

TEM analysis GaAs

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12-02-2020

STCA

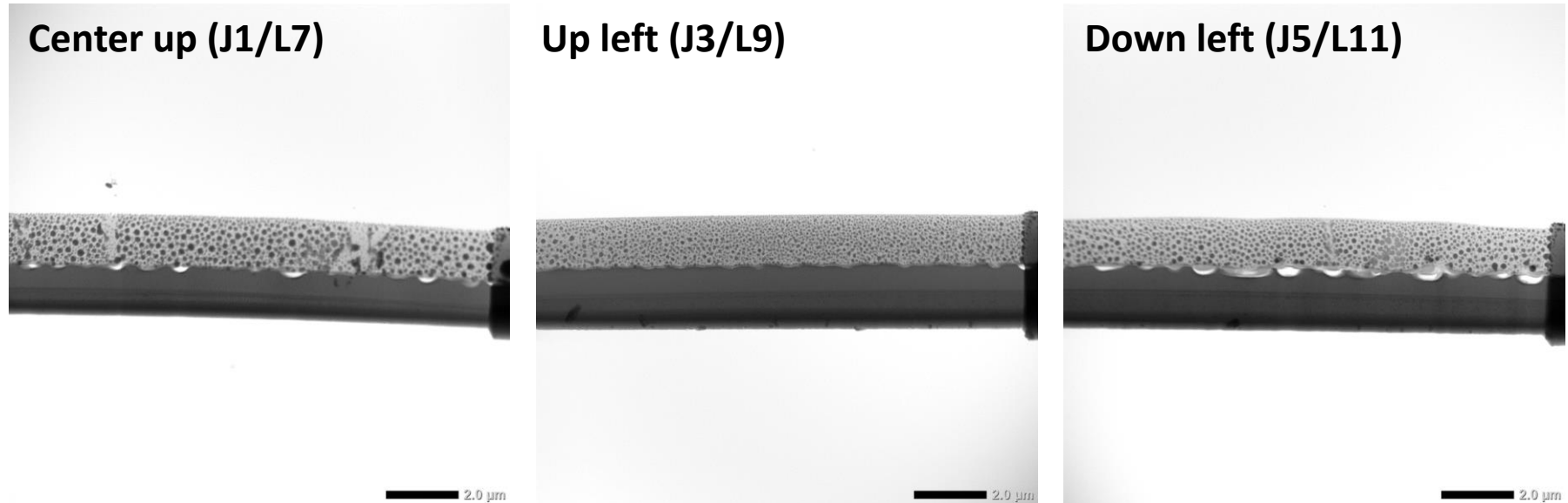
GaAs

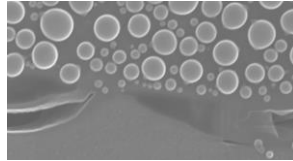
Samples analyzed by STEM, STEM-EDX (and BF-TEM)

1. Sample 6 - JE595 regular oxidized unannealed without silver plastic holder
21322459_068902_2020
2. Sample 10 - JE595 regular oxidized annealed without silver plastic holder
21322462_068902_2020
3. Sample 13 - JE540 regular oxidized annealed without silver plastic holder
21322464_068902_2020
4. Sample 15 - JE540 regular oxidized unannealed with silver plastic holder
21322464_068902_2020

1. Sample 6 - JE595 regular oxidized unannealed without silver plastic holder 21322459_068902_2020

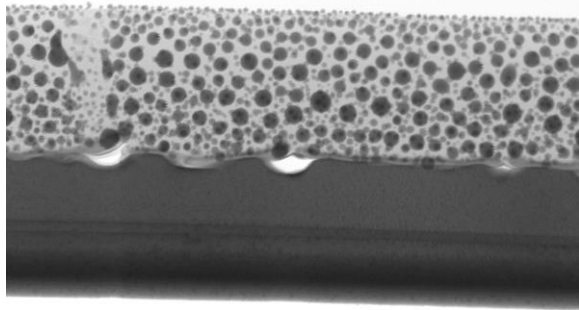
Overview of 3 lamella analyzed



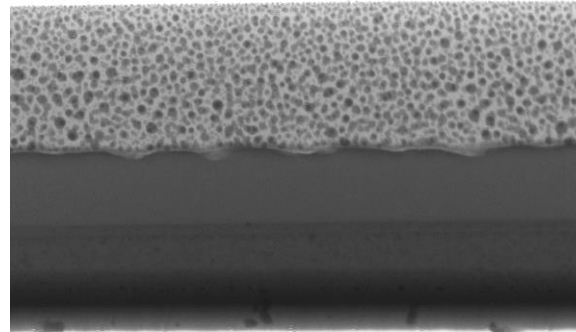
- Note: due to technical issues we seem to have deposited a lot of Ga “droplets” on top of the carbon layer, they reside on the surface as confirmed by secondary electron imaging:
- 
- Lamella taken from different regions of the wafer show somewhat different surface roughness (from 30 to 150 nm depth of surface ridges)
 - Aluminum-oxide layer seems to vary in thickness from 30 nm up to even 150 nm patches, also it seems to be broken, and in some places lifted up from GaAs to form pores beneath (see next slide and EDX)

1. Sample 6 - JE595 regular oxidized unannealed without silver plastic holder 21322459_068902_2020

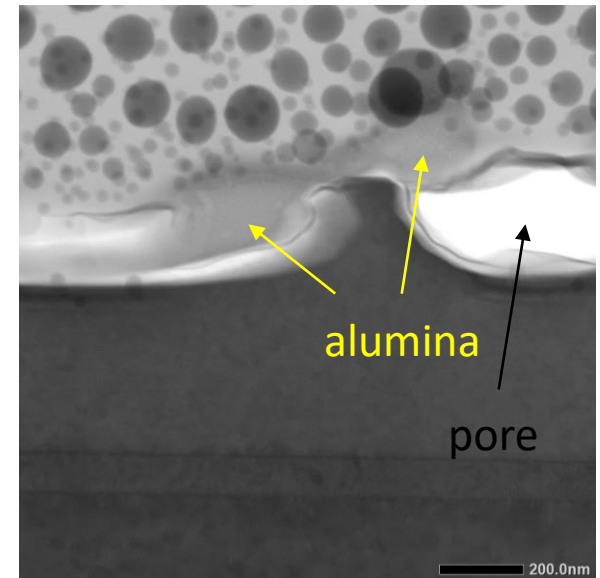
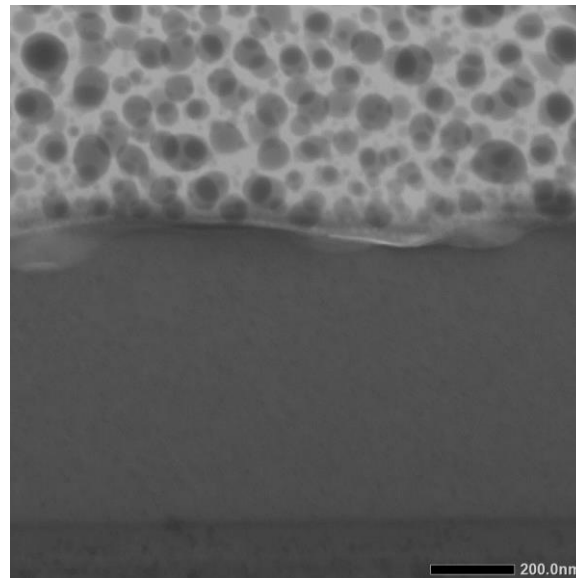
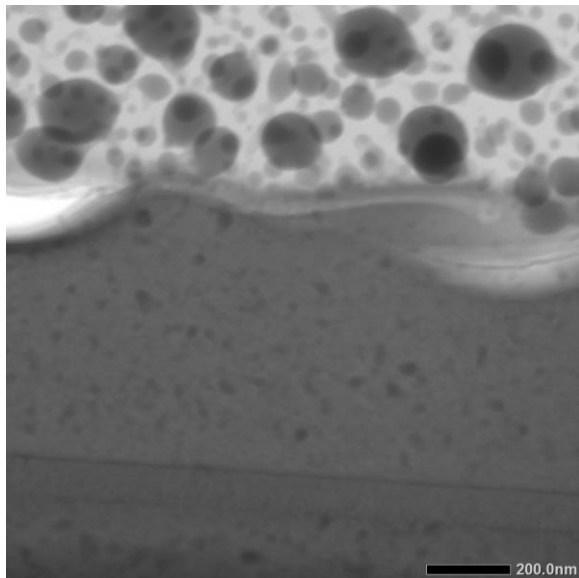
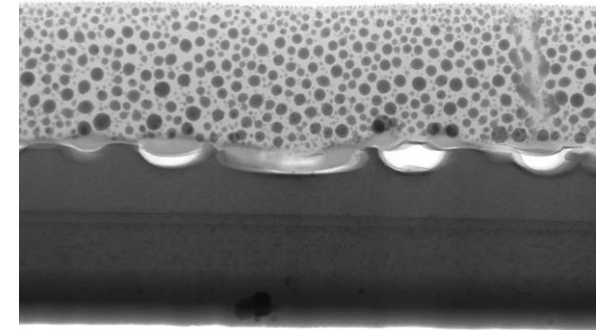
Center up (J1/L7)



