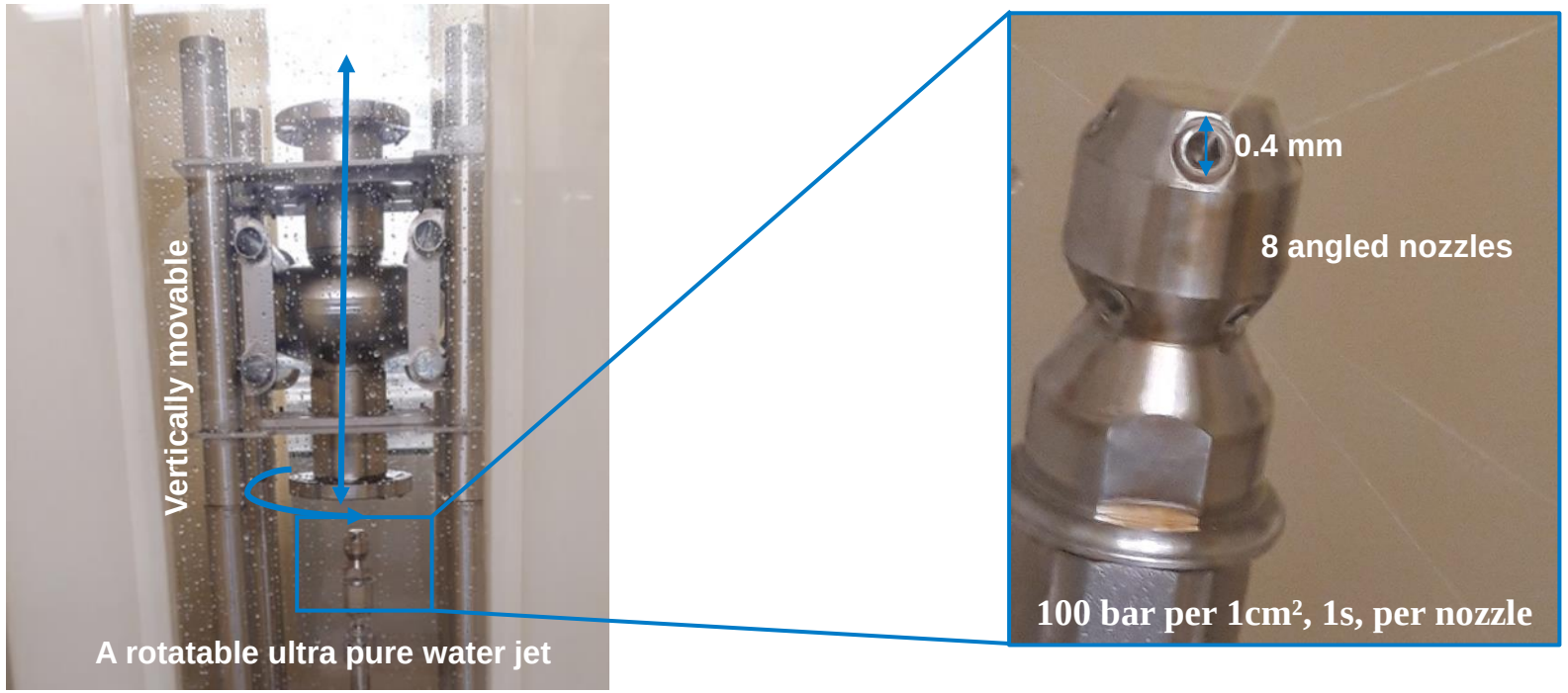
Influence of High Pressure Rinsing Prior to Mid-T Heat Treatment

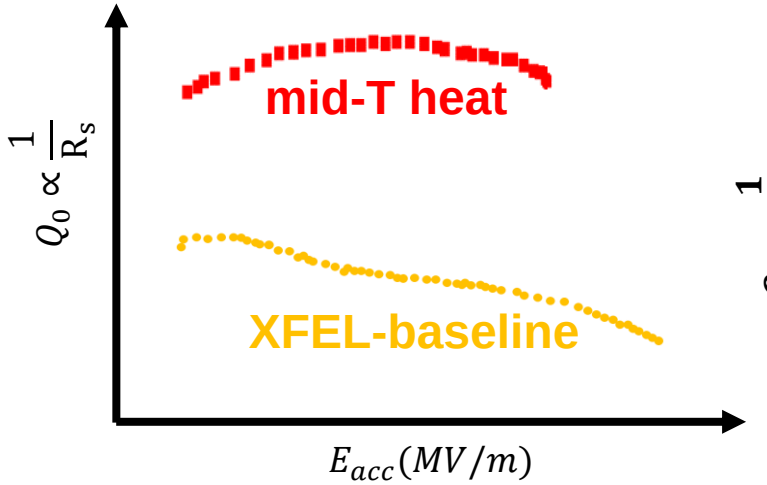
Rezvan Ghanbari, on behalf of SRF R&D and DESY Nanolab teams



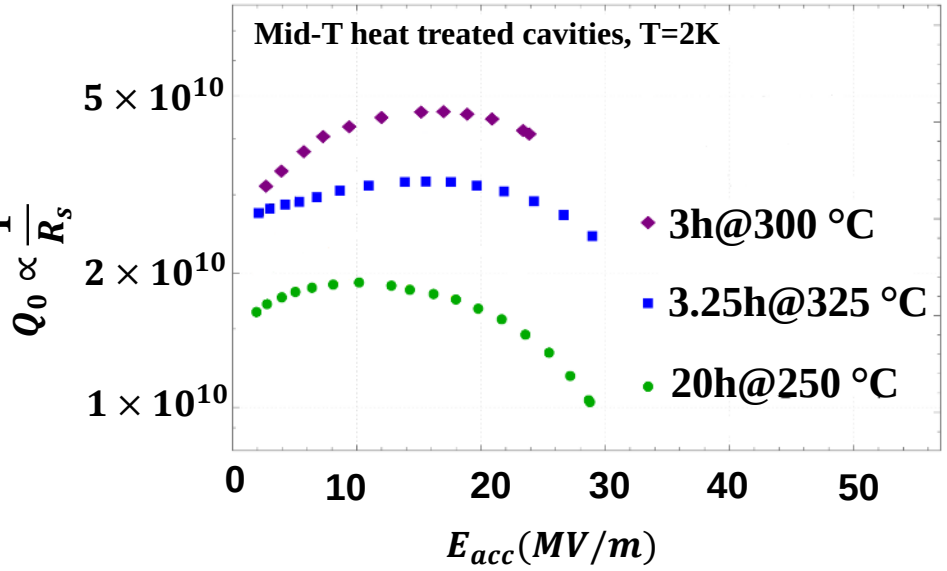
Tuning the interstitial oxygen concentration of mid-T heat treated cavities

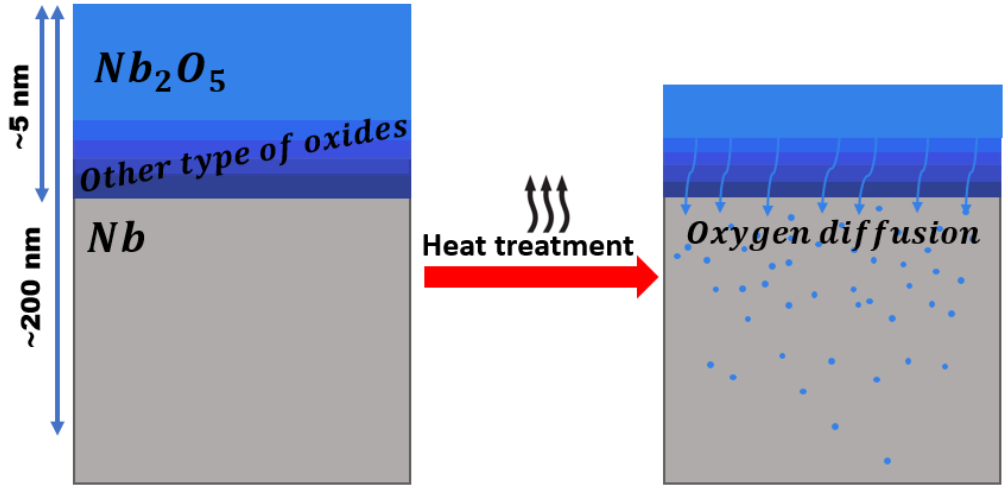
By the number of HPR cycles before the heat treatment

- Mid-T heat treatment
  (3-20 h @ 200-400°C in UHV)
  improves Q_0 and changes dQ_0/dE_{acc}
- Oxygen concentration is the key parameter for mid-T heat treatment
- HPR affects pentoxide growth



[L. Steder, et al., 10.18429/JACOW-LINAC2022-THPOGE22]





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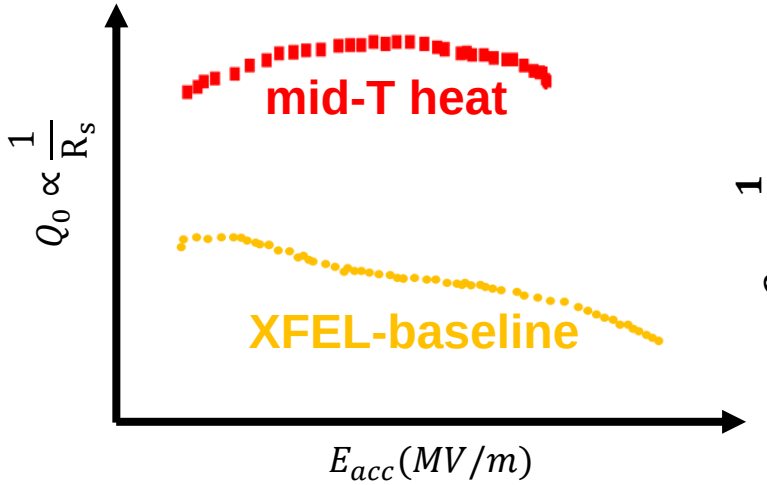

