

OXYGEN SCAVENGER NANOPARTICLES FOR FOOD PACKAGING

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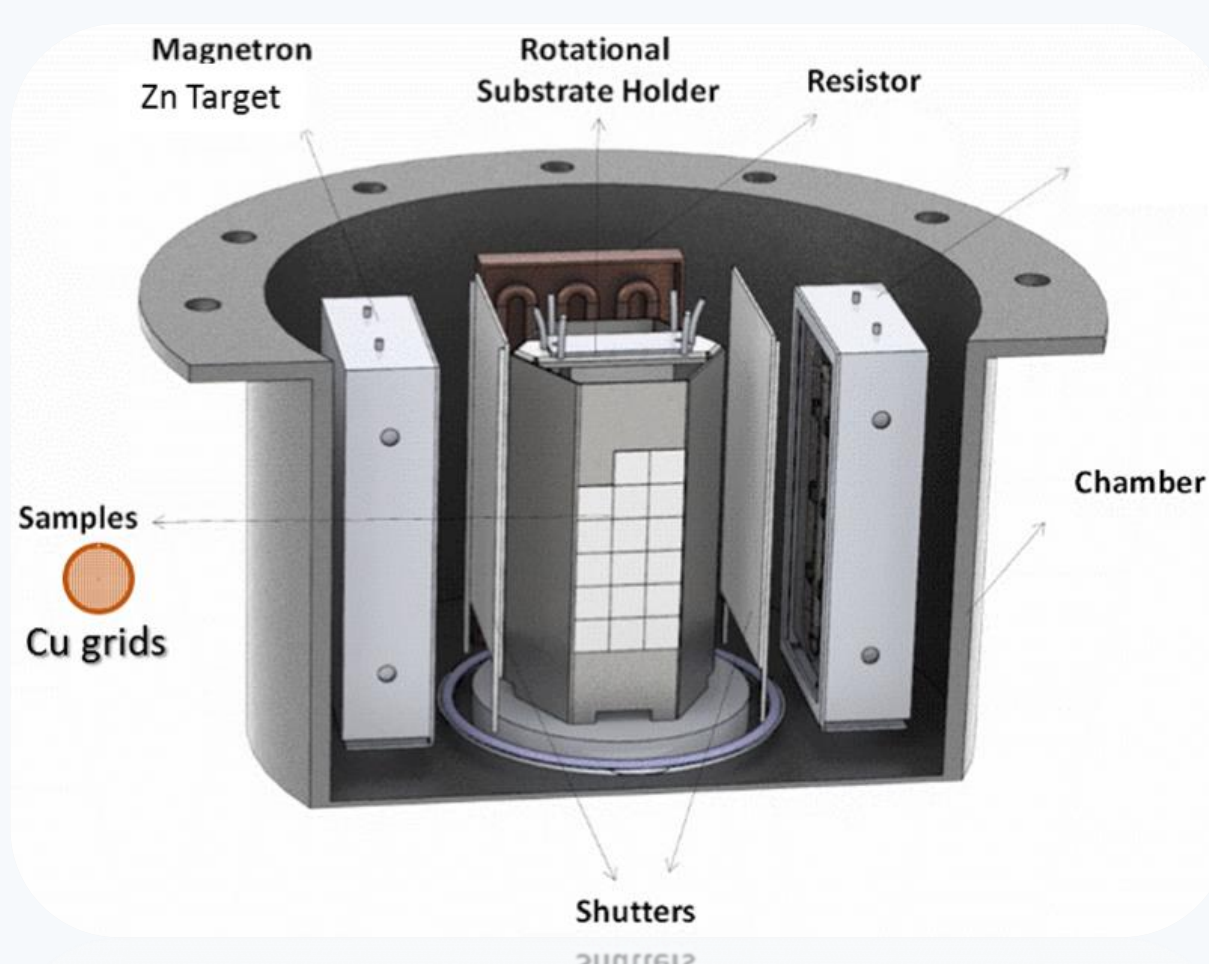
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INTRODUCTION