Up left (J3/L9)



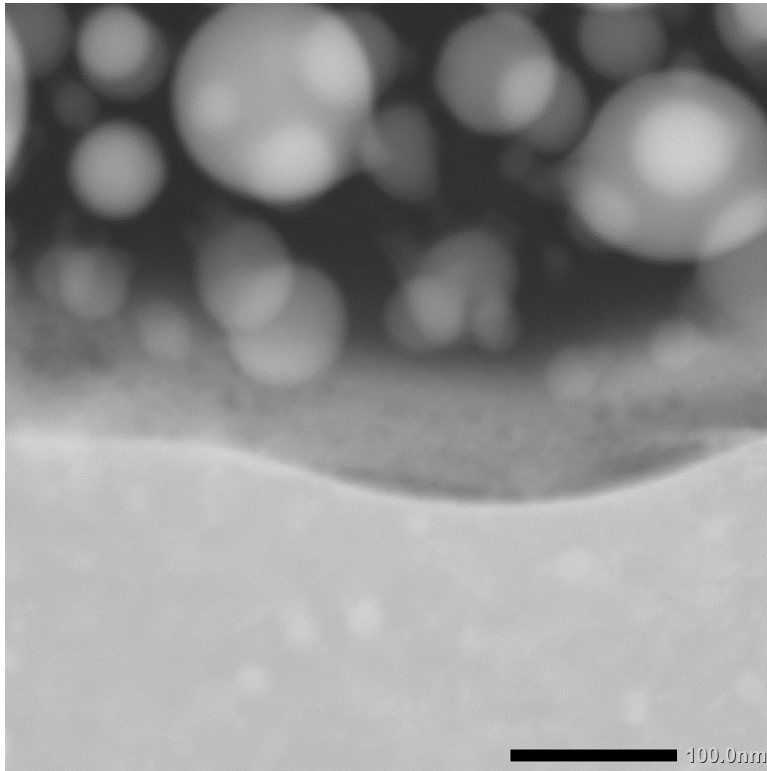
Down left (J5/L11)



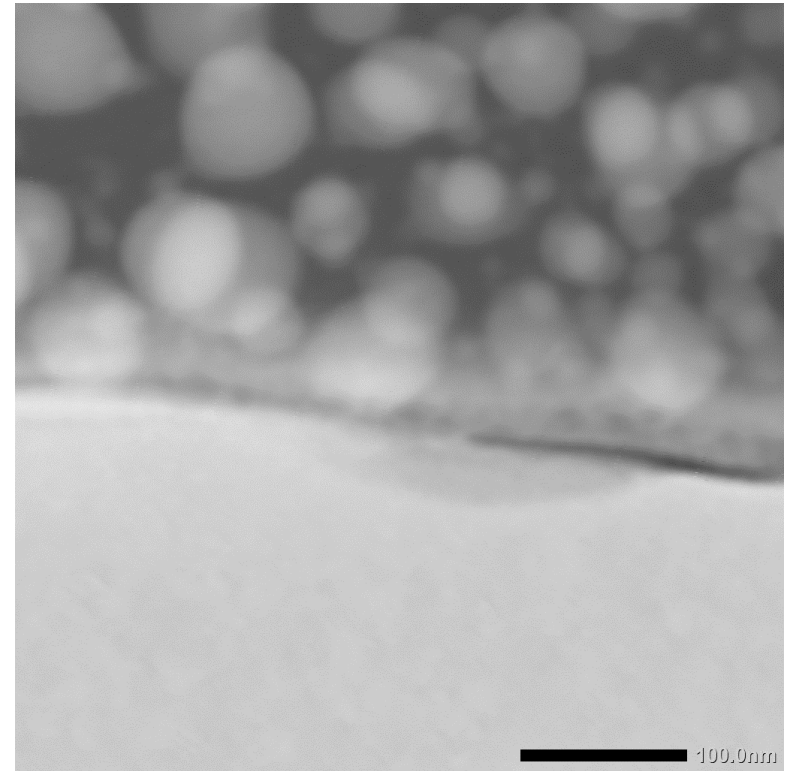
- Varying thickness of alumina layer, fills up some ridges to form 150 nm layer while occasionally it remains thin ~50 nm and “lifted up” forming a pore beneath (see arrows)

1. Sample 6 - JE595 regular oxidized unannealed without silver plastic holder 21322459_068902_2020

Center up (J1/L7)



Up left (J3/L9)

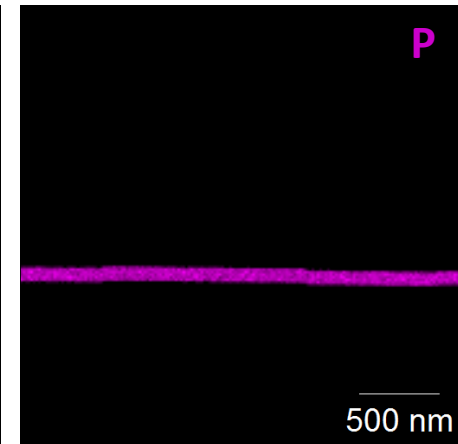
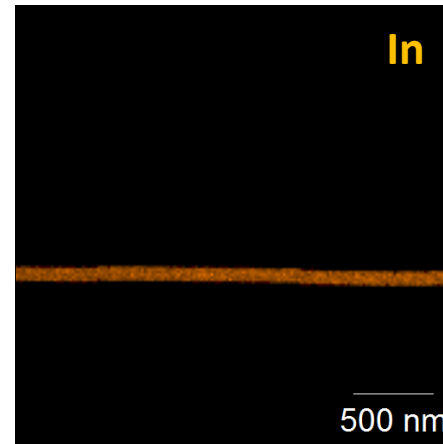
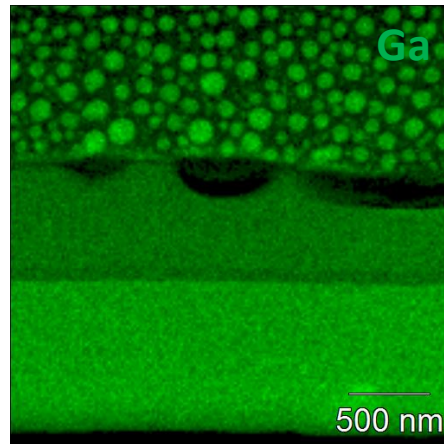
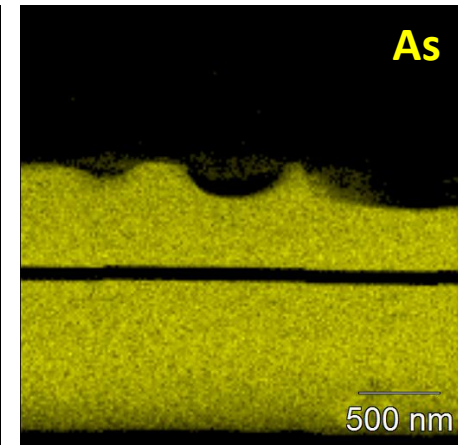
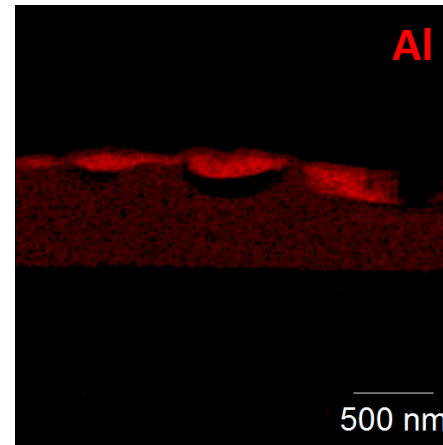
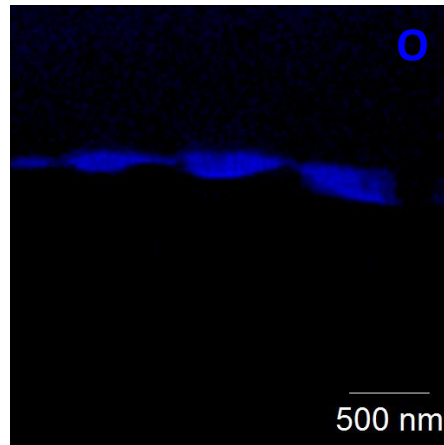
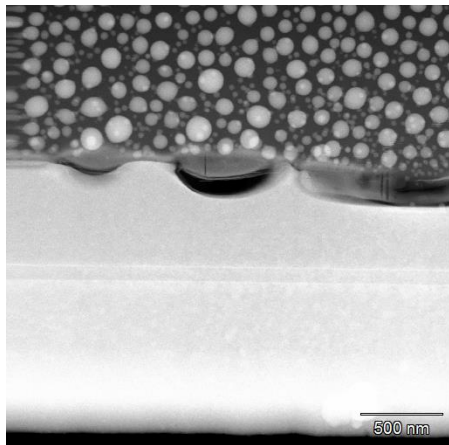


- High magnification images reveal that alumina layer, at least in part, shows pore-like structure with pores of about 5 nm.
- Unfortunately the presence of Ga deposits (technical issue) obstructs in part the view on top alumina layer.

