°C

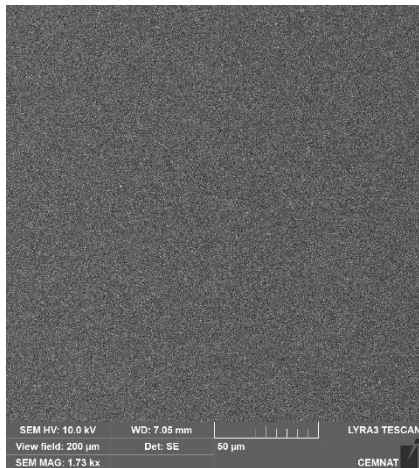


180°C

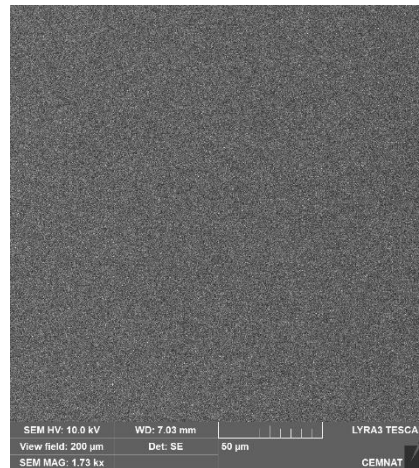
As₄₅S₁₀Se₄₅



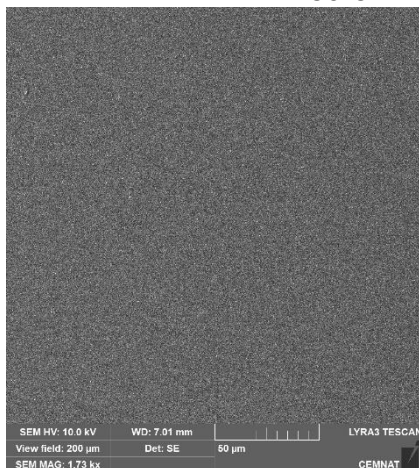
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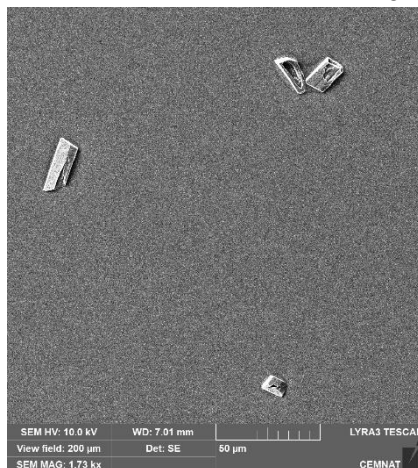
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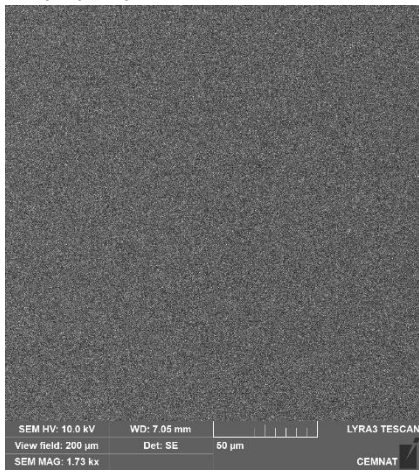
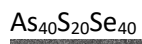
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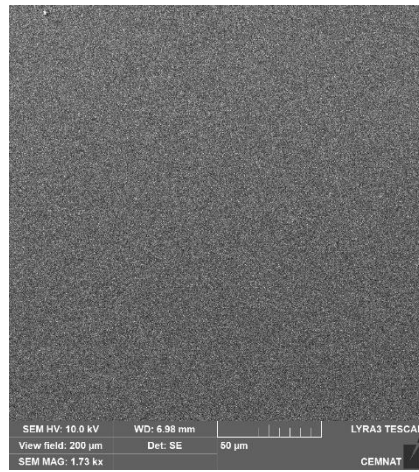
150°C