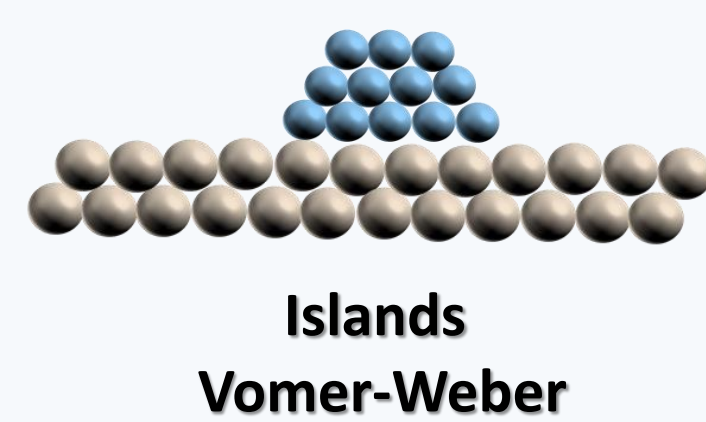
This work focus on the production of Zn nanoparticles to be used as oxygen scavenger in food packaging applications. The larger surface area/volume ratio of the nanoparticles enhances the oxygen-scavenging potential, decreasing the amount of Zn needed to absorb a given amount of oxygen. These scavenger nanoparticles confer to the package not only the ability to absorb oxygen permeating from the environment, but also produces ZnO, an antimicrobial agent extensively used in the food industry. The formation of ZnO is critically dependent on the amount of oxygen and humidity, and is thus controlled by the environment. In this context, it is essential to evaluate the oxidation kinetics of the nanoparticles at room temperature and atmospheric pressure.

MATERIALS AND METHODS

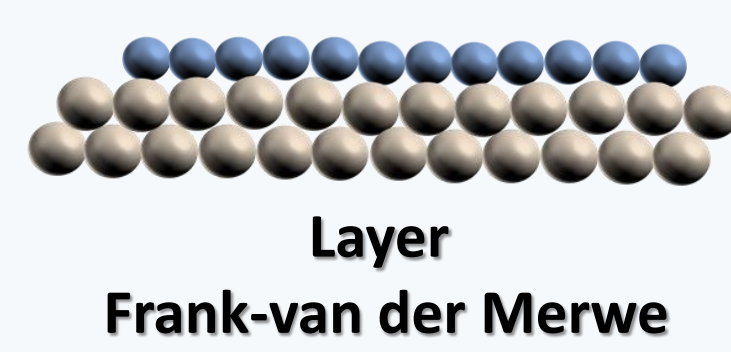
The deposition of nanoparticles was carried out using pulsed-DC-Magnetron sputtering in an Ar atmosphere. Different Zn power densities, Ar partial pressures and times were used to deposit the nanoparticles.



Nanoparticles are formed taking advantage of the larger energy interaction between the substrate (Carbon) and Zn.