1. Sample 6 - JE595 regular oxidized unannealed without silver plastic holder 21322459_068902_2020

- EDX maps confirm that presence of O is associated with Al signal, indicating alumina layer.
- Alumina layer seems to be patchy and broken
- A very well defined layer of Ga/In/P has been observed in the wafer separating Al-present and Ga-poor (top) from Al-absent and Ga-rich regions.

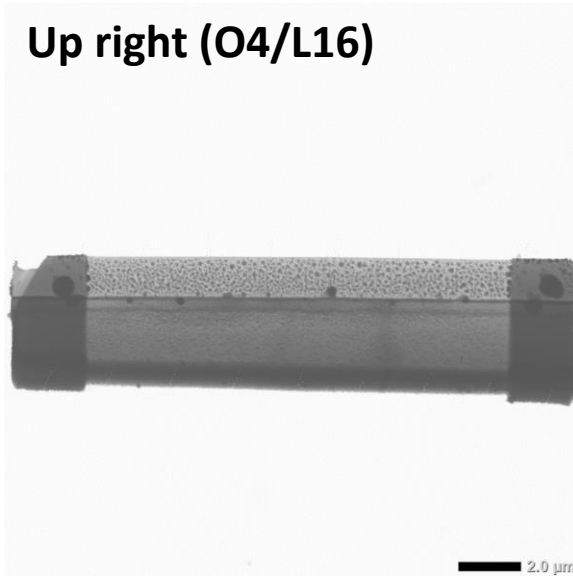
Down left (J5/L11)



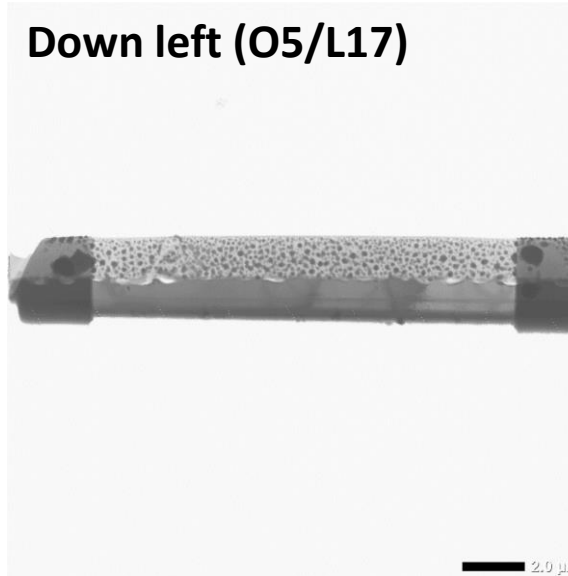
2. Sample 10 - JE595 regular oxidised annealed without silver plastic holder 21322462_068902_2020

Overview of 3 lamella analyzed

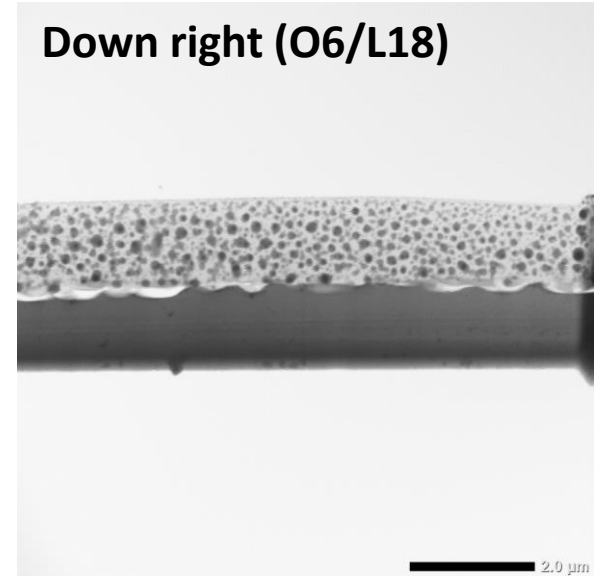
Up right (O4/L16)



Down left (O5/L17)



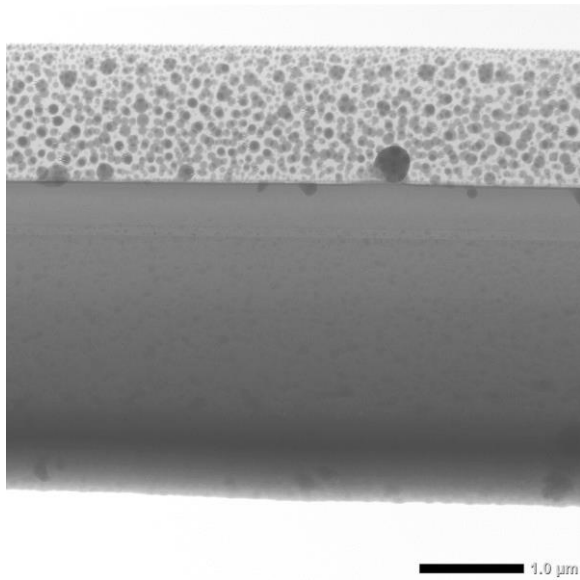
Down right (O6/L18)



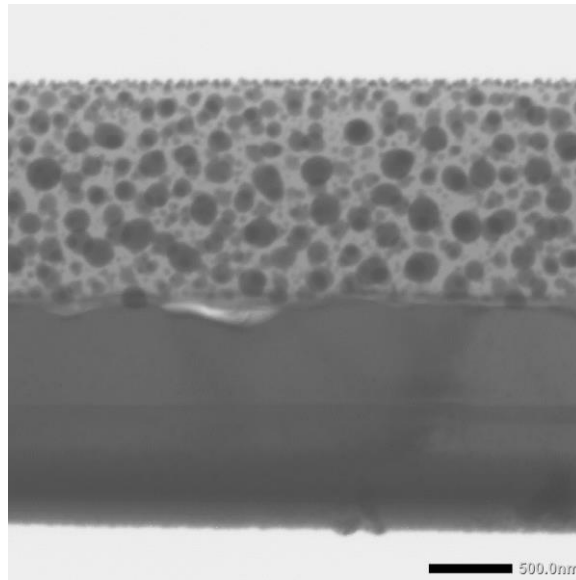
- Note: due to technical issues we seem to have deposited a lot of Ga “droplets” on top of the carbon layer, they reside on the surface as confirmed by secondary electron imaging.
- Lamella taken from different regions of the wafer show somewhat different surface roughness – from left-most lamella being nearly flat to the right-most having about 100 nm deep surface ridges.
- In case of rough wafer surface, aluminum-oxide layer seems to vary in thickness from 30 nm up to even 150 nm patches, also it seems to be broken, and in some places lifted up from GaAs to form pores beneath (see next slide and EDX). In case of flat wafer, thin (~50nm) and continuous alumina layer is seen.