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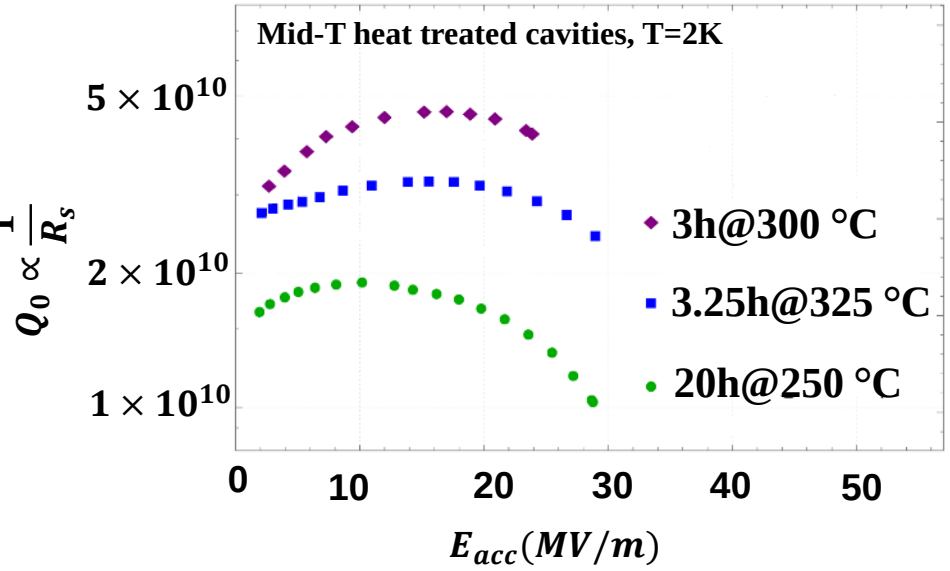
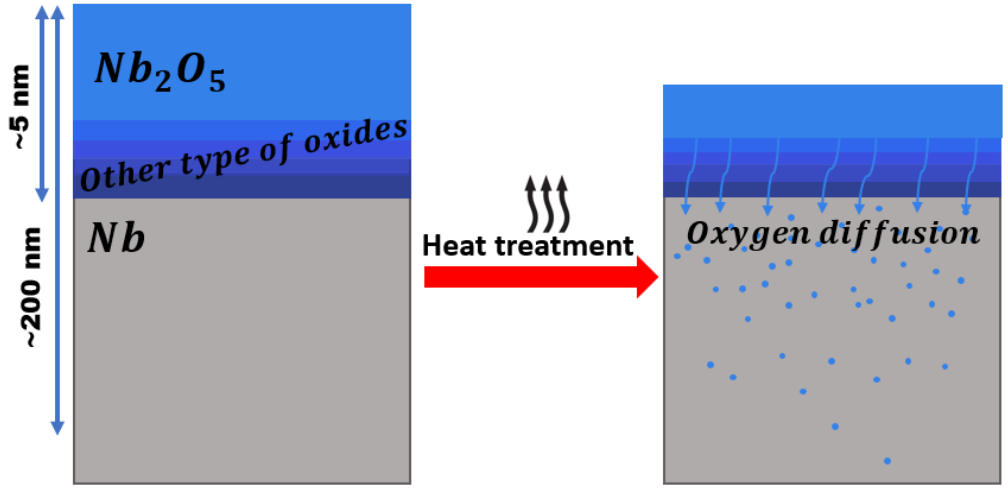
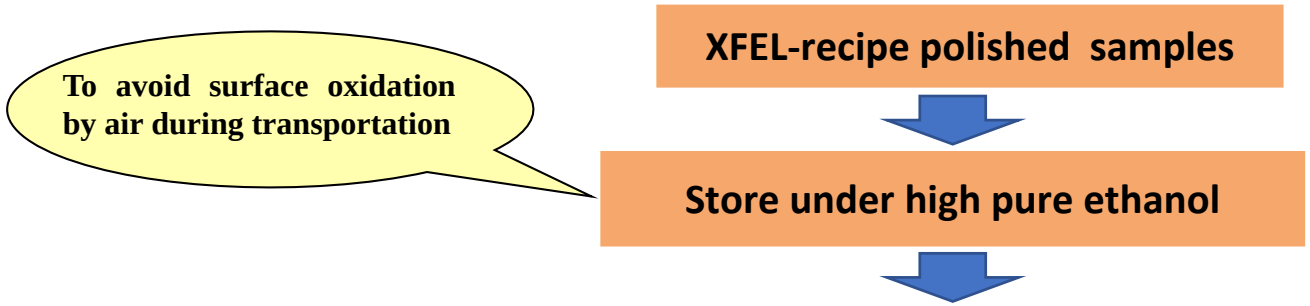


Higher number of HPR cycles



How does the oxygen concentration change?

Steps to study the influence of HPR on oxide layers



Steps to study the influence of HPR on oxide layers

To avoid surface oxidation by air during transportation

XFEL-recipe polished samples

Store under high pure ethanol

Reference 0 HPR cycle	Standard recipe 6 HPR cycles	18 HPR cycles

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XPS measurements

To identify and measure thickness of different oxide layers

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Mid-T heat treatment was done in the same furnace and the same run at 300 ℃ for 3h

To reset the oxide layers on the surfaces by removing saturated oxide layers and regrow oxide layers with HPR

HF acid rinsing and repeat HPR step

Mid-T heat treatment

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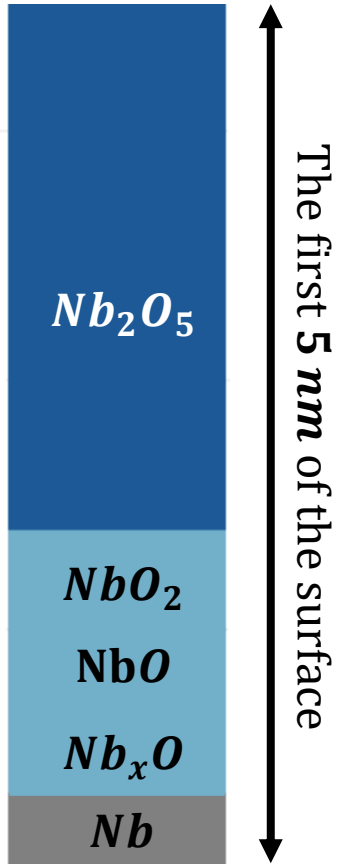
Mid-T heat treatment

Interstitial oxygen concentration after Mid-T heat treatment could depend on number of HPR cycles

SIMS & XPS measurements

X-ray photoelectron spectroscopy (XPS) to probe composition

- XPS measurements are done with the same voltage and condition
- penetrate **the first 5 nm** of the sample surfaces
- Deconvolute the spectra with known oxide layer structure



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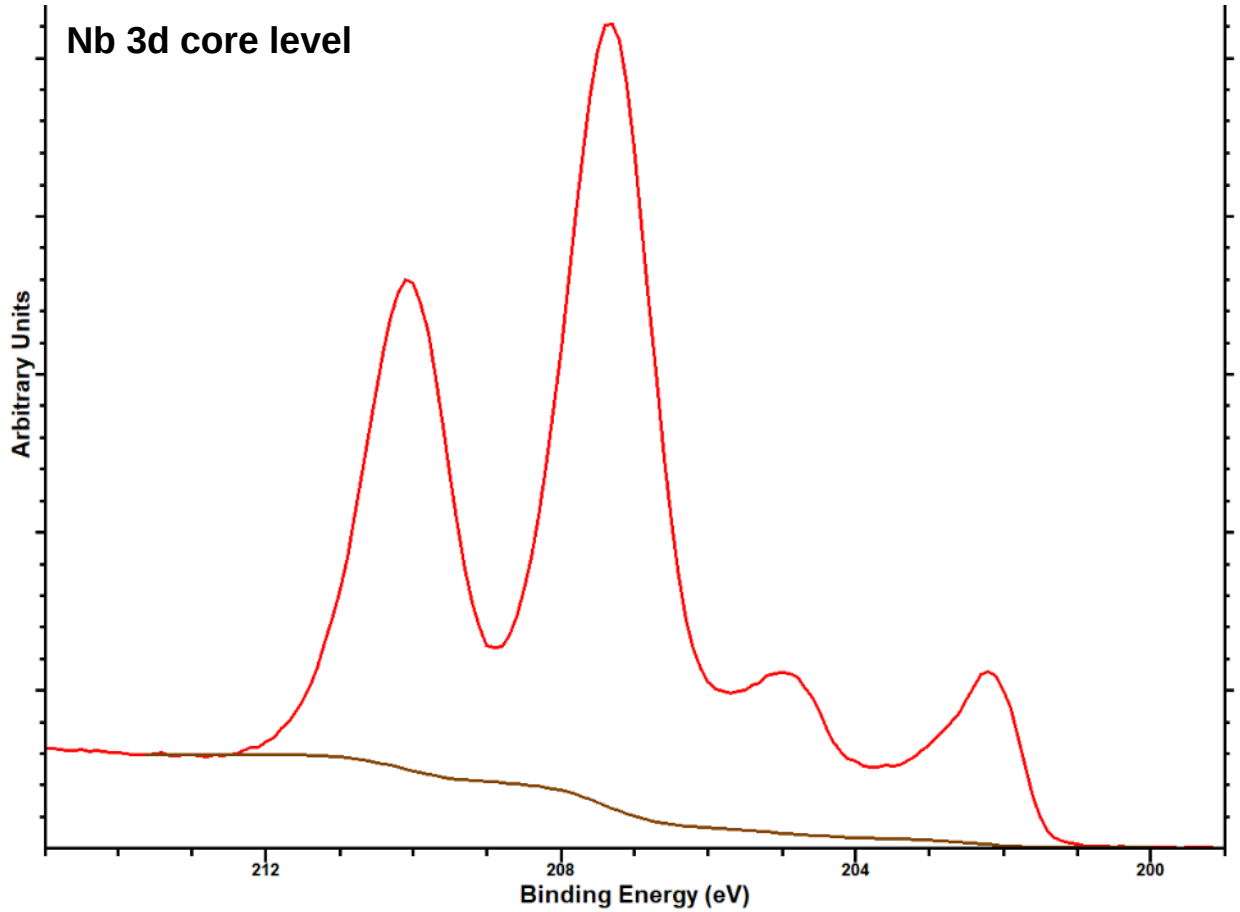