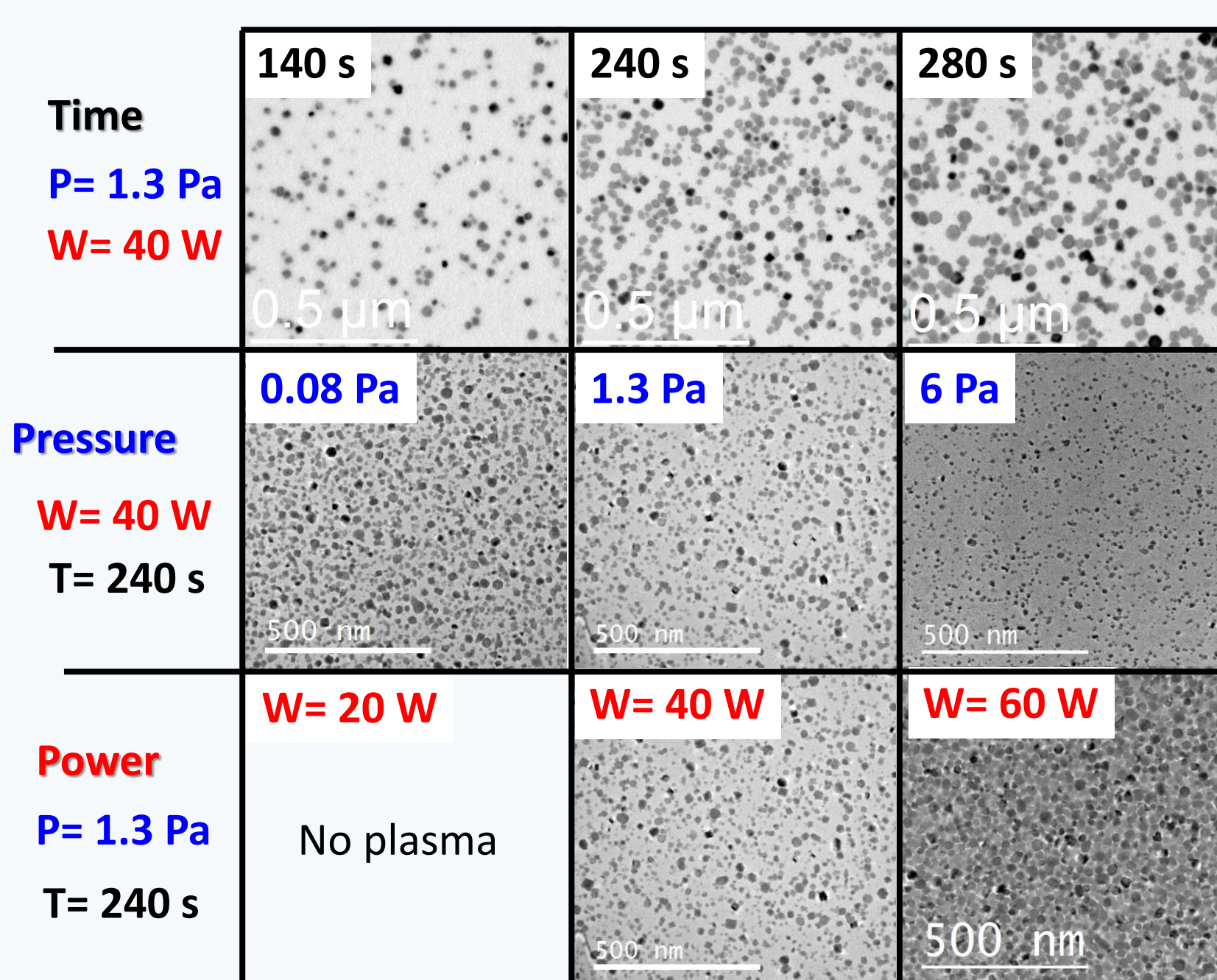
Islands Vomer-Weber
Atoms are more strongly bound to each other than to the substrate



Layer Frank-van der Merwe
Atoms are more strongly bound to the substrate than to each other