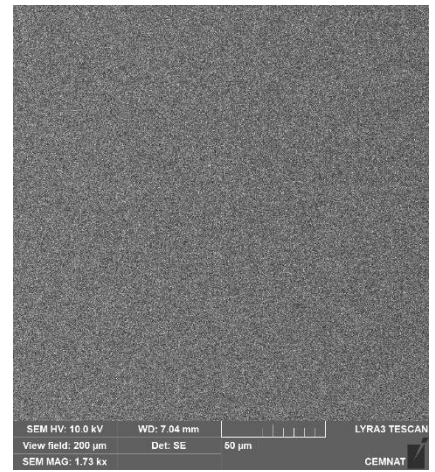
180°C



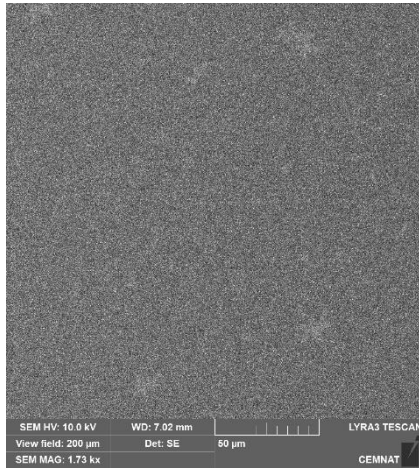
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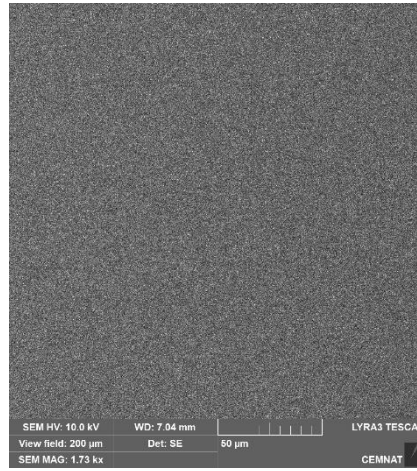
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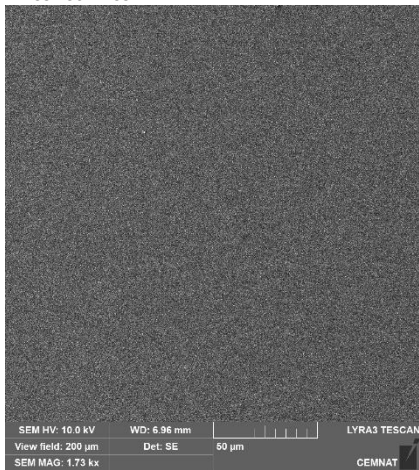
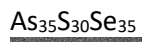
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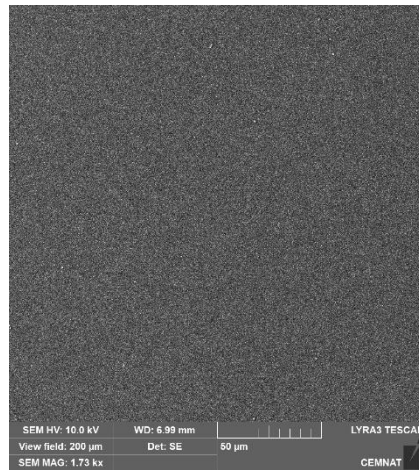
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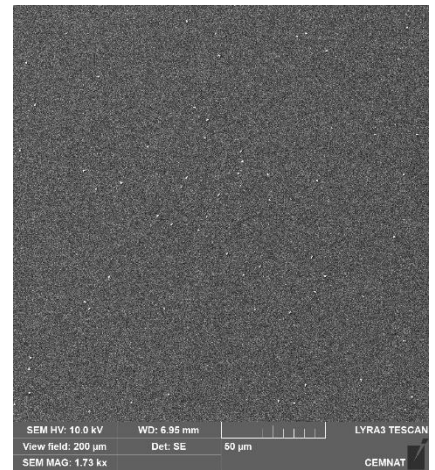
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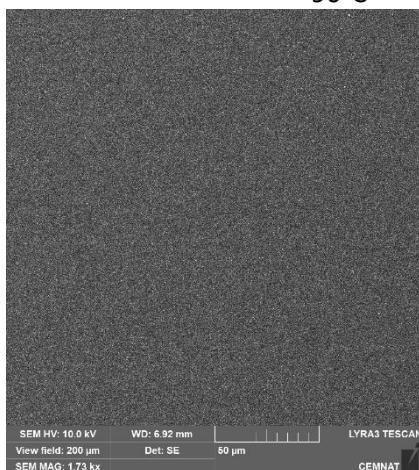
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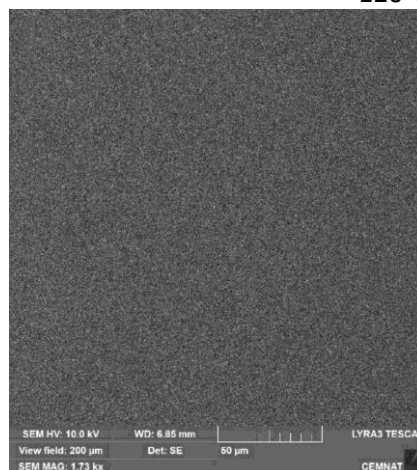
90°C