2. Sample 10 - JE595 regular oxidised annealed without silver plastic holder 21322462_068902_2020

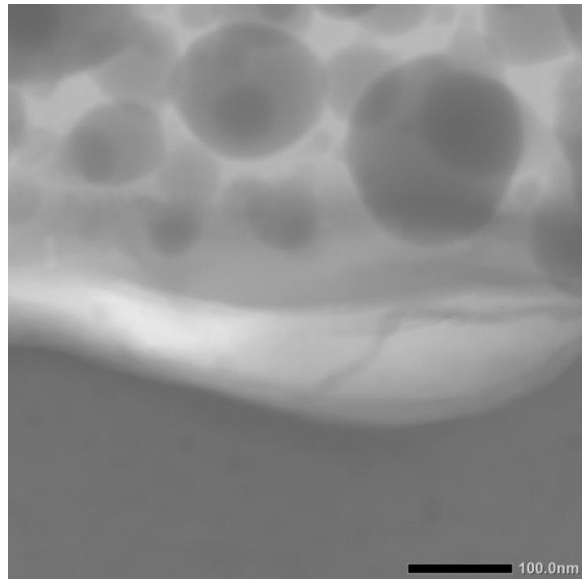
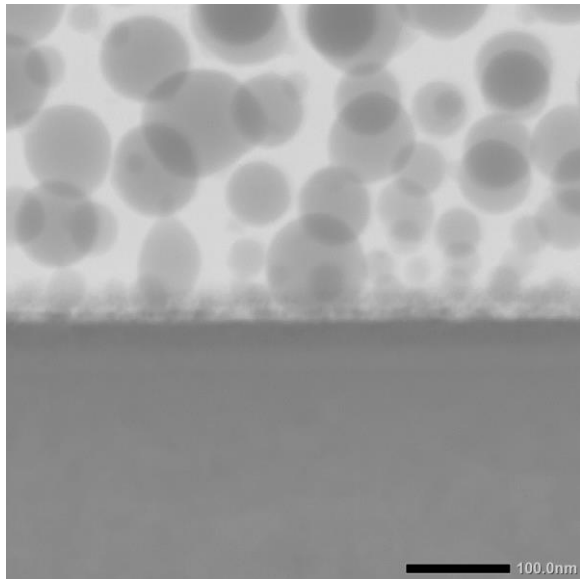
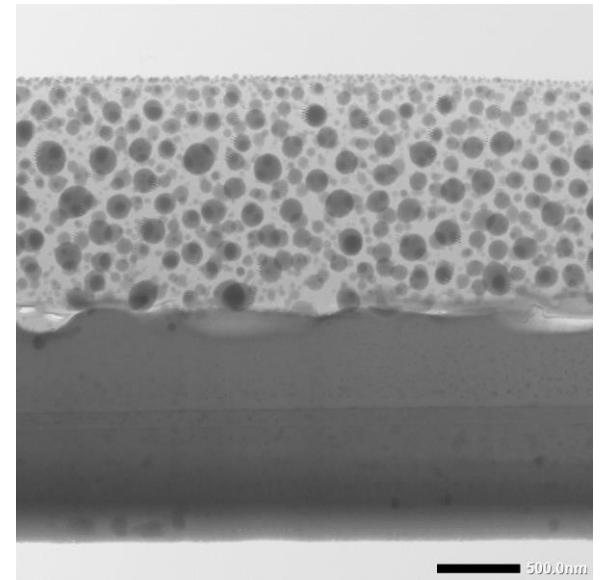
Up right (O4/L16)



Down left (O5/L17)

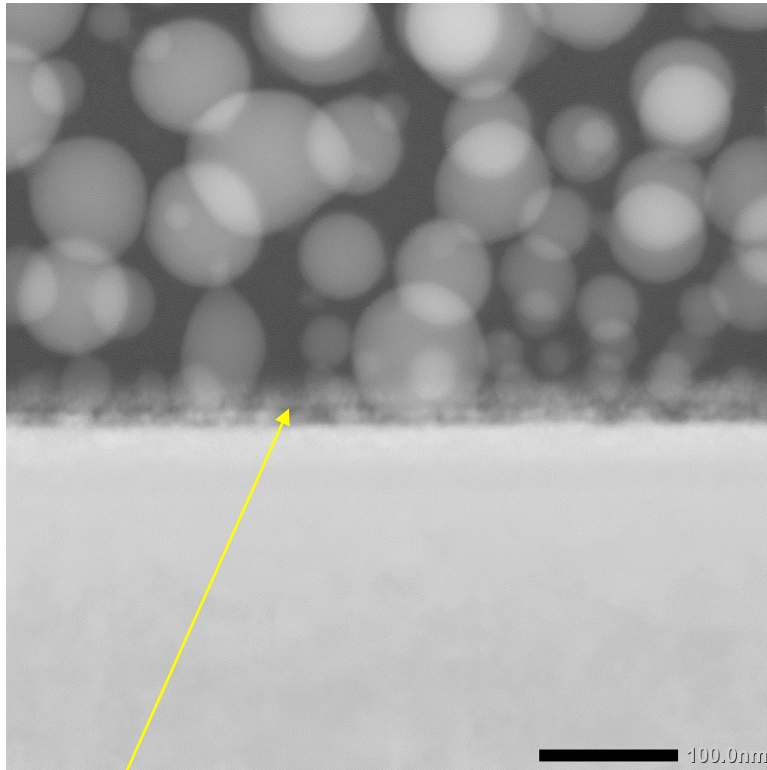


Down right (O6/L18)

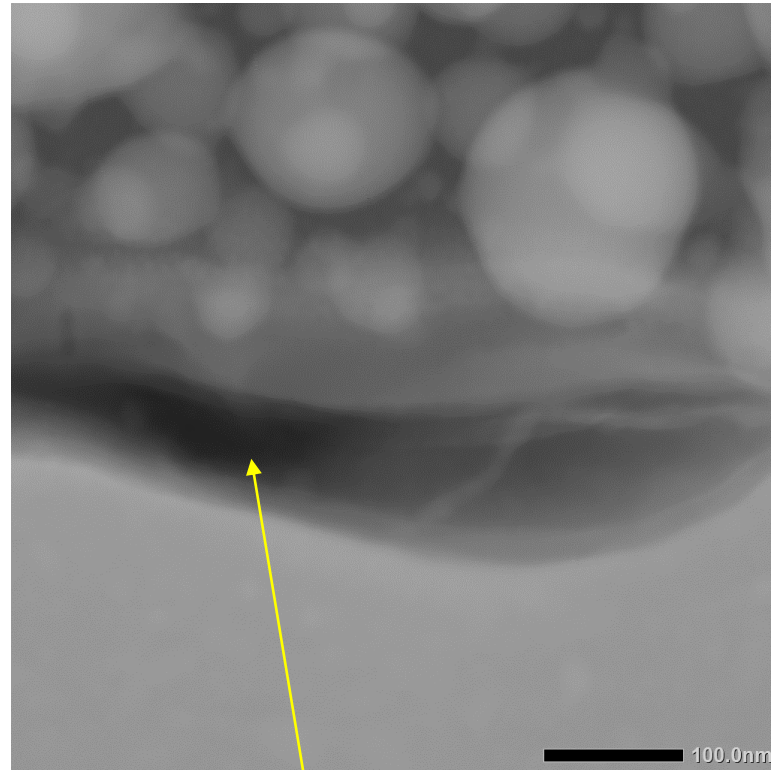


2. Sample 10 - JE595 regular oxidised annealed without silver plastic holder 21322462_068902_2020

Up right (O4/L16)



Down left (O5/L17)

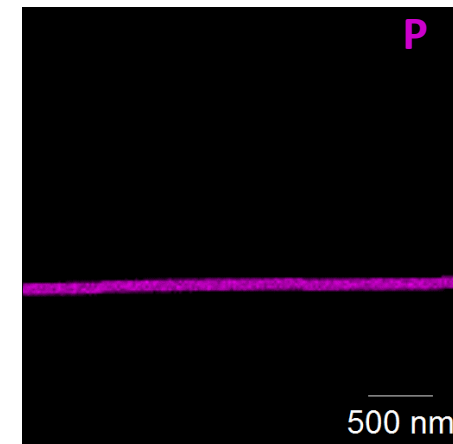
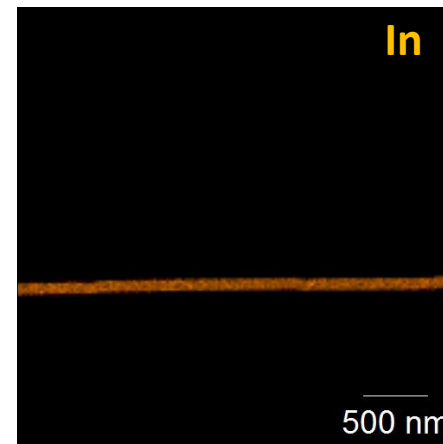
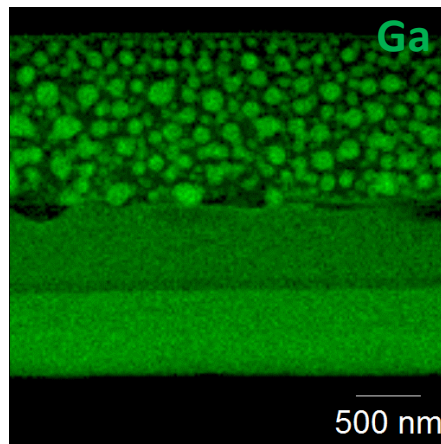
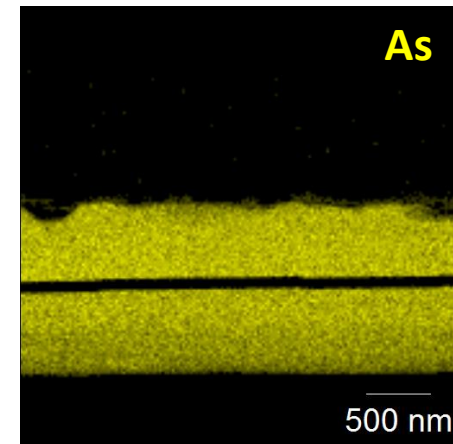
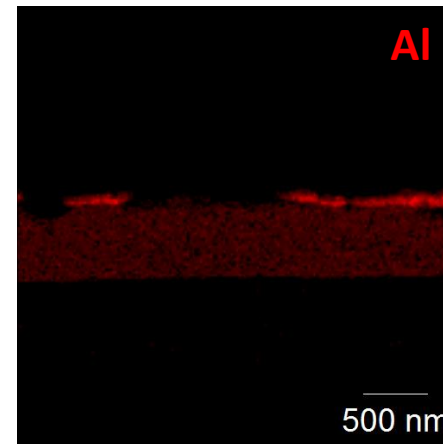
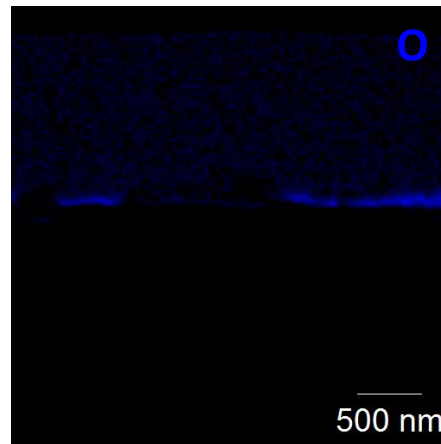
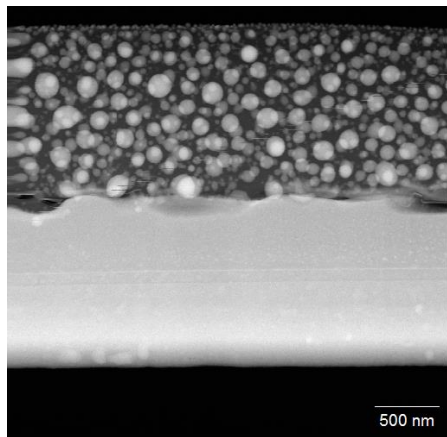