RESULTS AND DISCUSSION

NANOPARTICLE PRODUCTION BY MAGNETRON SPUTTERING

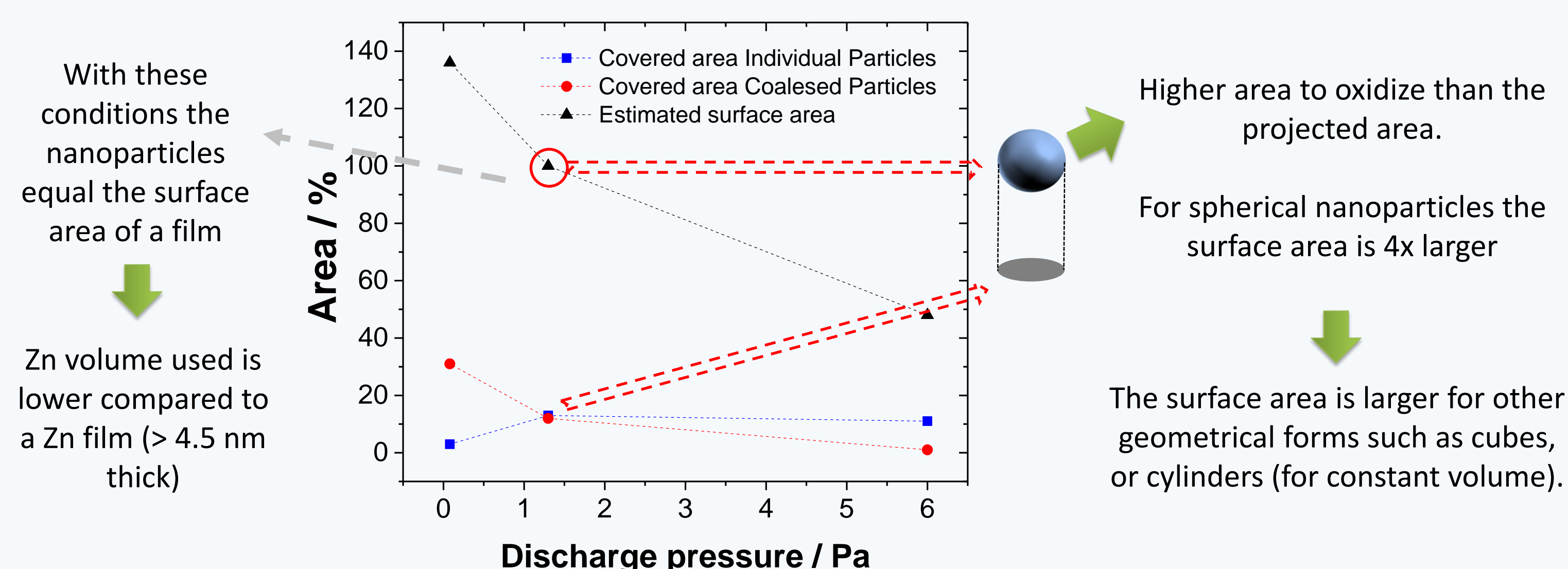