120°C



150°C



180°C

As₃₀S₄₀Se₃₀

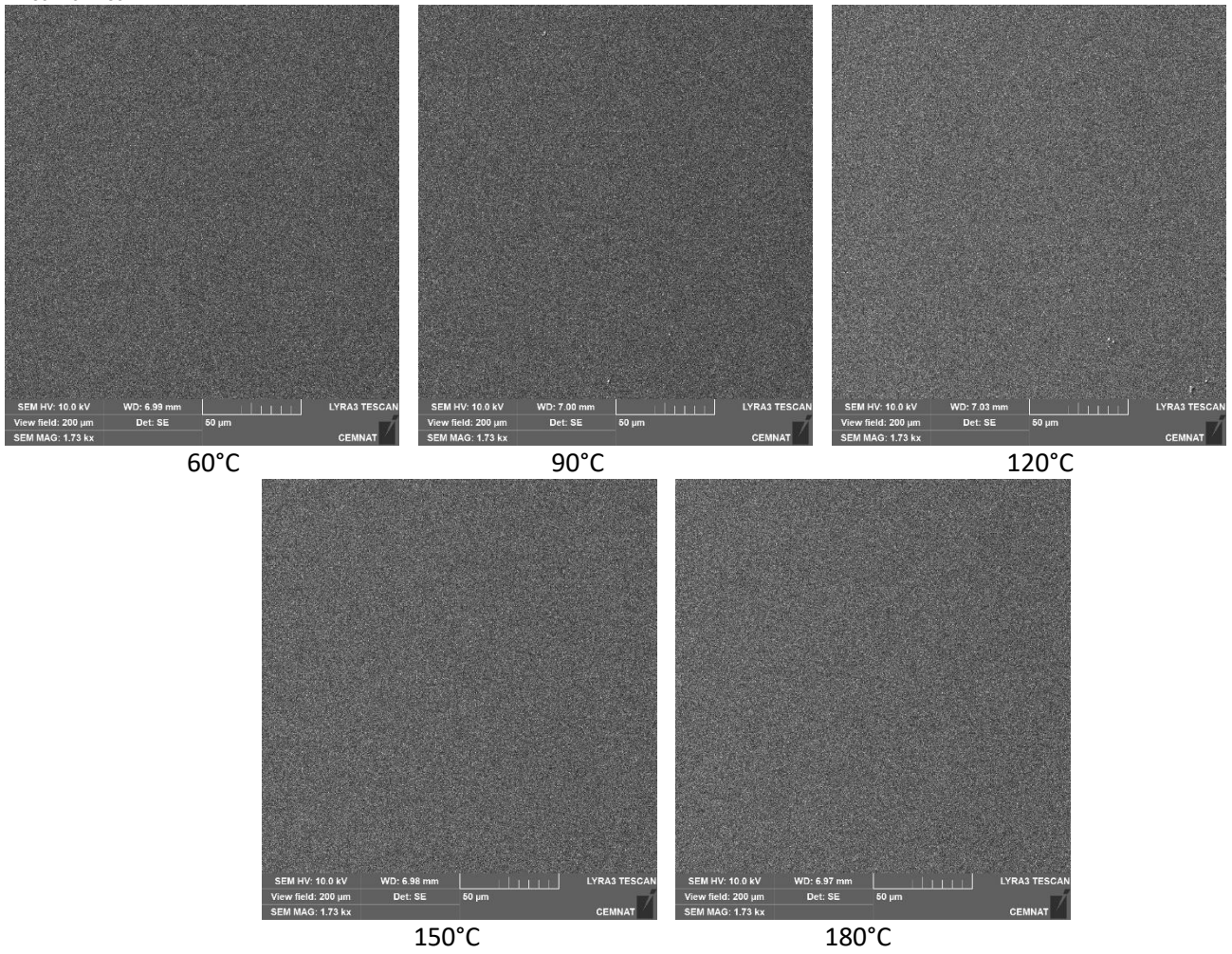