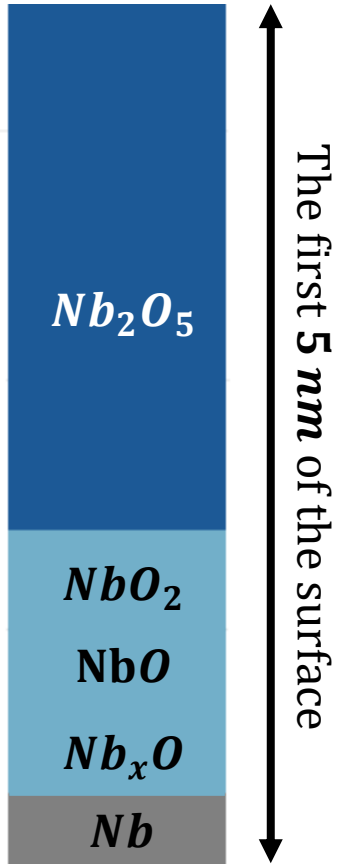

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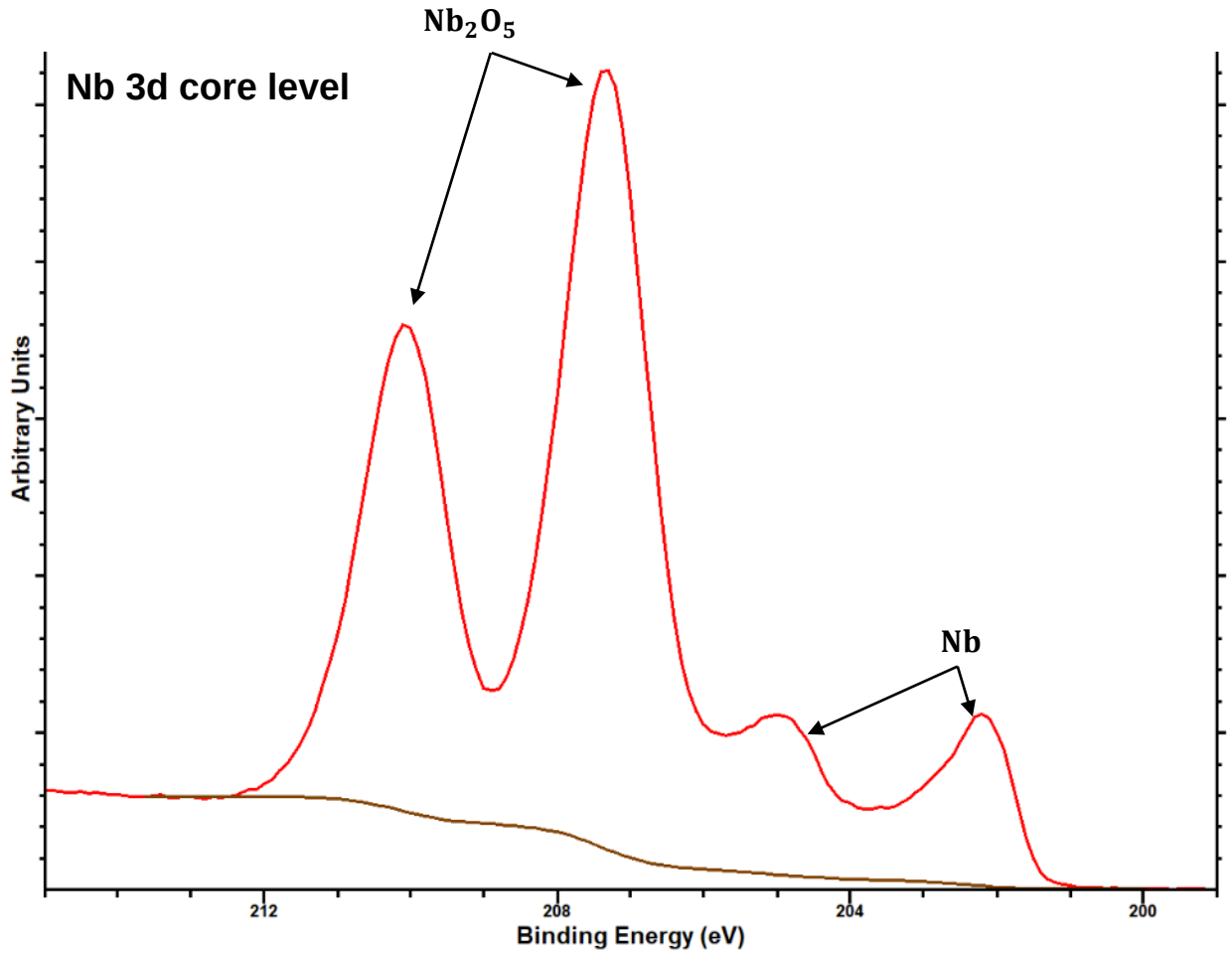

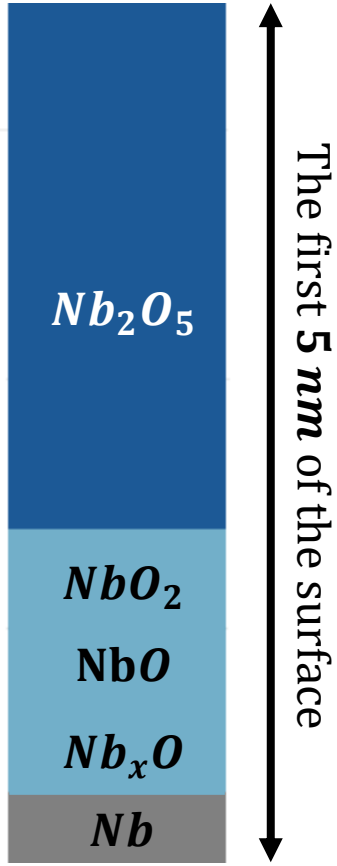

The first **5** ***nm*** of the surface

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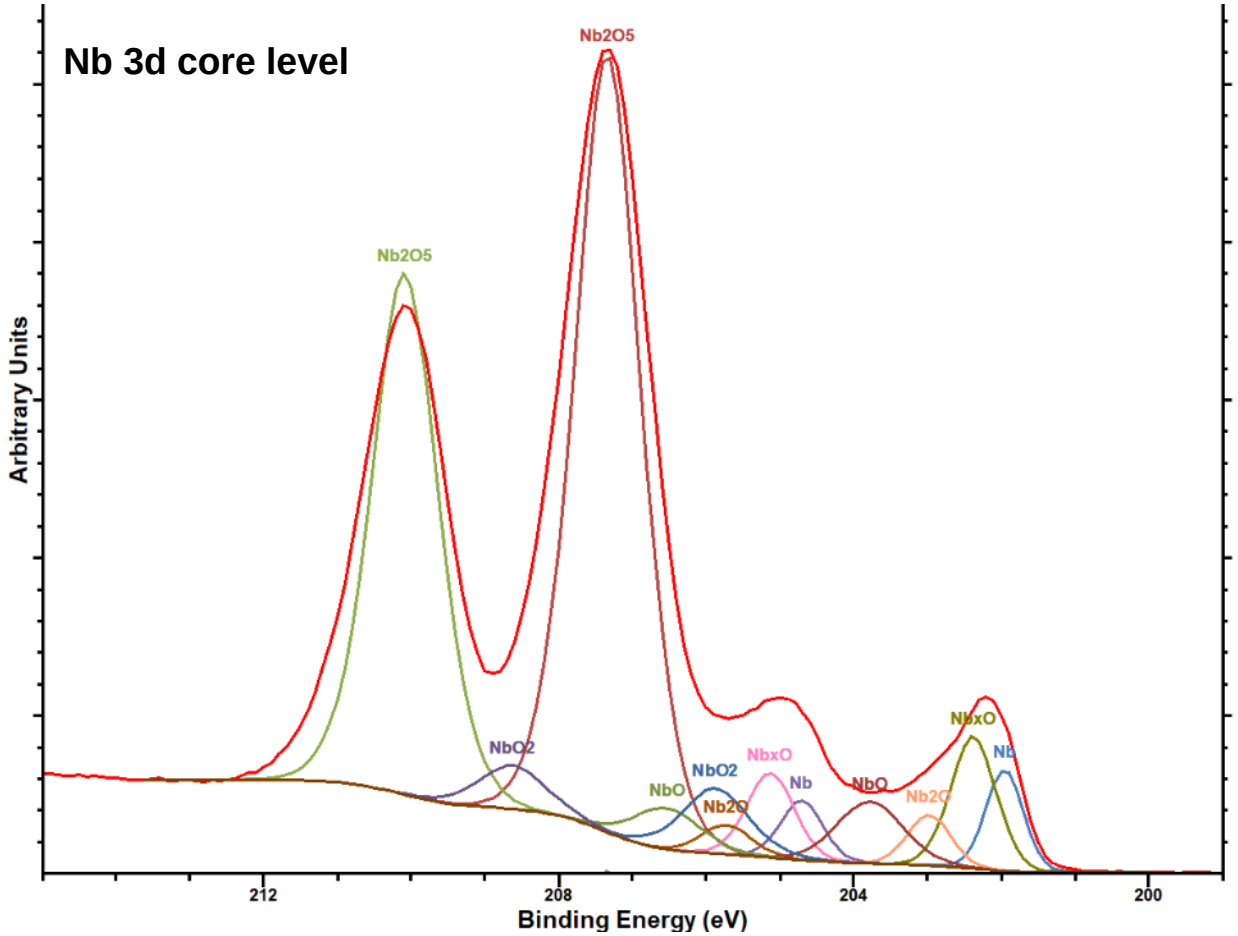