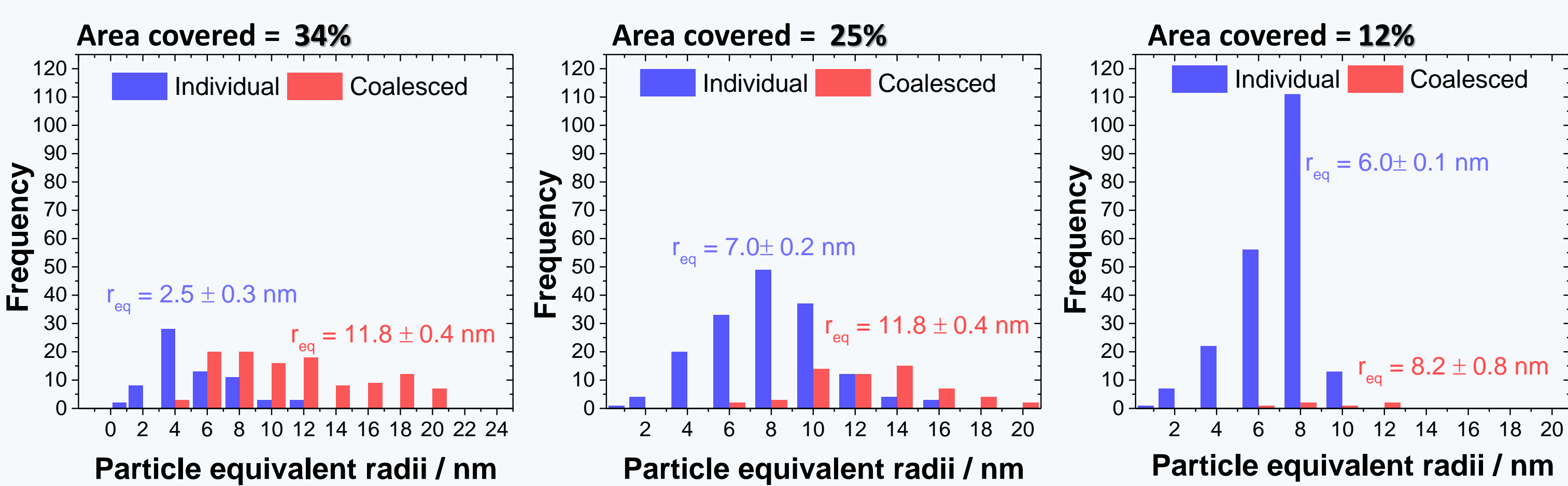
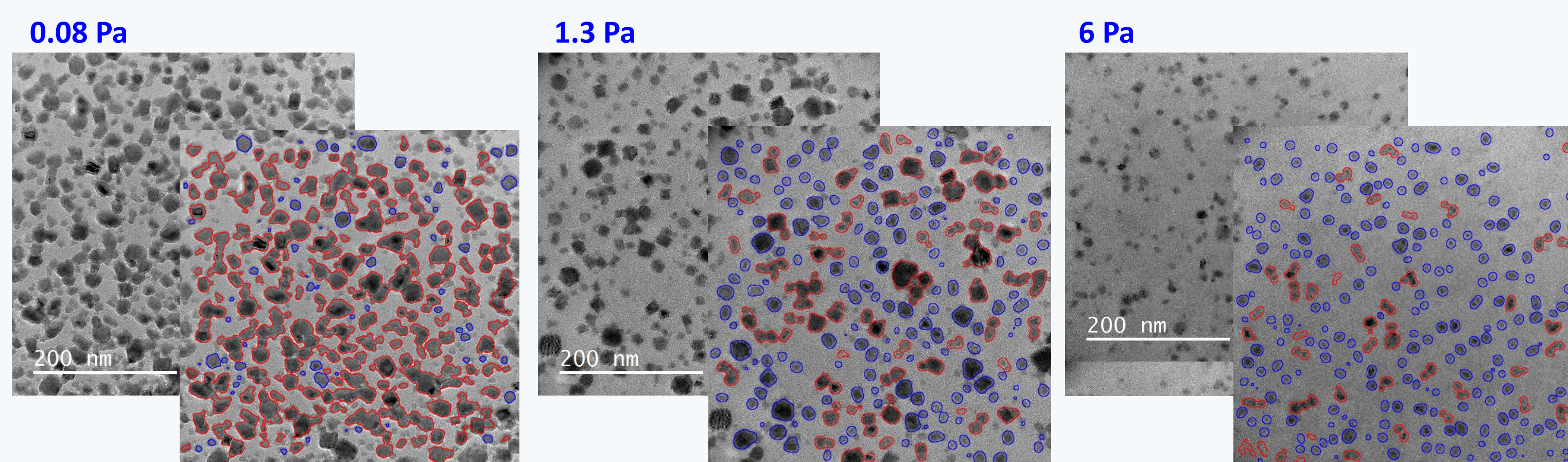