- Very thin alumina layer, porosity unclear
- Presence of pores in the ridges, with either absent or lifted alumina layer
- Unfortunately the presence of Ga deposits (technical issue) obstructs in part the view on top alumina layer.

2. Sample 10 - JE595 regular oxidised annealed without silver plastic holder 21322462_068902_2020

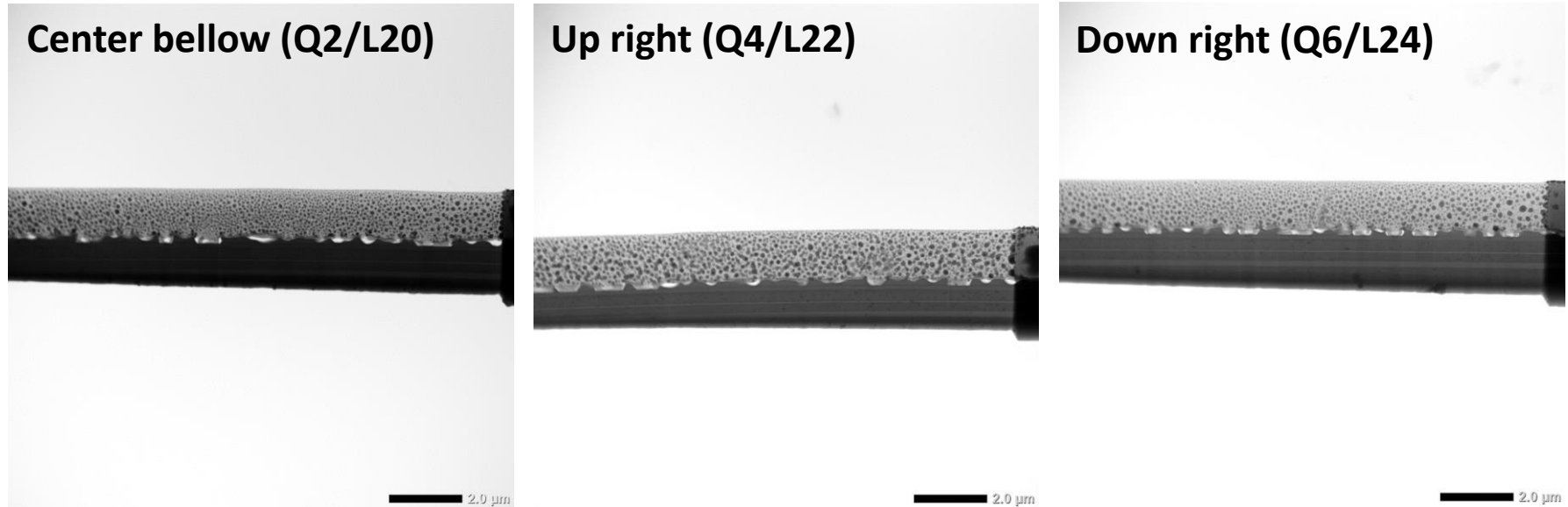
- Very thin alumina layer, broken in patches
- A very well defined layer of Ga/In/P has been observed in the wafer separating Al-present and Ga-poor (top) from Al-absent and Ga-rich regions

Down right (O6/L18)



3. Sample 13 - JE540 regular oxidised annealed without silver plastic holder 21322464_068902_2020

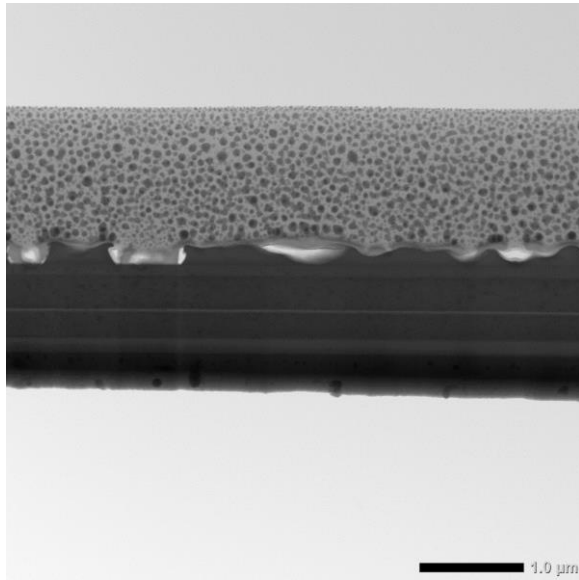
Overview of 3 lamella analyzed



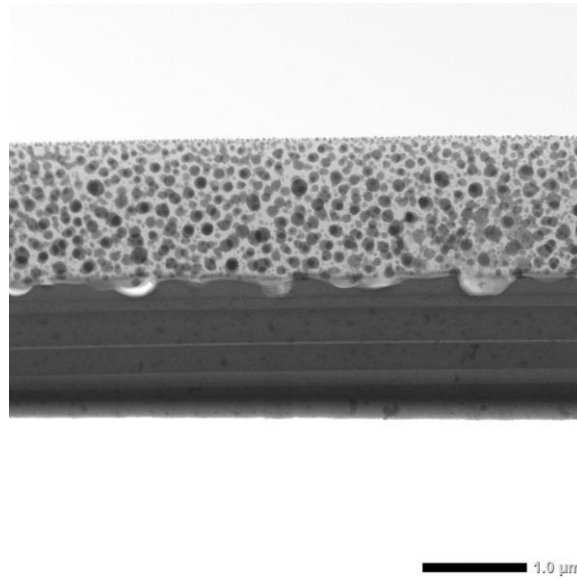
- Note: due to technical issues we seem to have deposited a lot of Ga “droplets” on top of the carbon layer, they reside on the surface as confirmed by secondary electron imaging.
- All lamella show similar surface roughness with depth of the ridges of ~30 to 150 nm.
- Aluminum-oxide layer seems to vary in thickness from 30 nm up to even 150 nm patches (filling up some ridges), also it seems to be broken, and in some places lifted up from GaAs to form pores beneath.