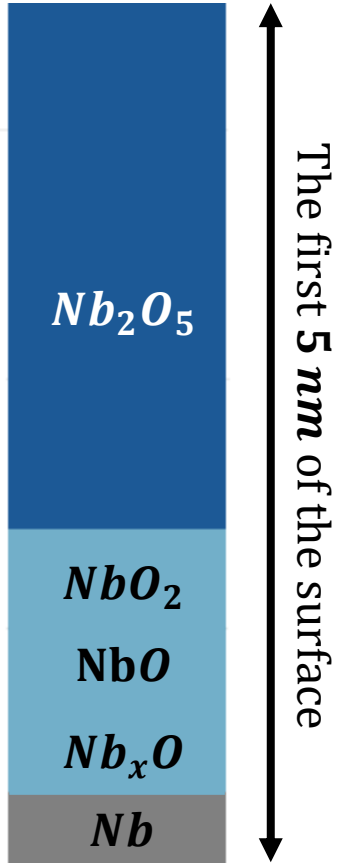

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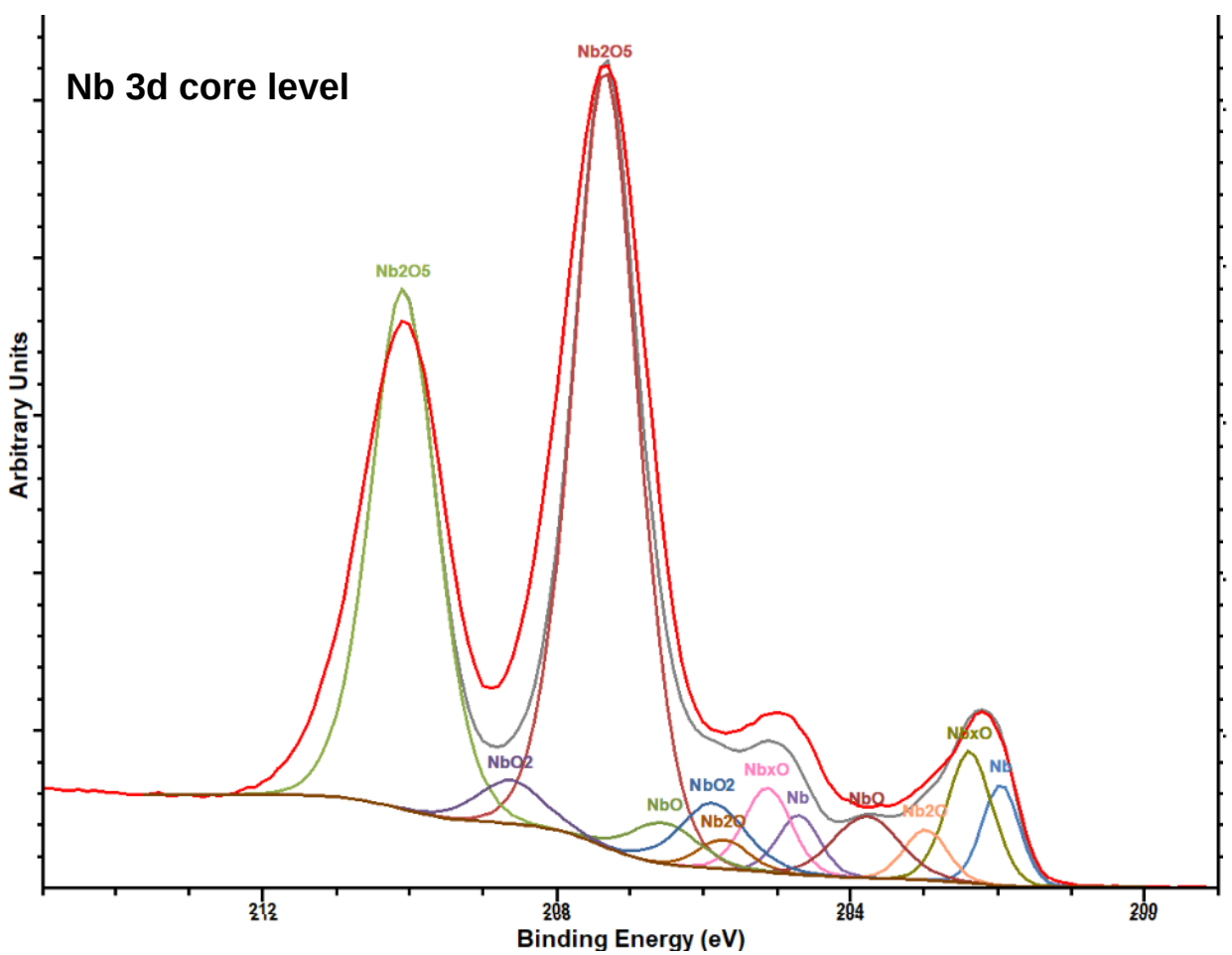

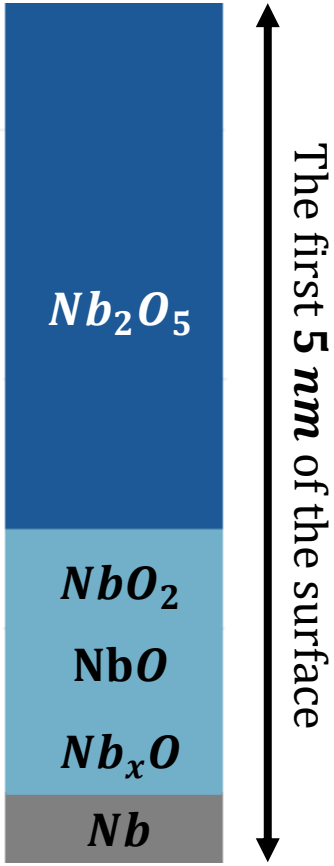

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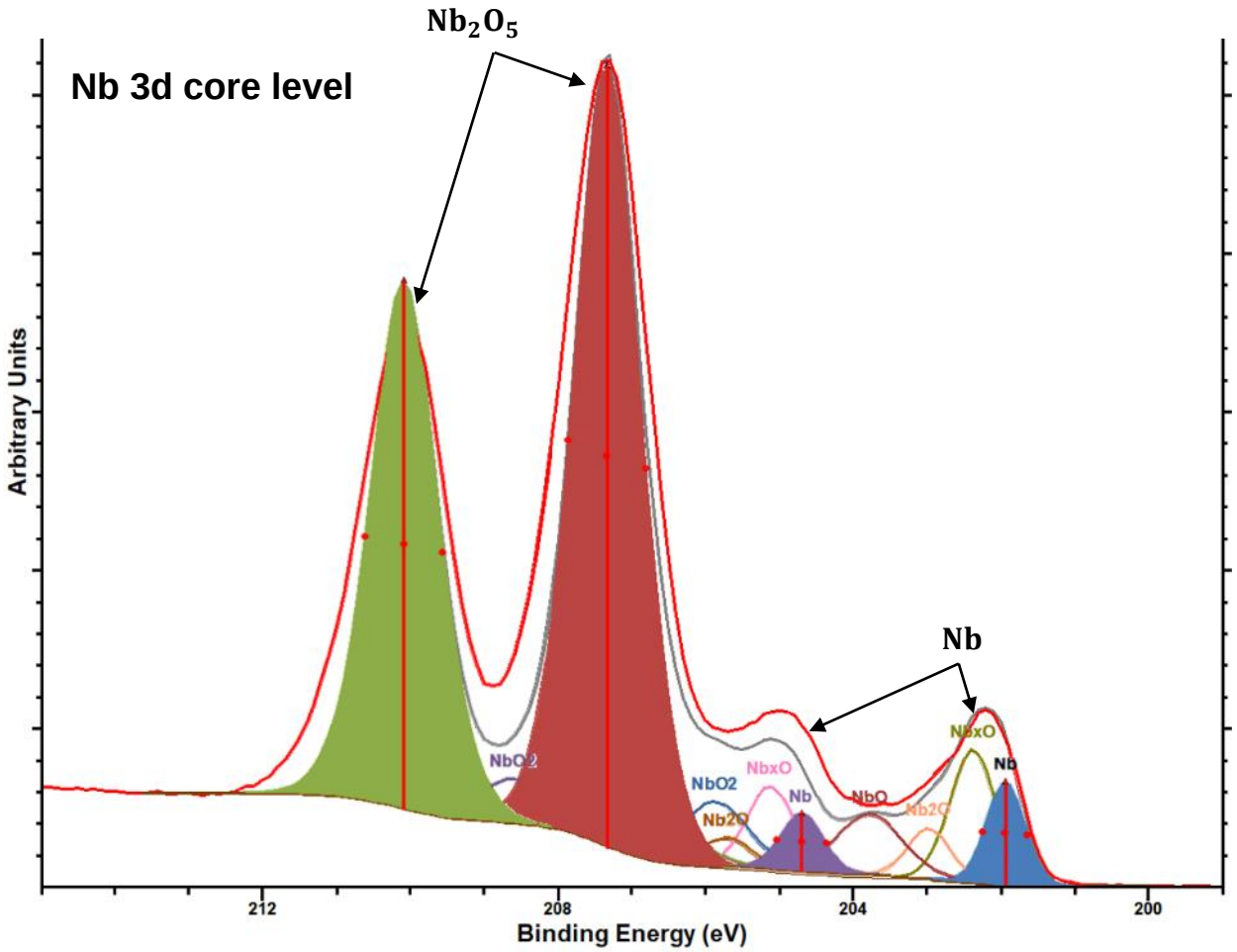
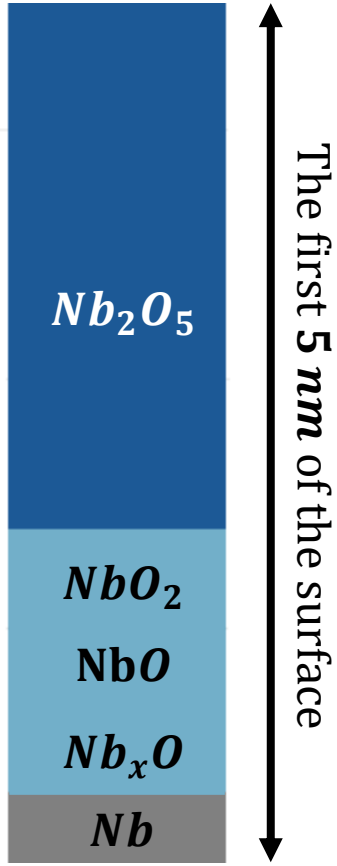
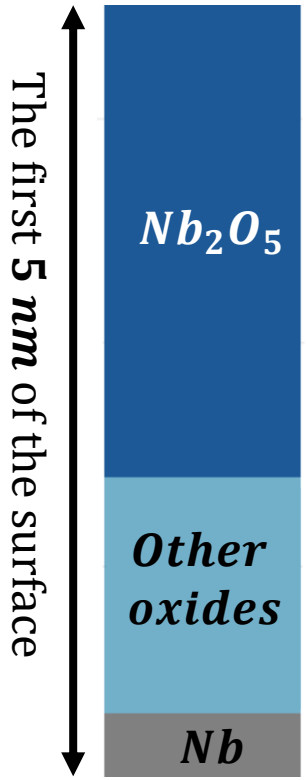




The first **5** ***nm*** of the surface

Extensive HPR grows thicker and mid-T heat treatment causes thinner pentoxide

X-Ray Photoelectron Spectroscopy (XPS)