Evolution of the nanoparticles as a function of deposition conditions:

- Time \rightarrow NPs size and number
- Pressure \rightarrow mean-free-path
- Discharge power \rightarrow target bombardment

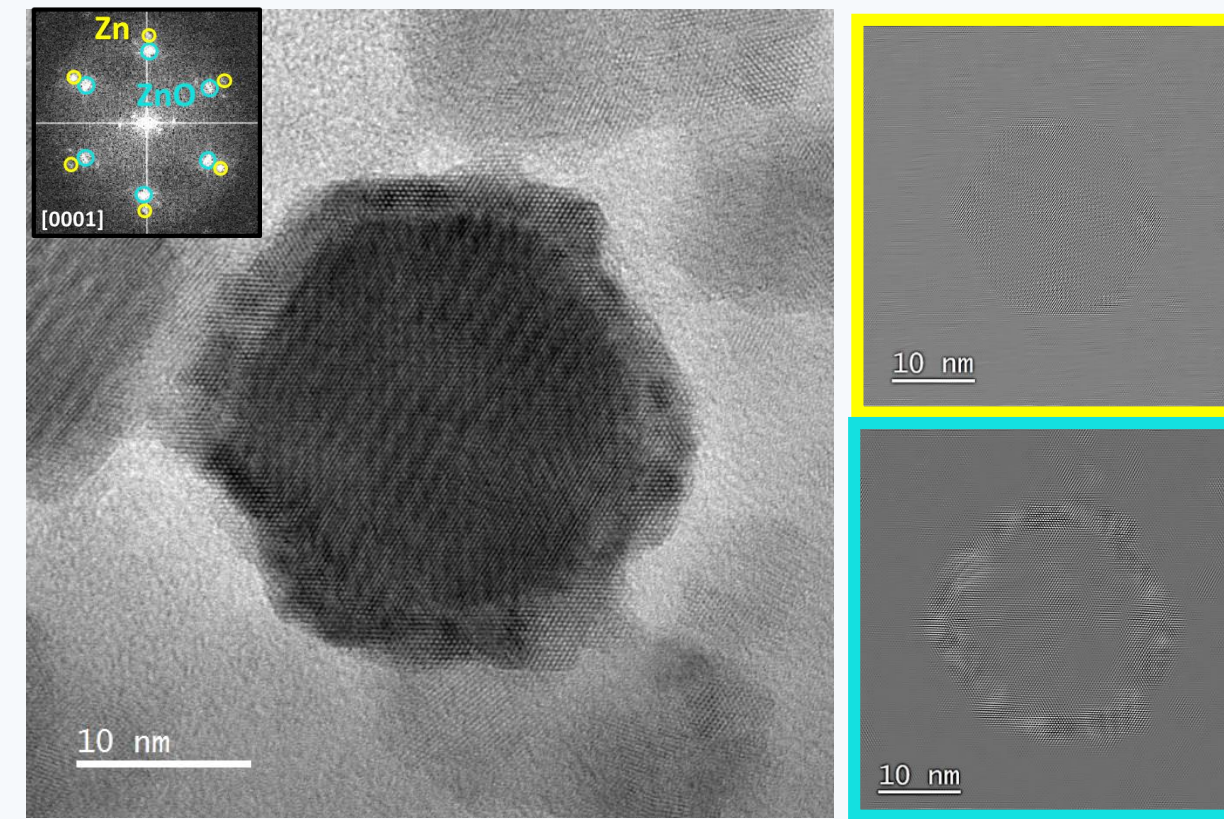
AREA COVERAGE AND SURFACE AREA