3. Sample 13 - JE540 regular oxidised annealed without silver plastic holder 21322464_068902_2020

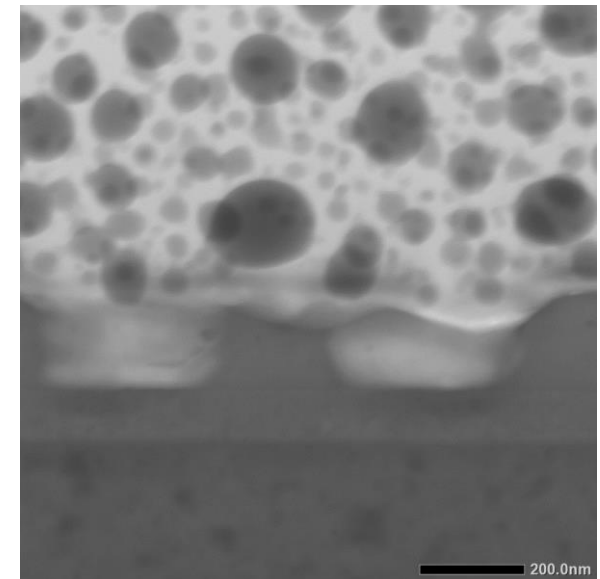
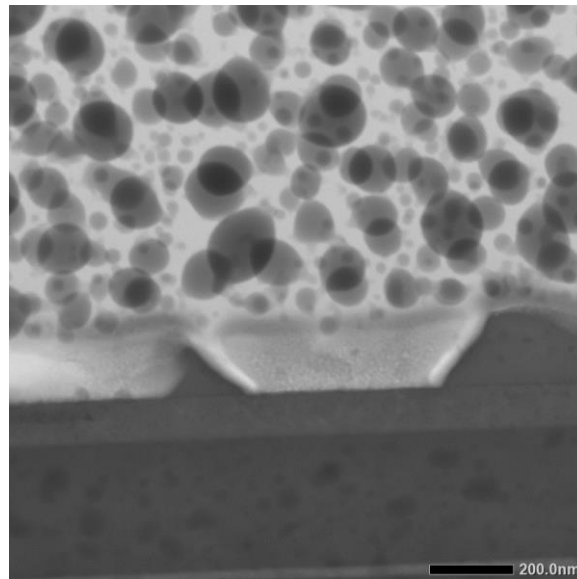
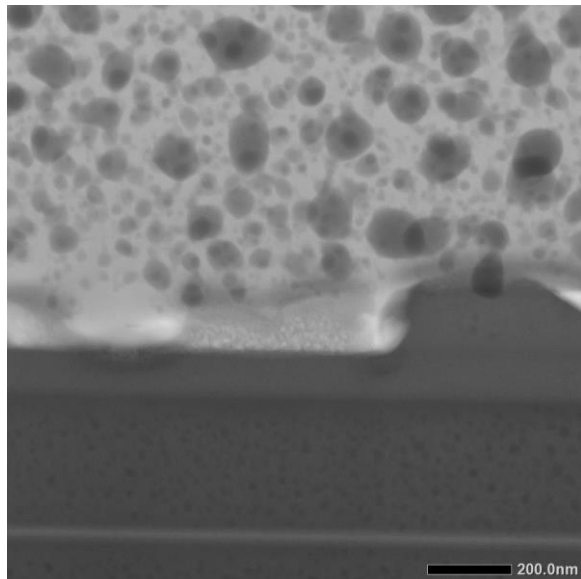
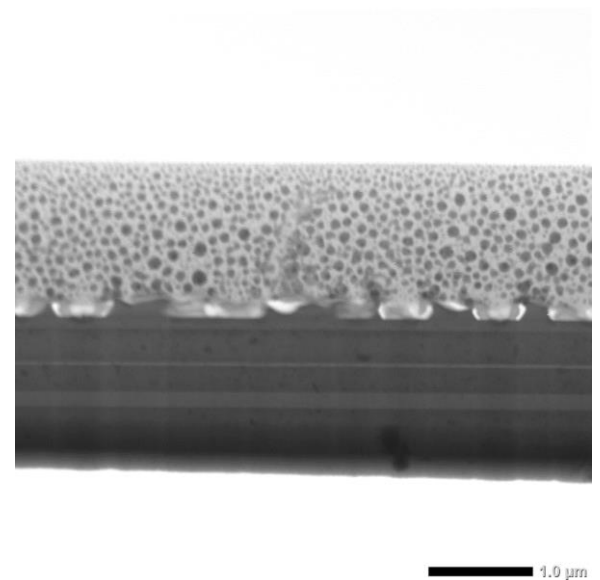
Center bellow (Q2/L20)



Up right (Q4/L22)

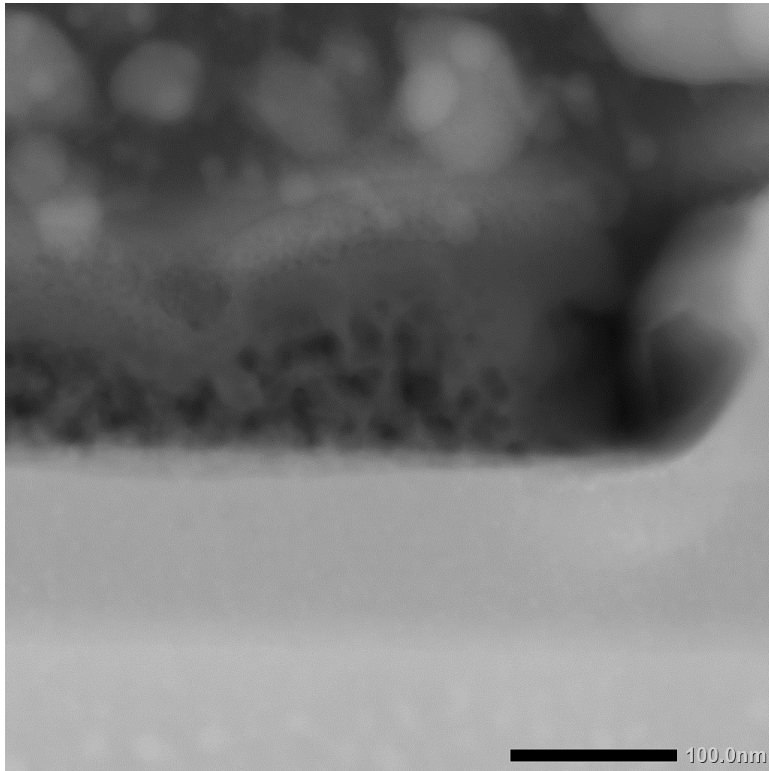


Down right (Q6/L24)

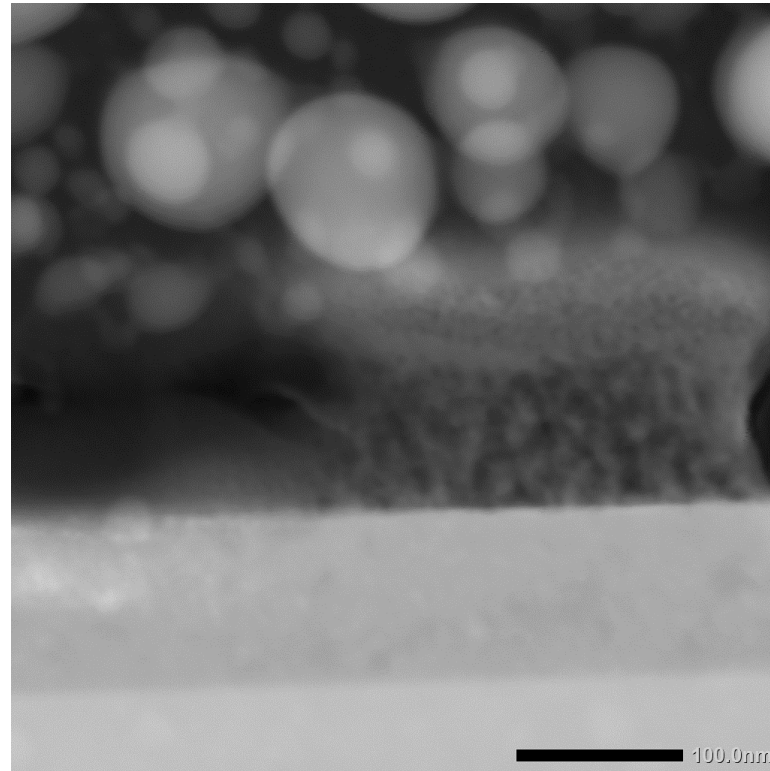


3. Sample 13 - JE540 regular oxidised annealed without silver plastic holder 21322464_068902_2020

Center bellow (Q2/L20)



Up right (Q4/L22)