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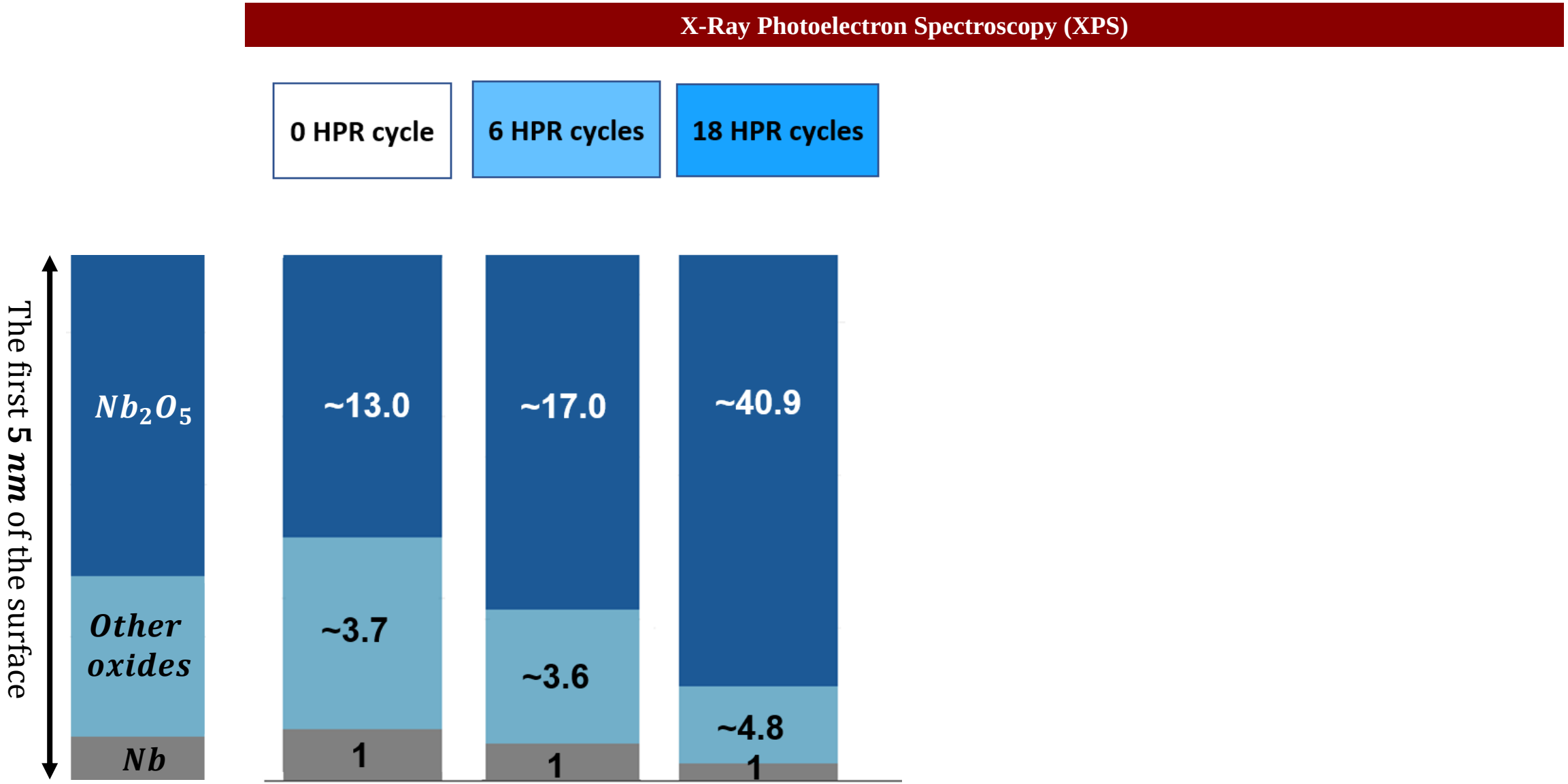

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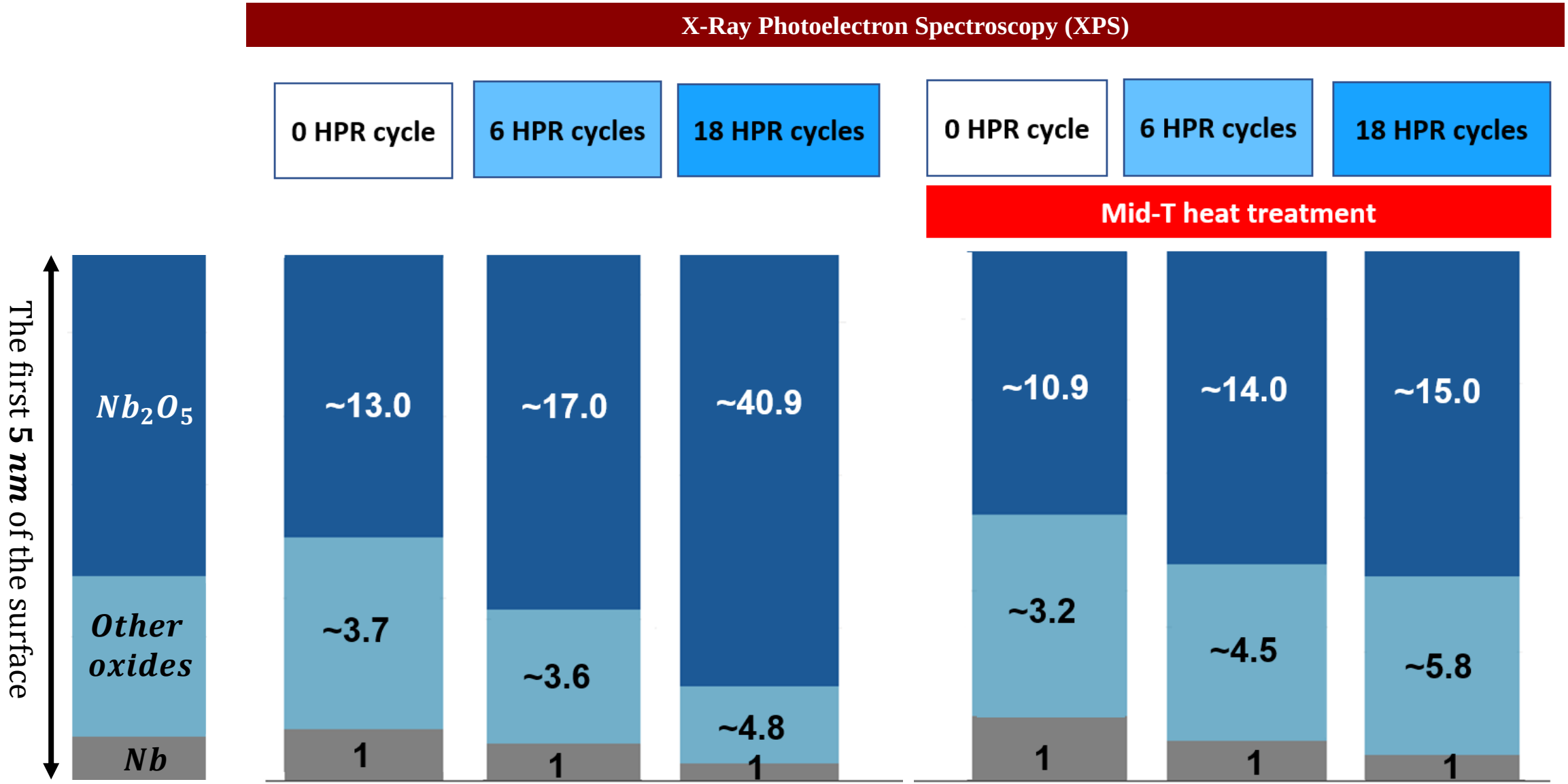
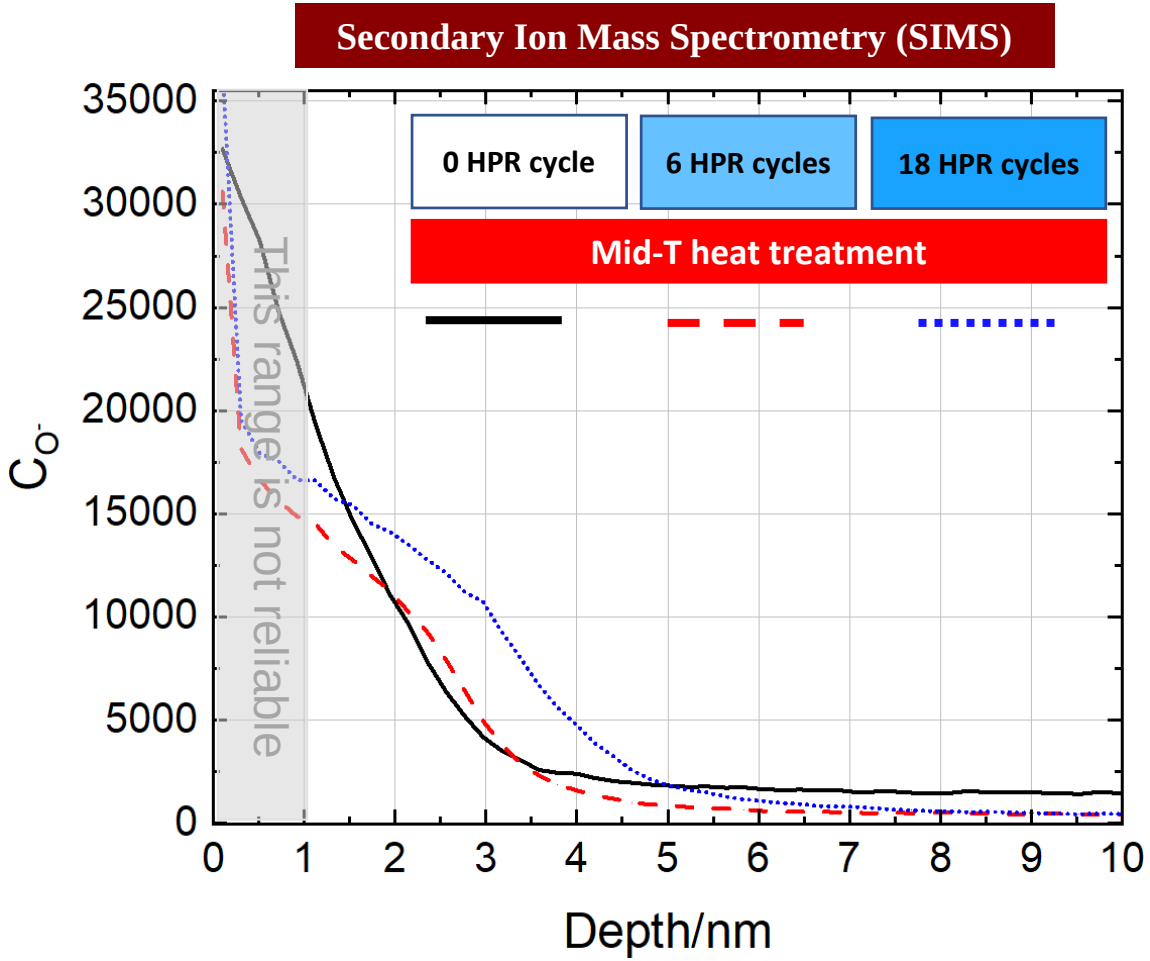