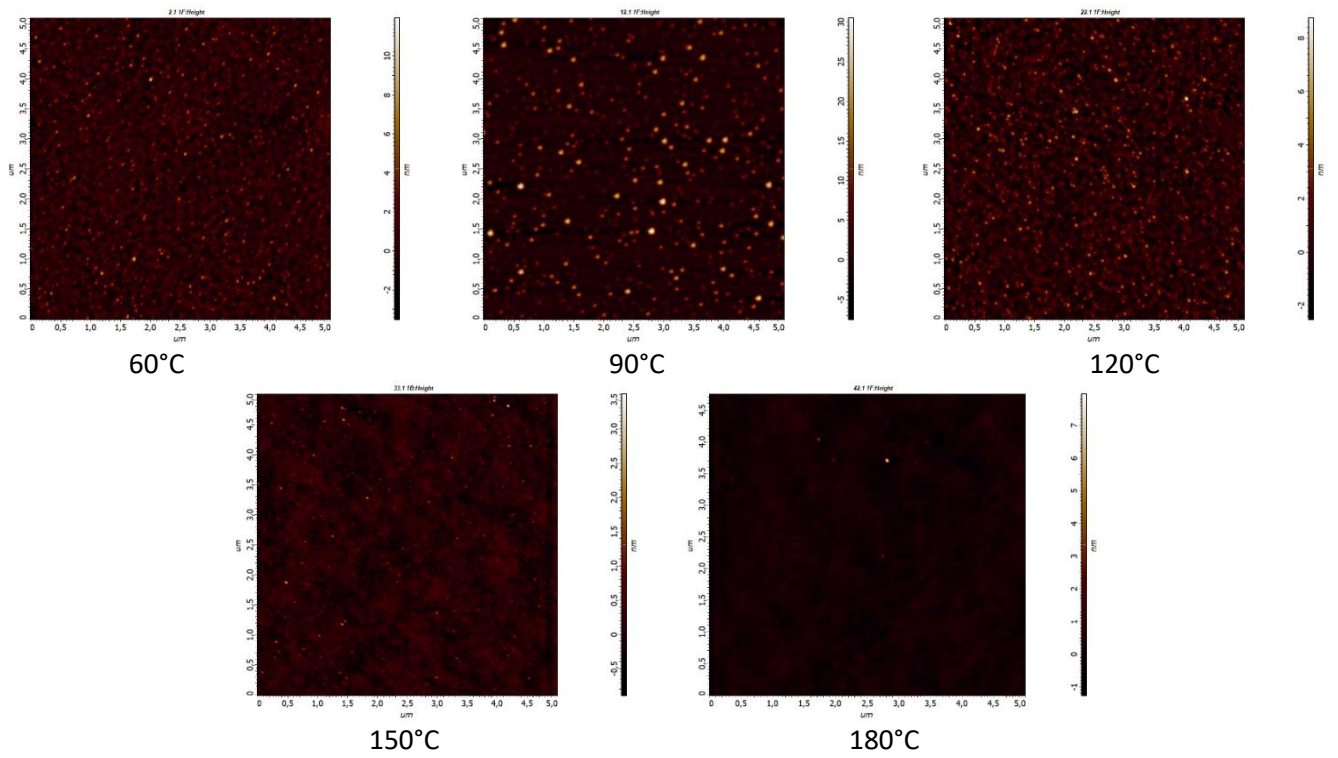
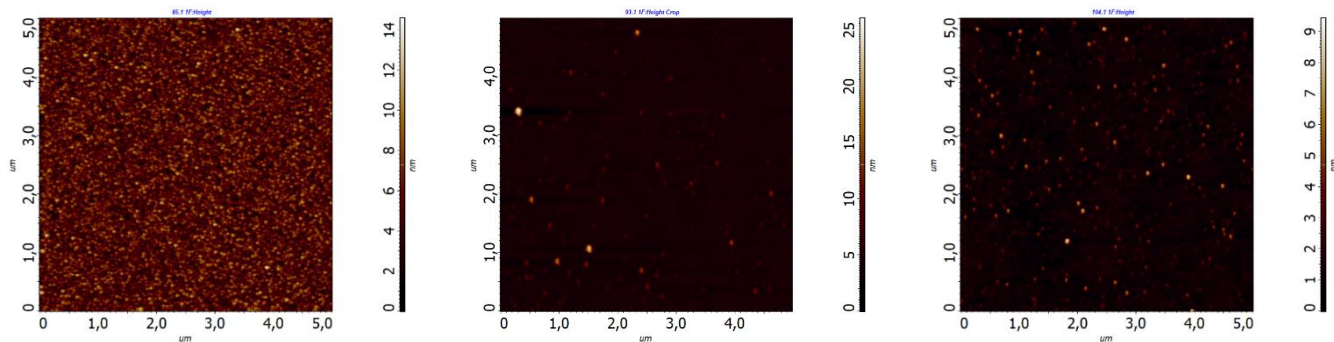