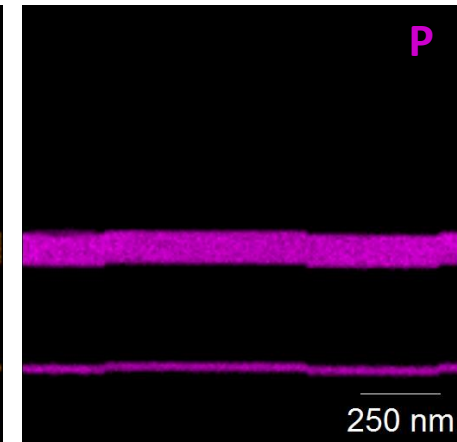
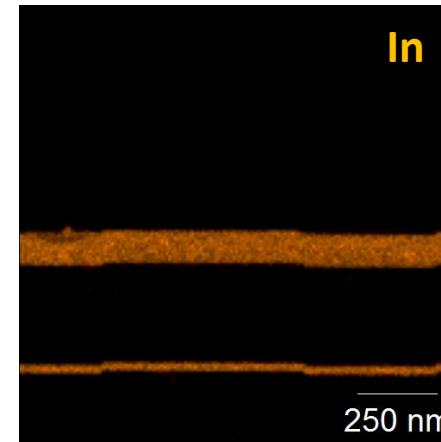
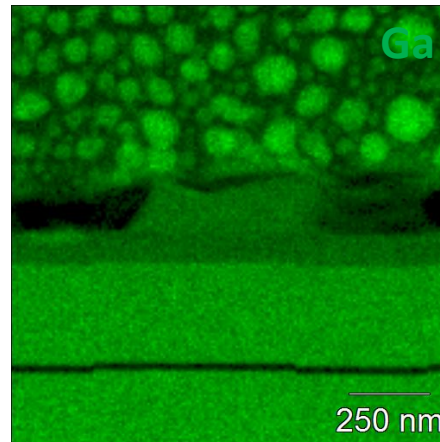
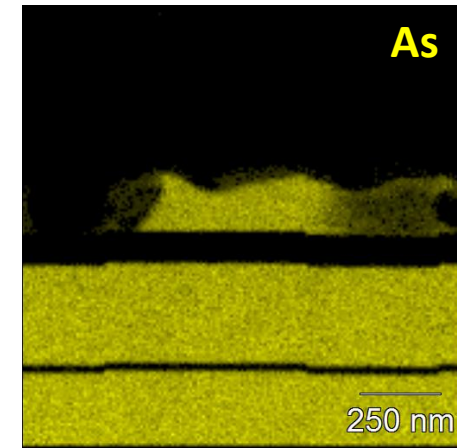
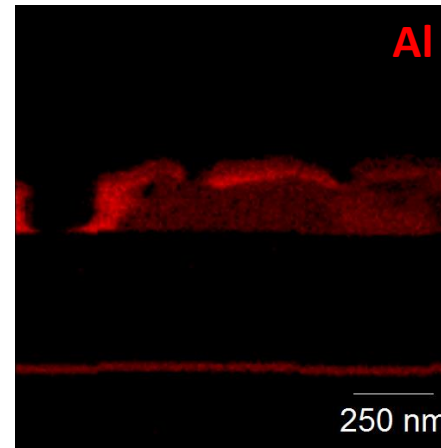
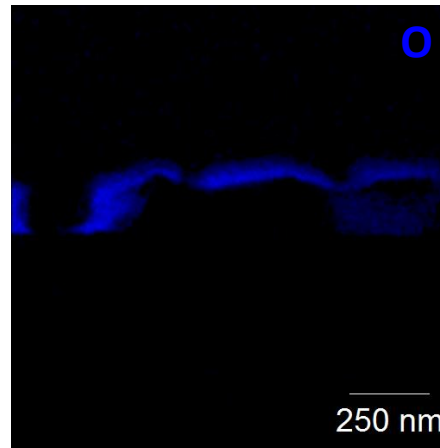
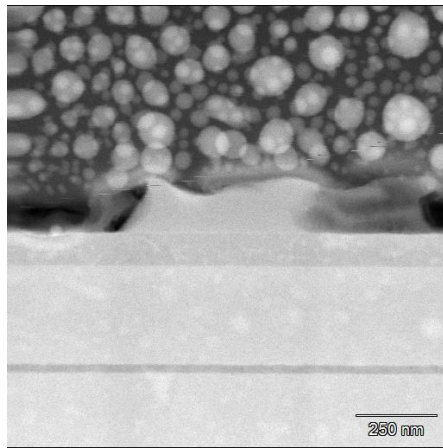


- High magnification images reveal that alumina layer shows pore-like structure with pores of about 5-10 nm.

3. Sample 13 - JE540 regular oxidised annealed without silver plastic holder 21322464_068902_2020

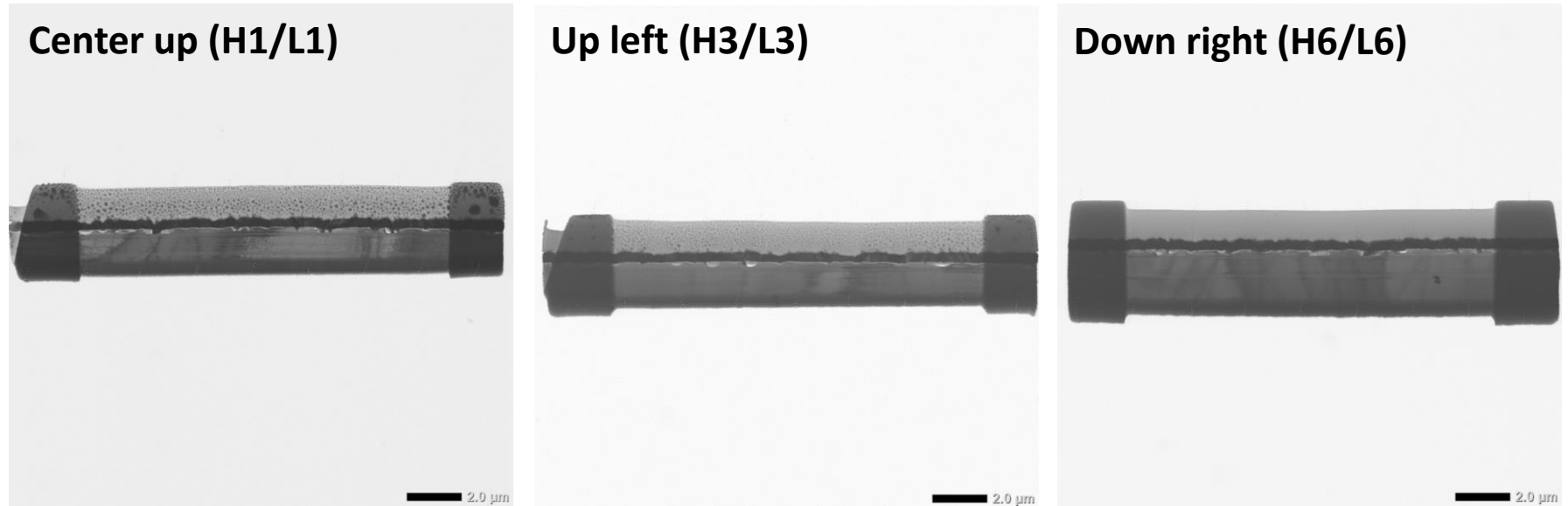
- A very well defined (and thicker) layer of Ga/In/P has been observed in the wafer, separating Al-present and Ga-poor (top) from Al-absent and Ga-rich regions, following is another In/P/Al thin layer
- Aluminum oxide region clearly defined with enriched Al and O signal

Down right (Q6/L24)



4. Sample 15 - JE540 regular oxidised unannealed with silver plastic holder 21322464_068902_2020

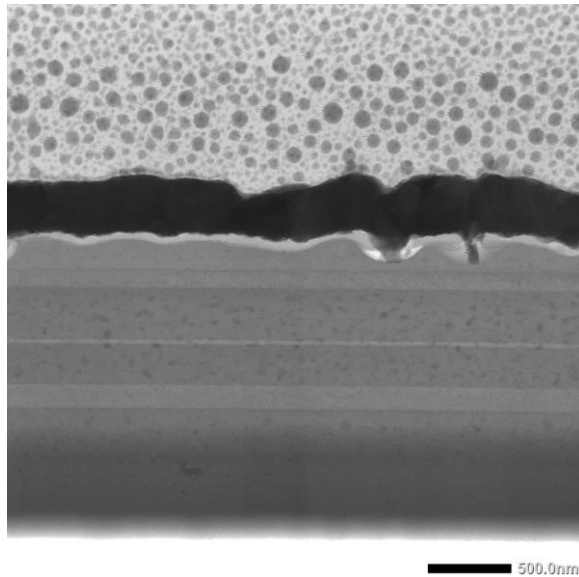
Overview of 3 lamella analyzed



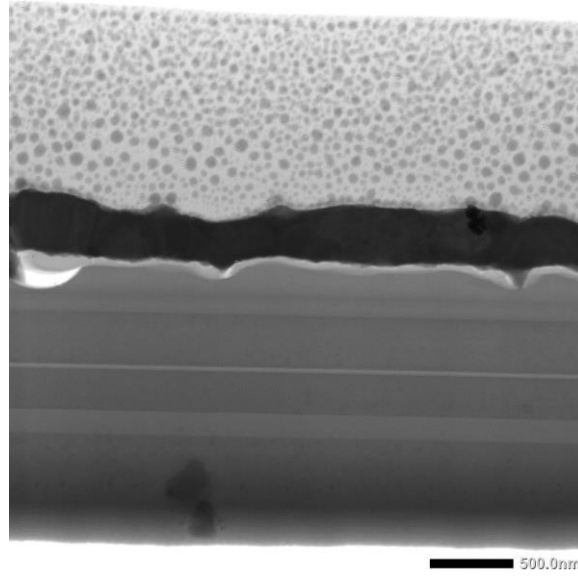
- Note: due to technical issues we seem to have deposited a lot of Ga “droplets” on top of the carbon layer, they reside on the surface as confirmed by secondary electron imaging. Interestingly right-most lamella seem to be free of this artefact.
- All lamella show similar Ag and GaAs wafer surface roughness with depth of the ridges of ~30 to 150 nm.
- Aluminum-oxide layer seems to vary in thickness from 50 nm to 150 nm patches (filling up ridges), also it seems to more continuous and less broken that in previous 3 samples.