HPR prior to mid-T heat treatment changes the oxygen concentration after heating

- Samples with HPR cycles have different oxygen distribution compared to no-HPR sample



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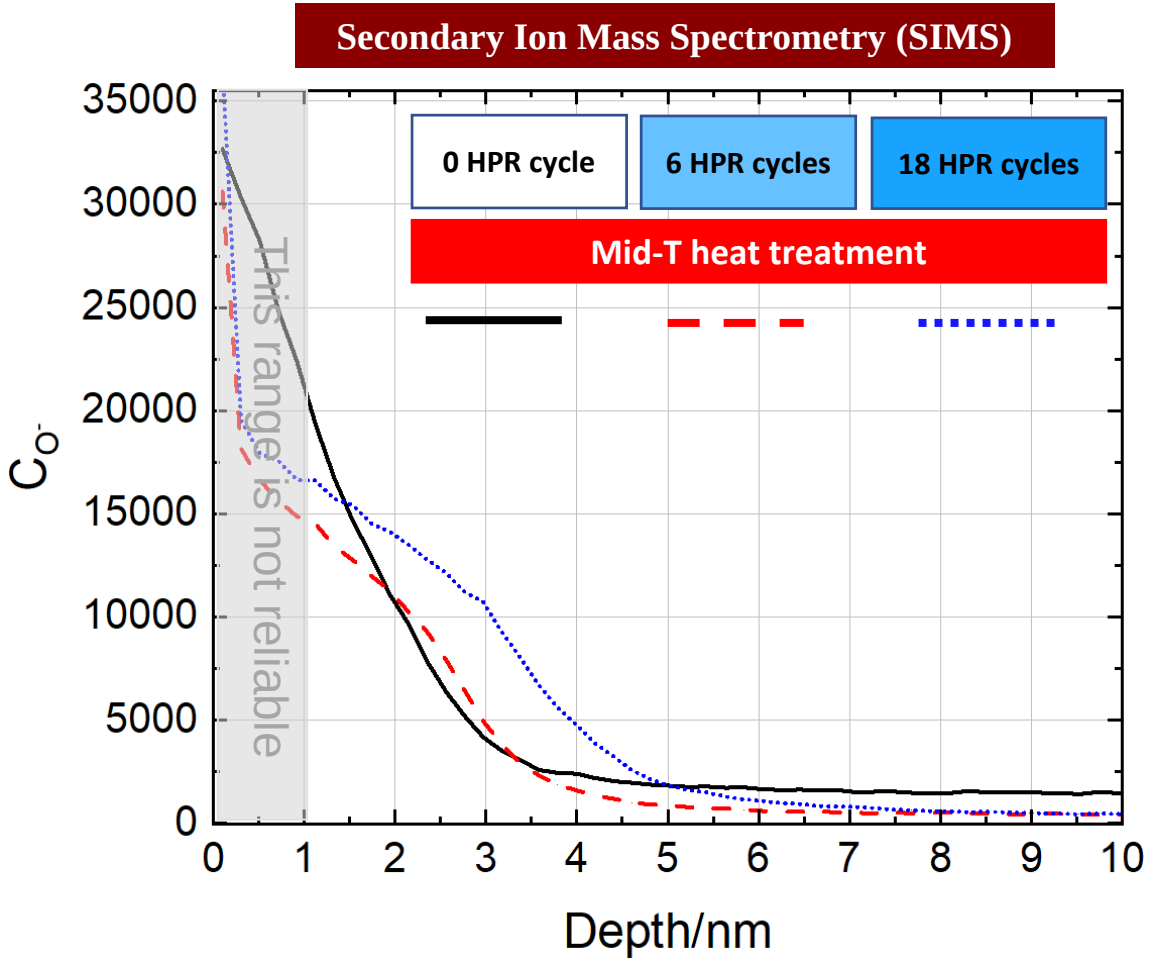

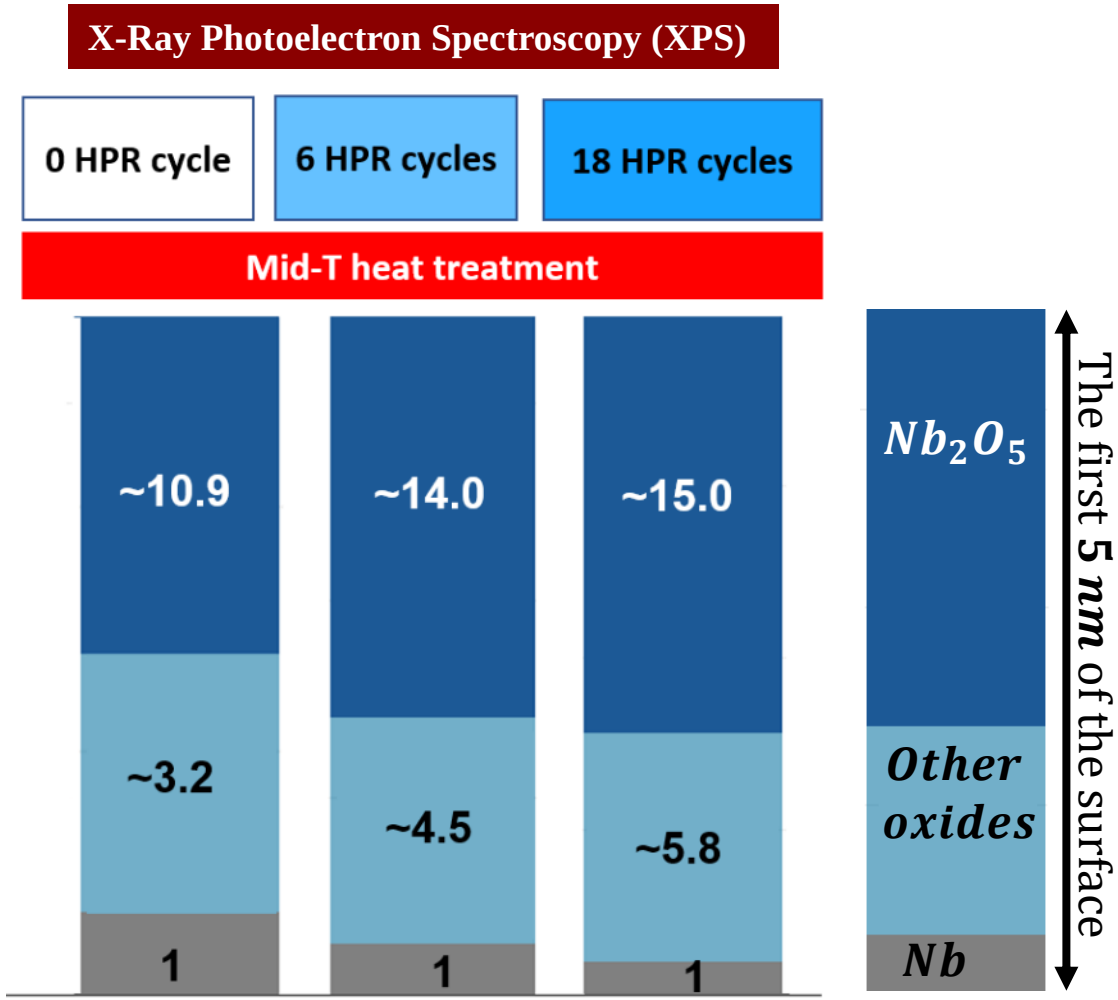

Conclusions

- Higher number of HPR cycles grows thicker pentoxide layer
- Higher number of HPR cycles prior to mid-T heat treatment causes different oxygen distribution

- **How does the performance of a cavity change with higher number of HPR prior to mid-T heat treatment?**
- **Is the increased oxygen concentration enough to alter the performance?**
- **Is more oxygen beneficial or detrimental?**

Cavity 1DE07 → **18 HPR** cycles → mid-T heat treatment → RF test is running

Thanks for your attention

Any questions?