Figure 4S. AFM scans of all studied thin film compositions at all annealing temperatures – scan size 5 x 5 µm .

As₃₀Se₇₀



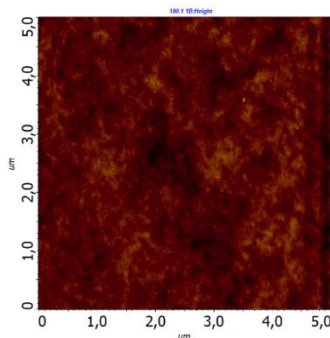
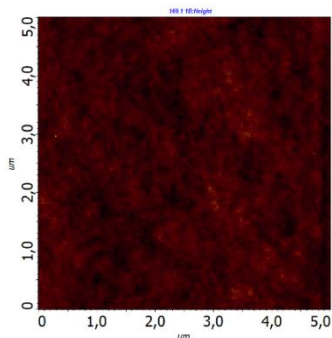
As₃₅Se₆₅



60°C

90°C

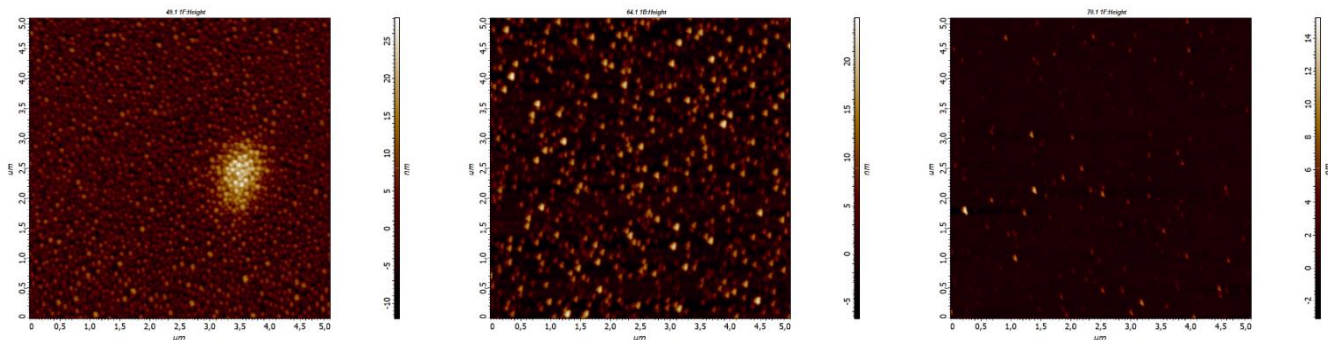
120°C



150°C

180°C

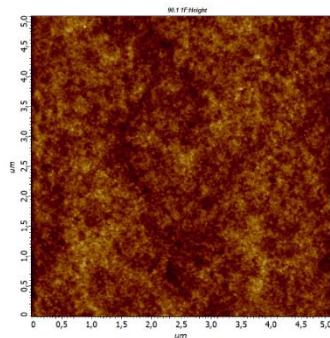
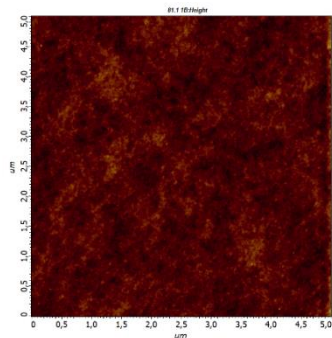
As₄₀Se₆₀



60°C

90°C

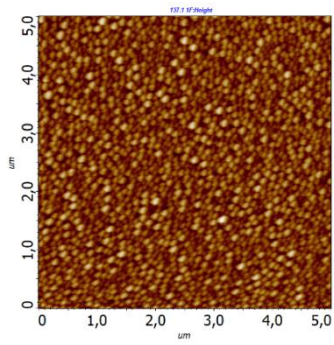
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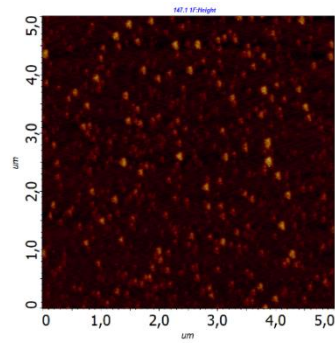
150°C

180°C

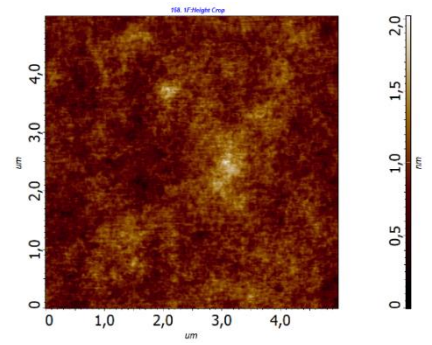
As₄₅Se₅₅



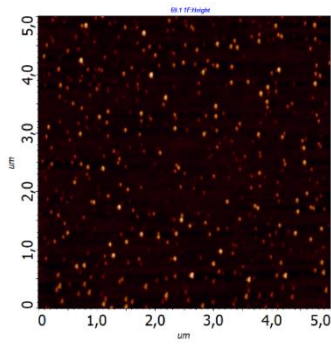
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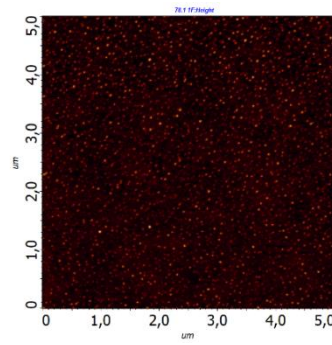
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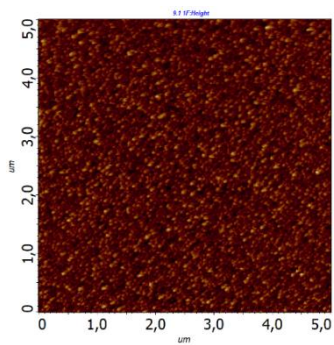