4. Sample 15 - JE540 regular oxidised unannealed with silver plastic holder 21322464_068902_2020

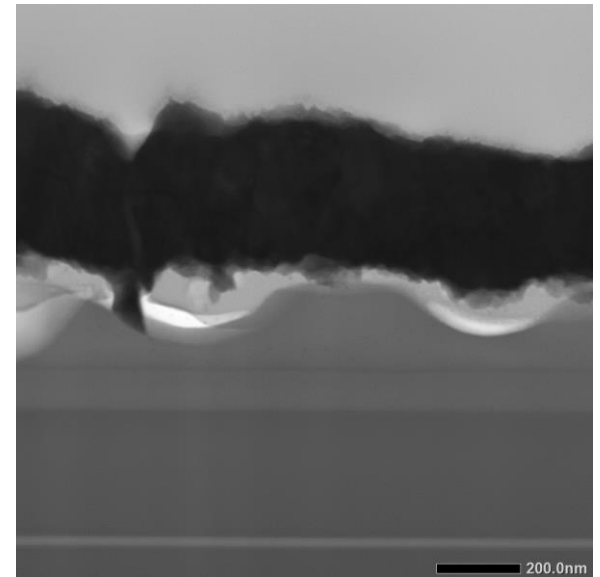
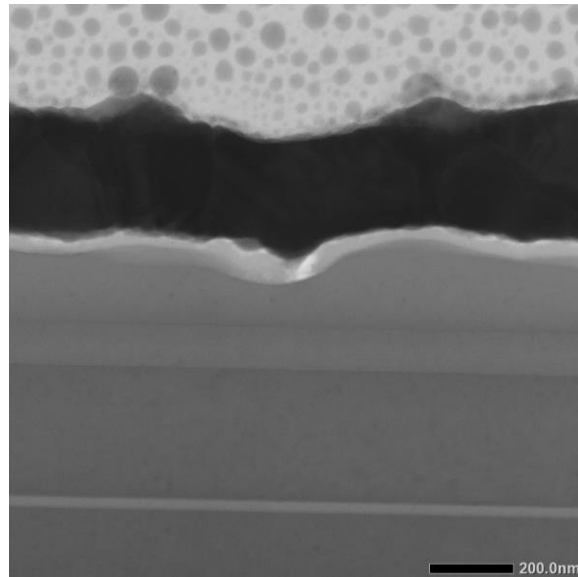
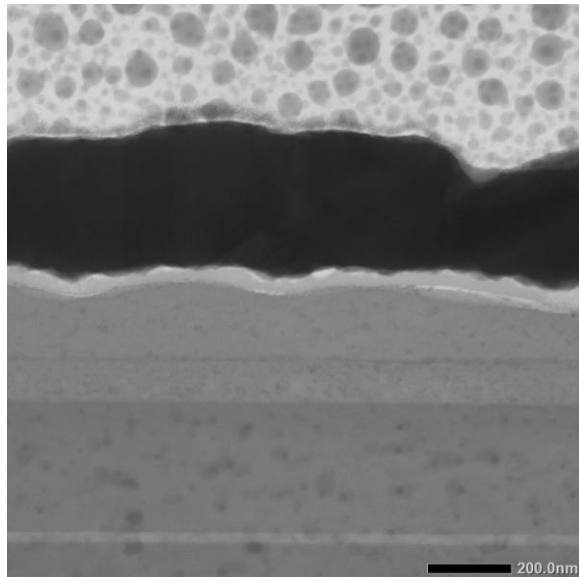
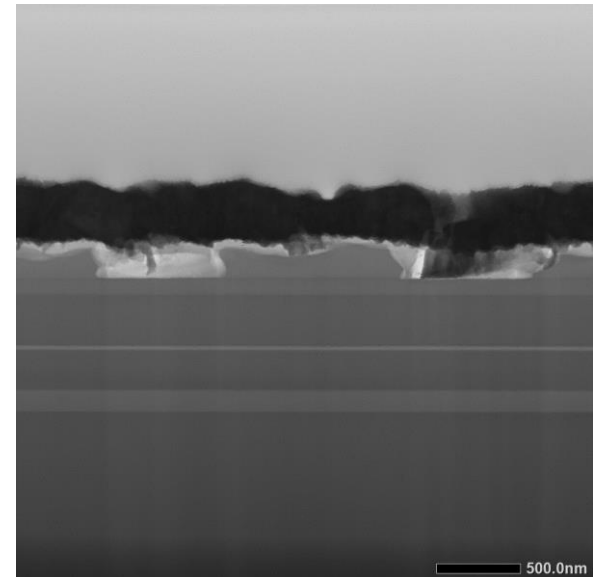
Center up (H1/L1)



Up left (H3/L3)

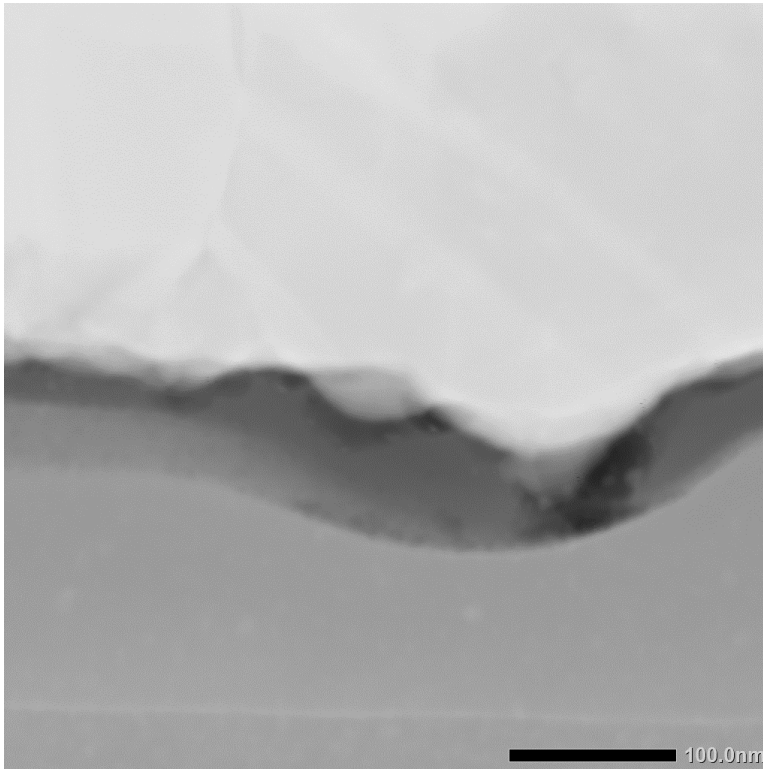


Down right (H6/L6)

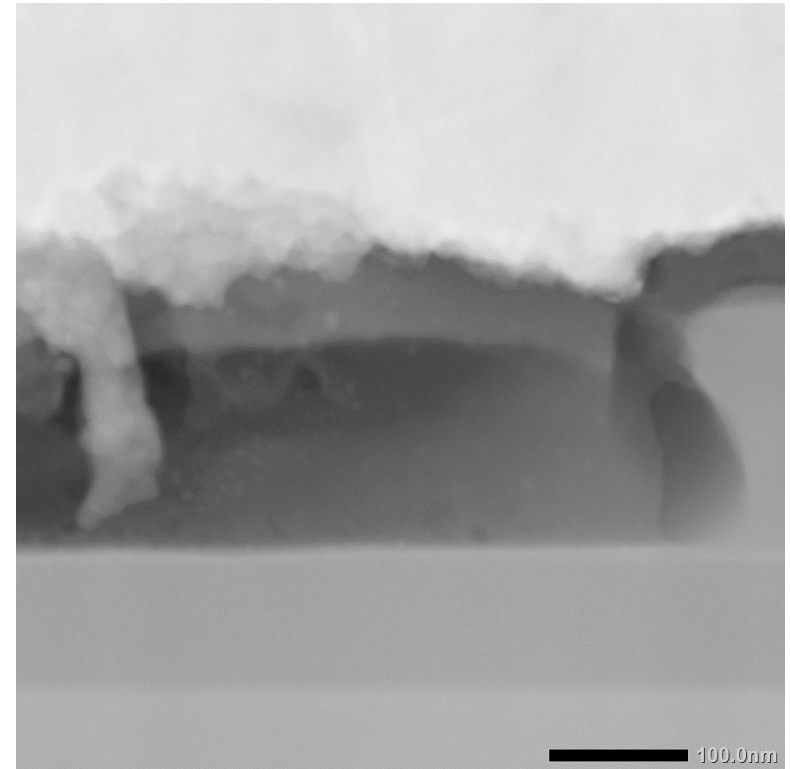


4. Sample 15 - JE540 regular oxidised unannealed with silver plastic holder 21322464_068902_2020

Up left (H3/L3)



Down right (H6/L6)



- High magnification images do not show as clearly the presence of pores in alumina.
- Protrusion of Ag through alumina is observed in several places.

4. Sample 15 - JE540 regular oxidised unannealed with silver plastic holder 21322464_068902_2020

- A very well defined (and thicker) layer of Ga/In/P has been observed in the wafer, separating Al-present and Ga-poor (top) from Al-absent and Ga-rich regions, following is another thinner In/P/Al layer
- Alumina layer clearly defined with enriched Al and O signals
- Alumina layer appears more intact and continuous.