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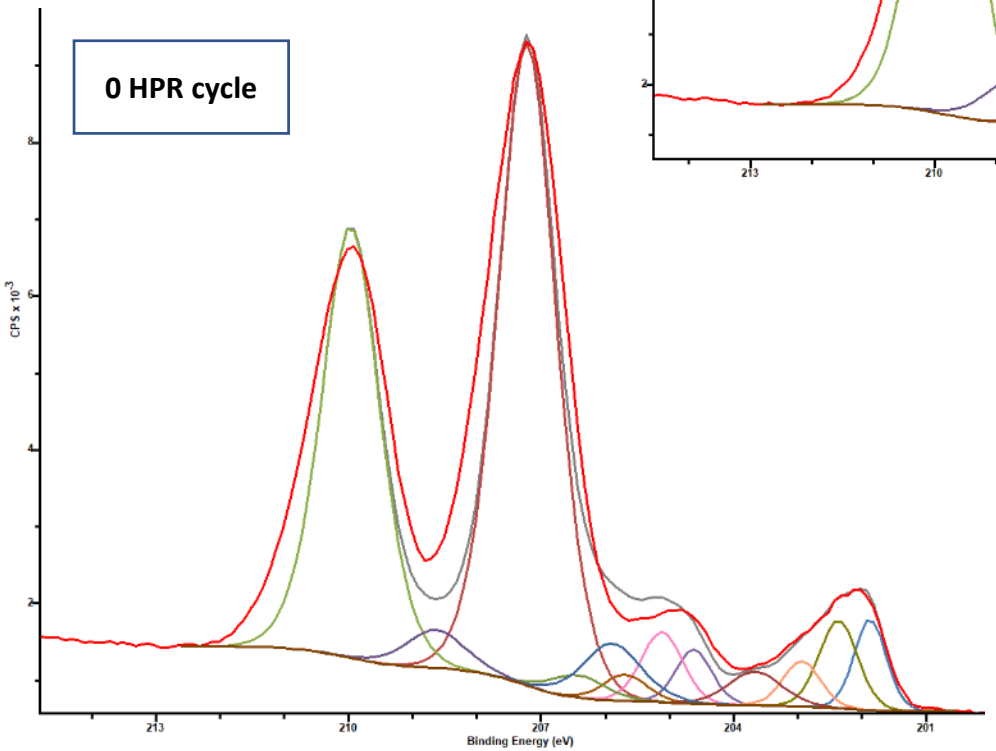
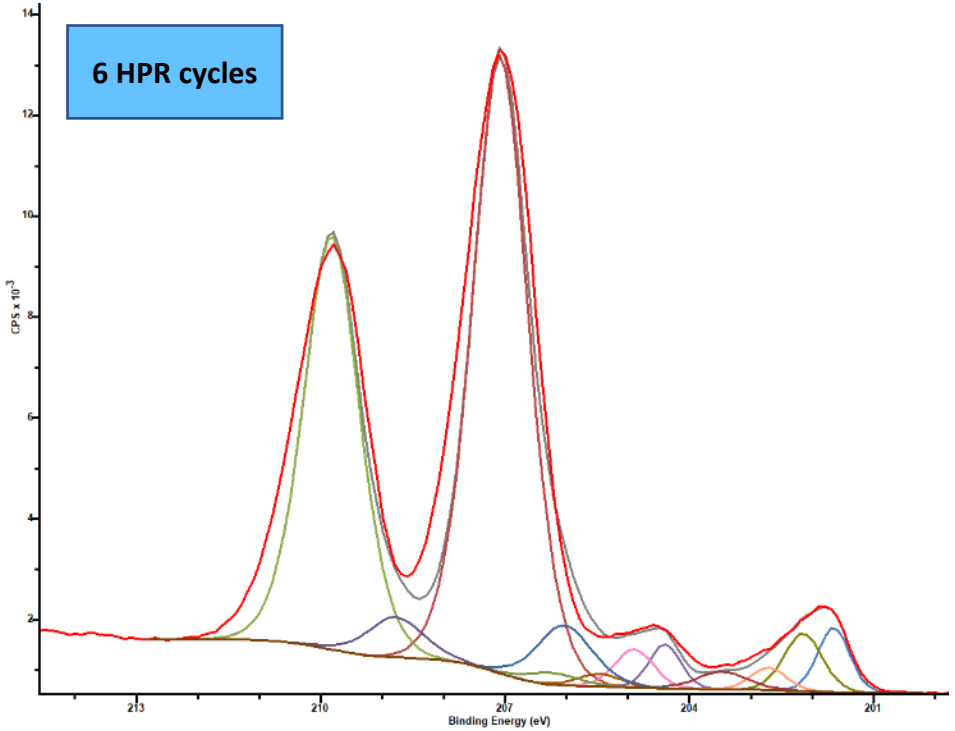
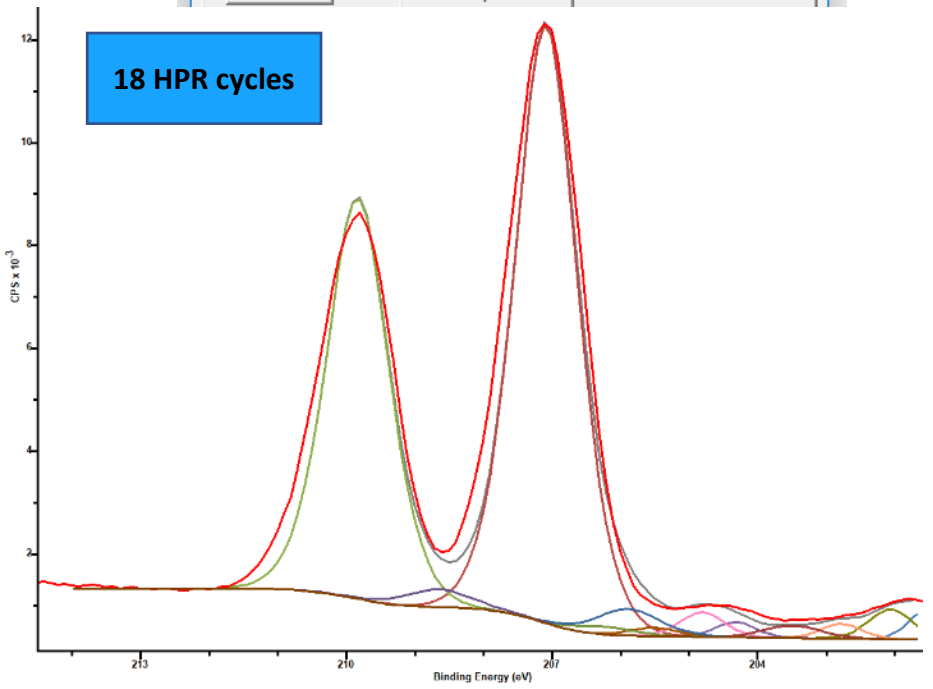
I would like to express my thanks to:
Dangwal Pandey, M. Kohantorabi, and H. Noei for their support of XPS measurements.
S. Nouri Shirazi and T. Fladung for SIMS measurements.
Nicoly Krupka, D. Reschke, L. Steder, and my MSL colleagues for HPRs and RF performance tests.
M. Wenskat and W. Hillert for their support.

BACKUP







Quantification Parameters

Regions | Components | Data Editor | Report Spec. | RPT Report

Nb 3d 186_Newsample [RMS = 55359.1; D. of F. = 97] [Eff. RSF = 1.

Component	A	B	C
Name	Nb2O5	Nb2O5	Nb
R.S.F.	1.0	0.0	1.0
Line Shape	GL(50)	GL(50)	GL(30)
Area	17635.9	11816.1	1626.2
Area Constr.	0.0 , 941651.8	A * 0.67	0.0 , 941651.8
fwhm	1.08	1.08	0.62
fwhm Constr.	0.99 , 1.08	A * 1	0.53 , 0.62
Position	207.1185	209.8685	202.0142
Pos. Constr.	207.16 , 207	A + 2.75	202.11 , 201.99
Tag	No Tag	NoTag	NoTag
Comp Index	0	0	0
Asymmetry Index	0.0000	0.0000	0.0000
% Concentr.	72.00	0.00	6.64

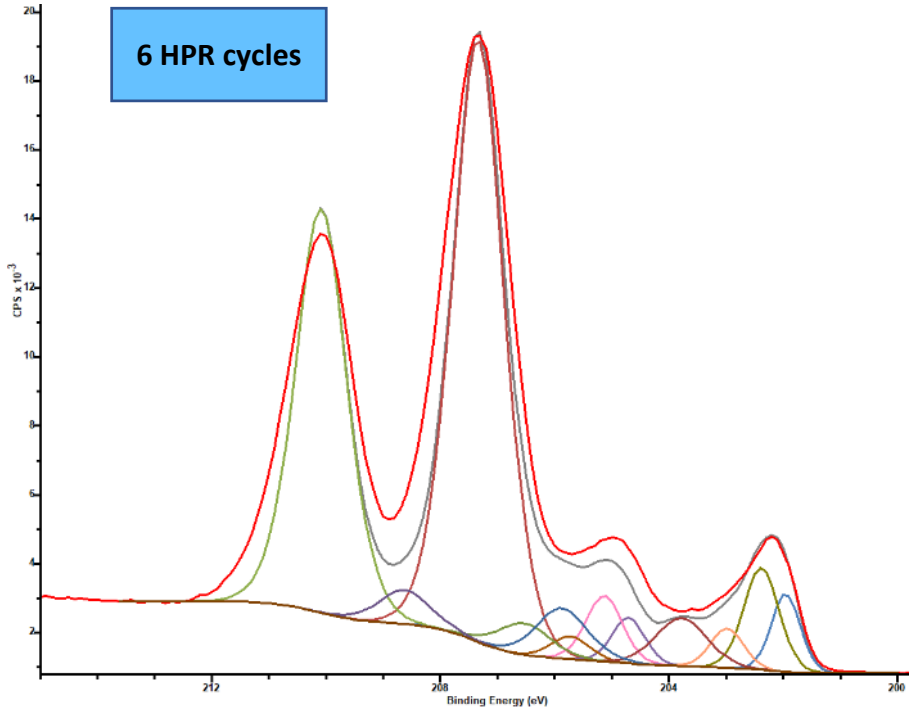
Create | Create x 2 | Marquardt | Simplex | Paste | Copy All | Fit Components | Paste Replace

X-Ray Photoelectron Spectroscopy (XPS)