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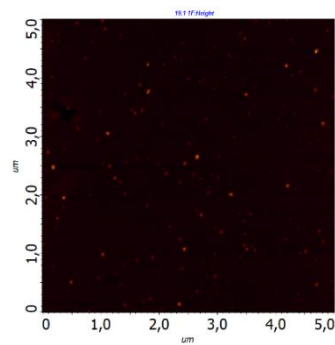


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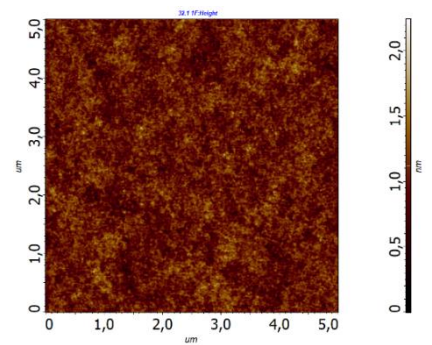
As₅₀Se₅₀



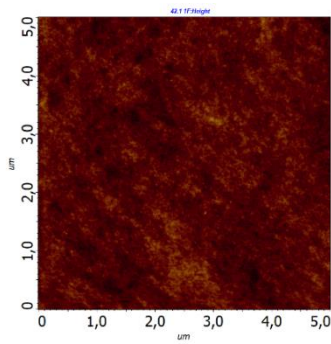
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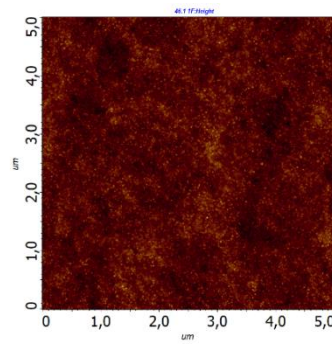
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120°C

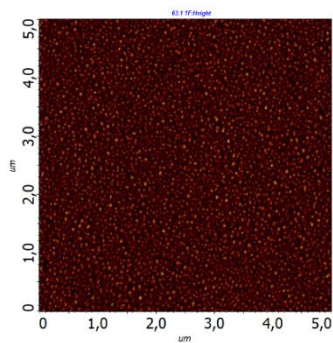


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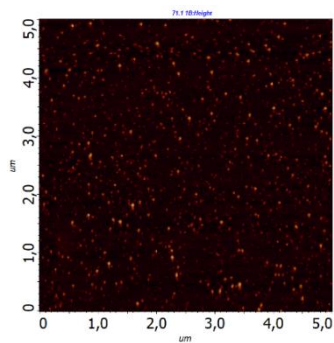


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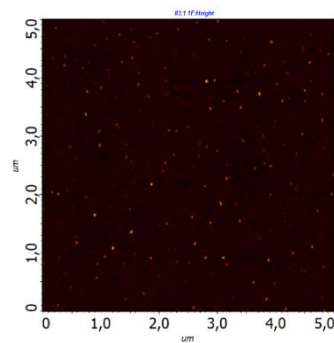
As₄₅S₁₀Se₄₅



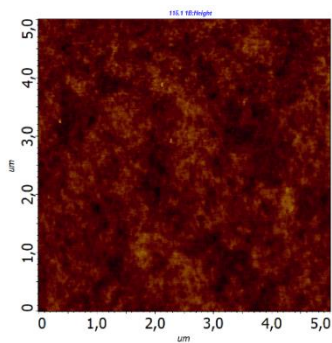
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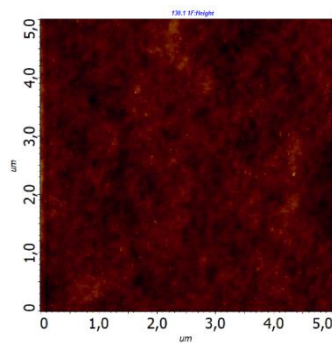
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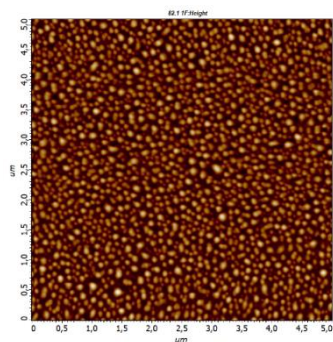


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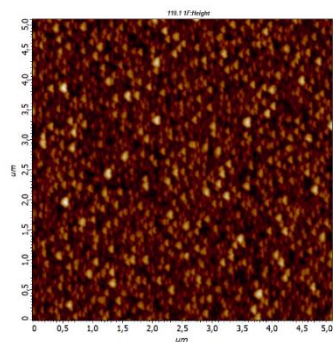


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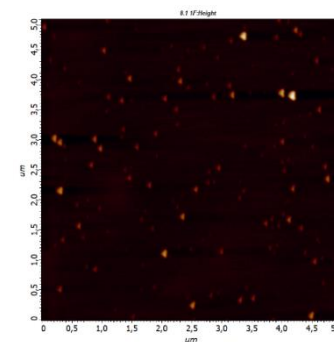
As₄₀S₂₀Se₄₀