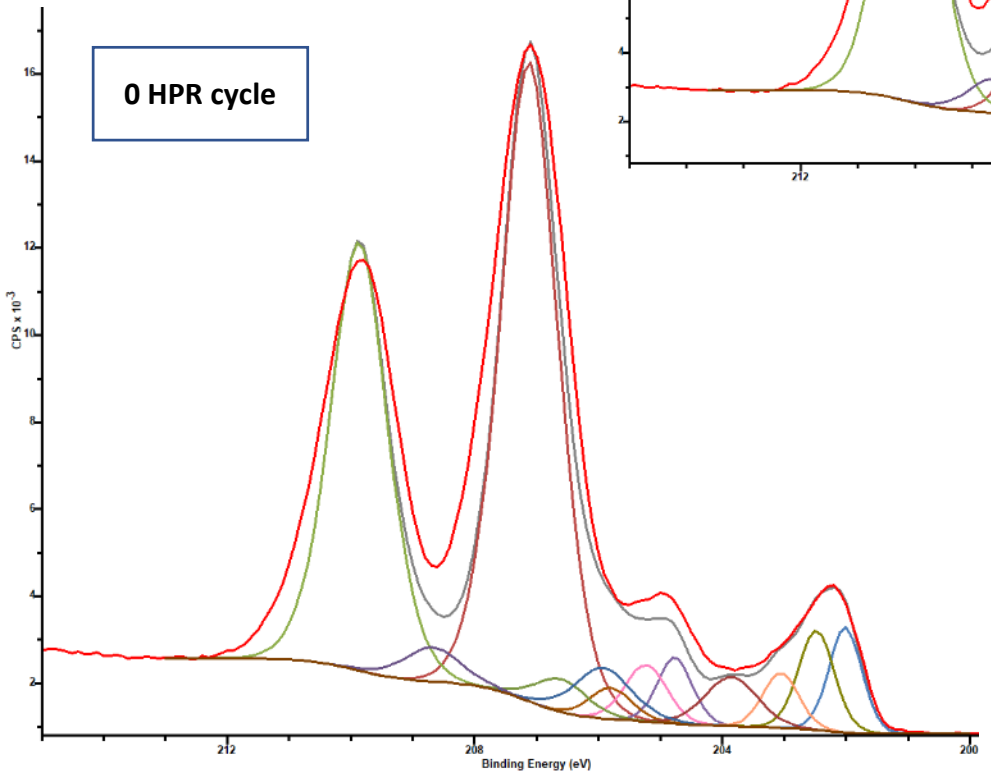
BACKUP

Mid-T heat treatment

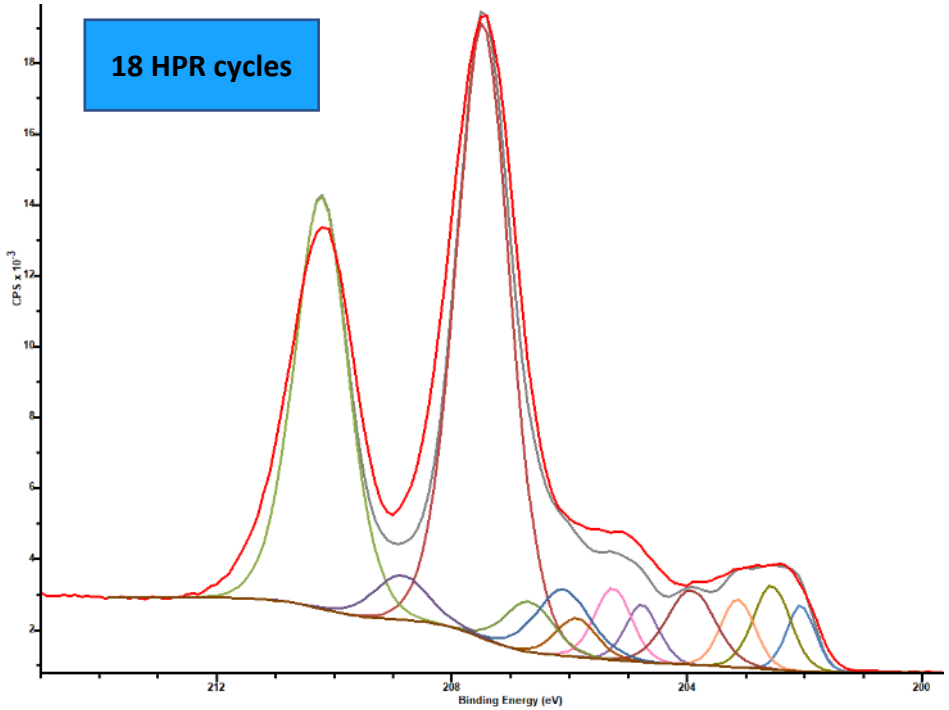
6 HPR cycles



0 HPR cycle



18 HPR cycles



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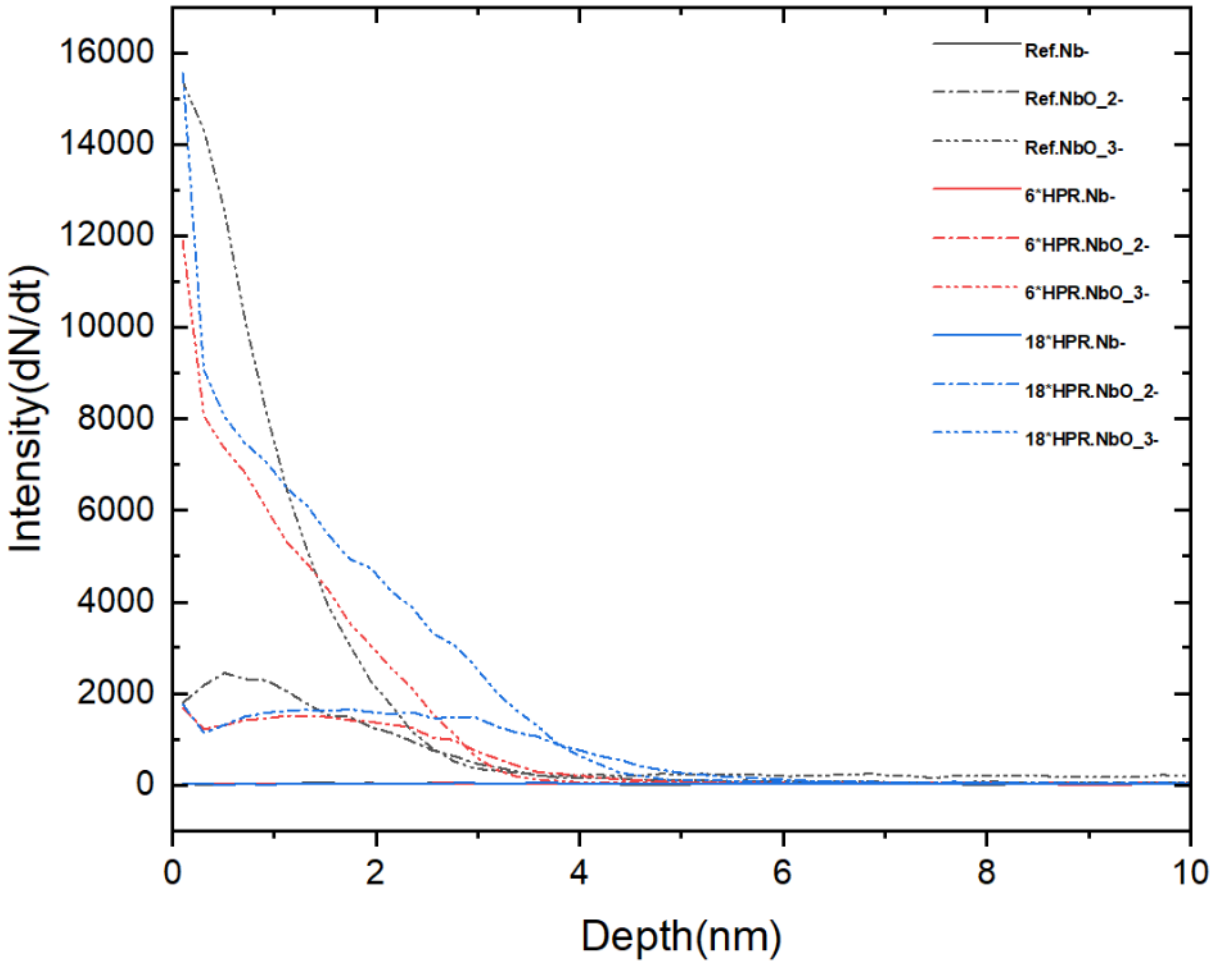
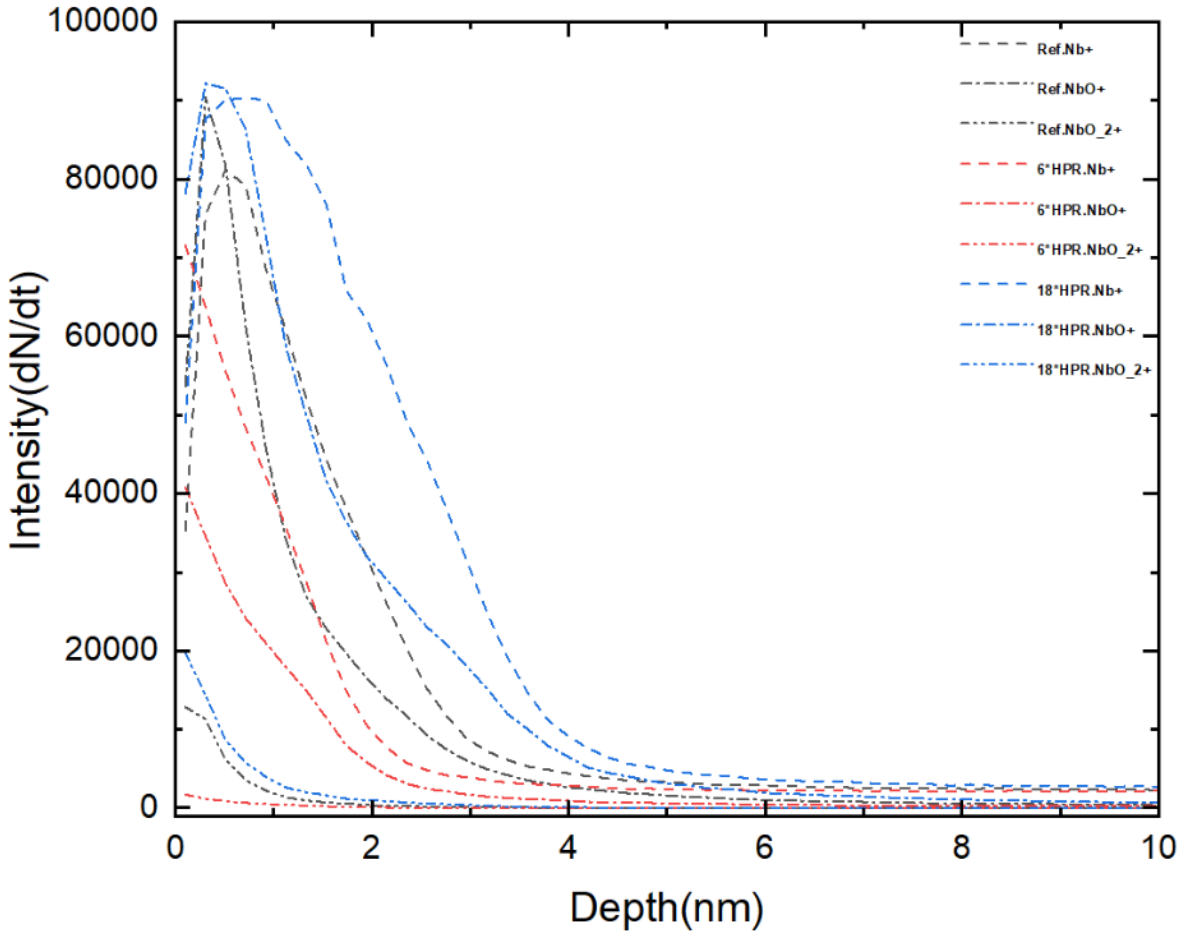

Intensity(dN/dt)
Depth(nm)
Ref.Nb-
Ref.NbO_2-
Ref.NbO_3-
6°HPR.Nb-
6°HPR.NbO_2-
6°HPR.NbO_3-
18°HPR.Nb-
18°HPR.NbO_2-
18°HPR.NbO_3-


Intensity(dN/dt)
Depth(nm)
Ref.Nb+
Ref.NbO+
Ref.NbO_2+
6°HPR.Nb+
6°HPR.NbO+
6°HPR.NbO_2+
18°HPR.Nb+
18°HPR.NbO+
18°HPR.NbO_2+