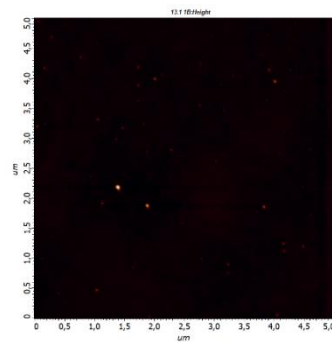
60°C



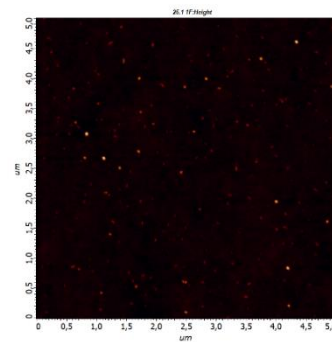
90°C



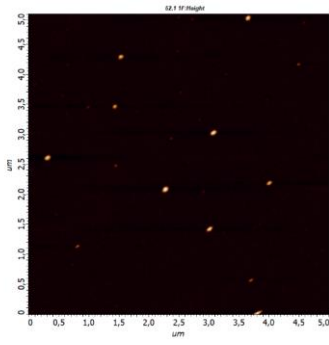
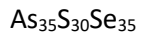
120°C



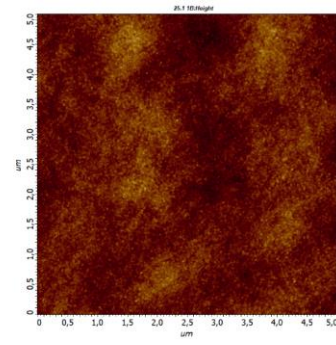
150°C



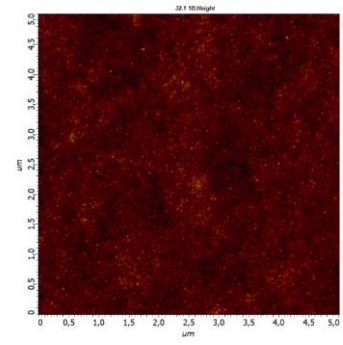
180°C



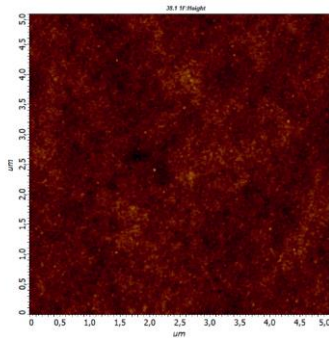
60°C



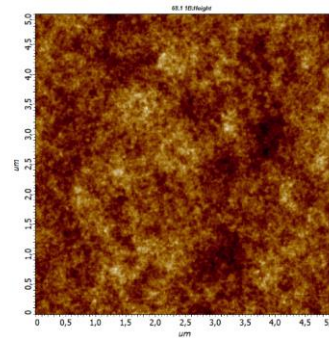
90°C



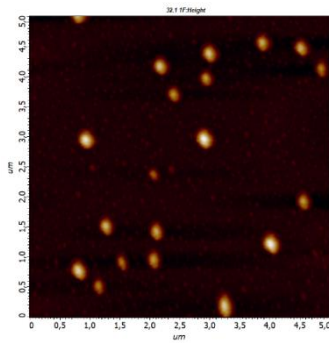
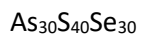
120°C



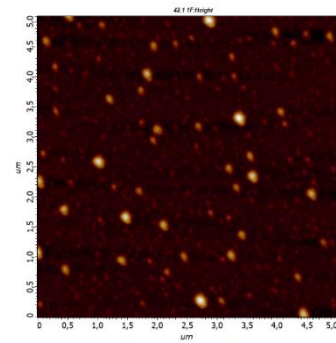
150°C



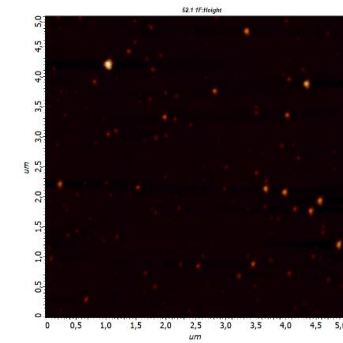
180°C



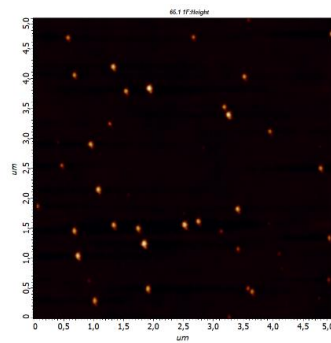
60°C



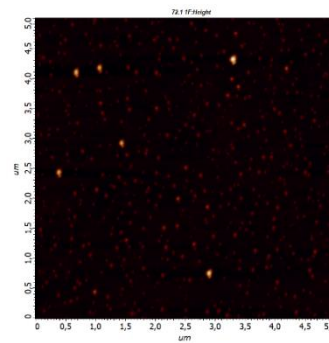
90°C



120°C



150°C



180°C

Table 2S. Values of thickness for all studied thin film compositions at all annealing temperatures.

d [nm]	T = 60°C	T = 90°C	T = 120°C	T = 150°C
As₃₀Se₇₀	295.0 ± 7.9	276.4 ± 5.2	268.9 ± 5.8	253.3 ± 5.4
As₃₅Se₆₅	319.8 ± 10.6	301.5 ± 6.0	291.8 ± 6.0	279.8 ± 5.9
As₄₀Se₆₀	343.2 ± 5.7	321.9 ± 5.9	312.2 ± 5.9	304.7 ± 5.2
As₄₅Se₅₅	325.0 ± 8.1	308.4 ± 6.2	298.5 ± 3.0	280.9 ± 4.9
As₅₀Se₅₀	317.6 ± 4.8	295.3 ± 9.7	279.0 ± 6.1	255.4 ± 4.9
As₄₅S₁₀Se₄₅	353.6 ± 15.7	328.6 ± 11.9	321.3 ± 6.9	302.8 ± 11.7
As₄₀S₂₀Se₄₀	420.1 ± 24.2	390.4 ± 18.4	370.7 ± 14.1	360.1 ± 15.5
As₃₅S₃₀Se₃₅	489.6 ± 17.7	459.6 ± 23.9	436.2 ± 27.3	408.6 ± 19.8
As₃₀S₄₀Se₃₀	539.3 ± 10.2	483.0 ± 4.1	455.8 ± 6.0	412.6 ± 8.3

Table 3S. Values of refractive index at 1550 nm for all studied thin film compositions at all annealing temperatures.

n_{1550 nm}	T = 60°C	T = 90°C	T = 120°C	T = 150°C
As₃₀Se₇₀	2.47 ± 0.02	2.53 ± 0.01	2.56 ± 0.02	2.62 ± 0.02
As₃₅Se₆₅	2.51 ± 0.02	2.58 ± 0.04	2.61 ± 0.03	2.67 ± 0.04
As₄₀Se₆₀	2.52 ± 0.02	2.61 ± 0.01	2.64 ± 0.02	2.69 ± 0.02
As₄₅Se₅₅	2.54 ± 0.01	2.59 ± 0.03	2.63 ± 0.03	2.71 ± 0.02
As₅₀Se₅₀	2.51 ± 0.03	2.57 ± 0.03	2.63 ± 0.02	2.71 ± 0.02
As₄₅S₁₀Se₄₅	2.44 ± 0.02	2.50 ± 0.02	2.52 ± 0.02	2.59 ± 0.03
As₄₀S₂₀Se₄₀	2.41 ± 0.01	2.50 ± 0.01	2.54 ± 0.01	2.58 ± 0.01
As₃₅S₃₀Se₃₅	2.35 ± 0.02	2.40 ± 0.01	2.45 ± 0.01	2.51 ± 0.03
As₃₀S₄₀Se₃₀	2.23 ± 0.01	2.32 ± 0.01	2.37 ± 0.02	2.45 ± 0.02

Table 4S. Values of optical band gap for all studied thin film compositions at all annealing temperatures.

E_g^{opt} [eV]	T = 60°C	T = 90°C	T = 120°C	T = 150°C
As₃₀Se₇₀	1.74 ± 0.01	1.74 ± 0.01	1.74 ± 0.01	1.73 ± 0.01
As₃₅Se₆₅	1.73 ± 0.01	1.70 ± 0.01	1.70 ± 0.01	1.68 ± 0.01
As₄₀Se₆₀	1.73 ± 0.01	1.70 ± 0.01	1.69 ± 0.01	1.67 ± 0.01
As₄₅Se₅₅	1.71 ± 0.01	1.69 ± 0.01	1.69 ± 0.01	1.68 ± 0.01
As₅₀Se₅₀	1.70 ± 0.01	1.69 ± 0.01	1.69 ± 0.01	1.69 ± 0.01
As₄₅S₁₀Se₄₅	1.83 ± 0.01	1.80 ± 0.01	1.78 ± 0.01	1.76 ± 0.01
As₄₀S₂₀Se₄₀	1.87 ± 0.01	1.84 ± 0.01	1.83 ± 0.01	1.82 ± 0.01
As₃₅S₃₀Se₃₅	1.96 ± 0.02	1.94 ± 0.01	1.93 ± 0.01	1.92 ± 0.01
As₃₀S₄₀Se₃₀	2.06 ± 0.01	2.04 ± 0.01	2.03 ± 0.01	2.04 ± 0.01