Pressure For constant $t = 240 \text{ s}$ $W = 40 \text{ W}$



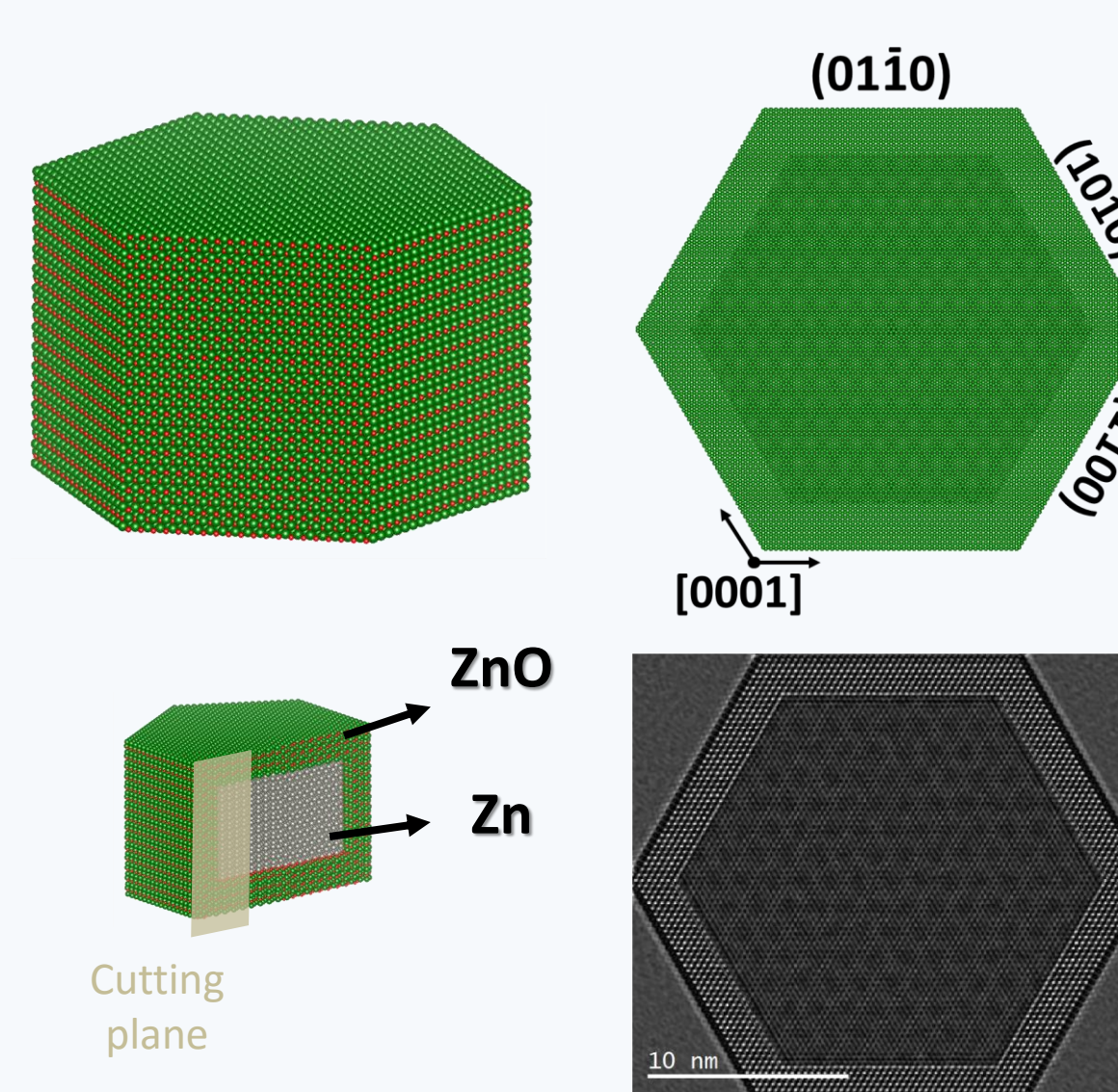
AS-DEPOSITED NANOPARTICLES

HR-TEM images

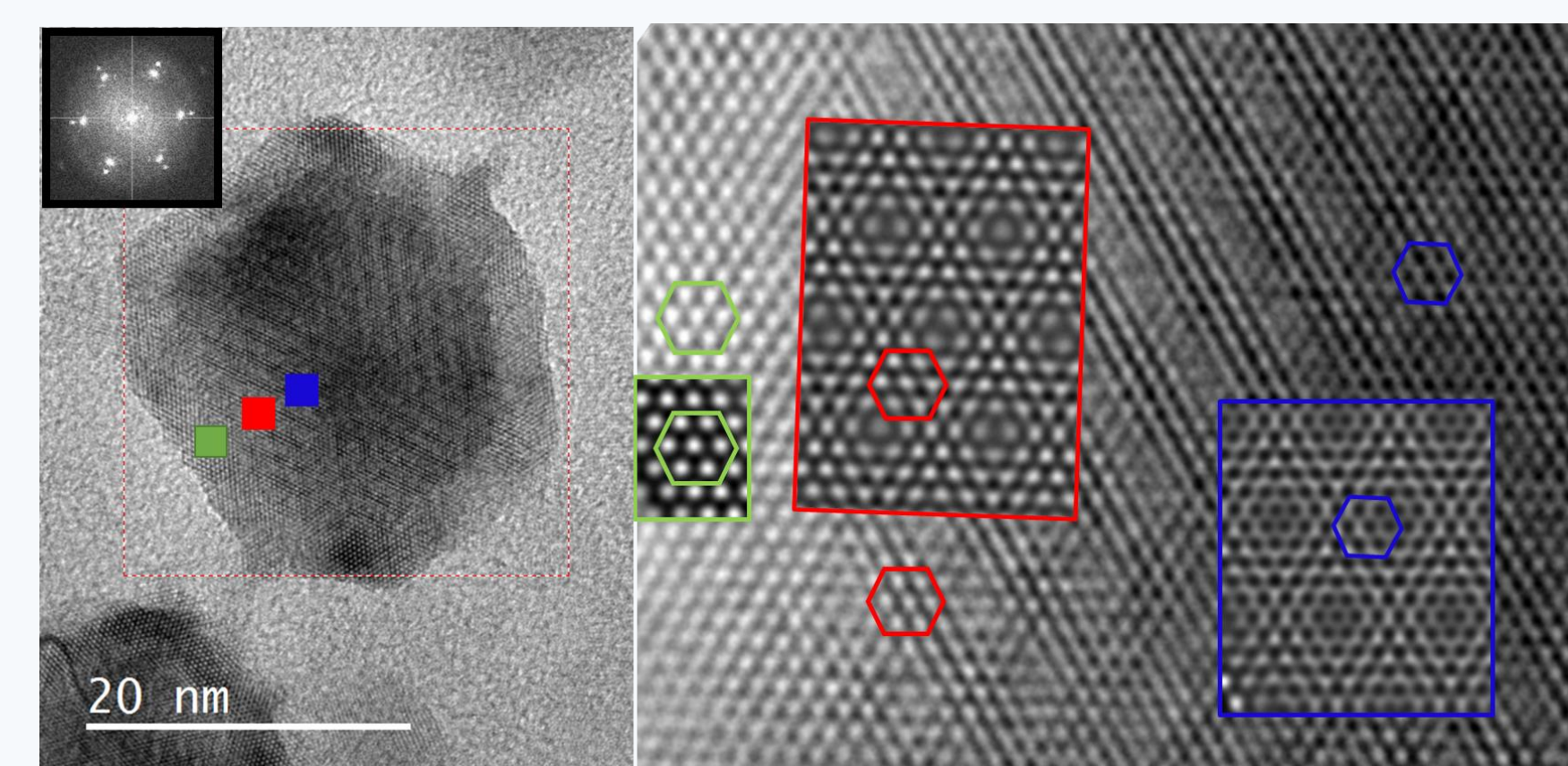


- HR-TEM image shows a self-assembled Zn-ZnO core-shell nanoparticle viewed along the [0001] zone axis.
- The Fast Fourier transform (FFT) of the image reveals that the two phases are crystallographically aligned.
- Inverse FFT (IFFT) based on the FFT spots of Zn (yellow circles) and ZnO (blue circles) allows the location of the phases to be identified, confirming the core-shell structure.

HR-TEM multi-sliced computer simulation

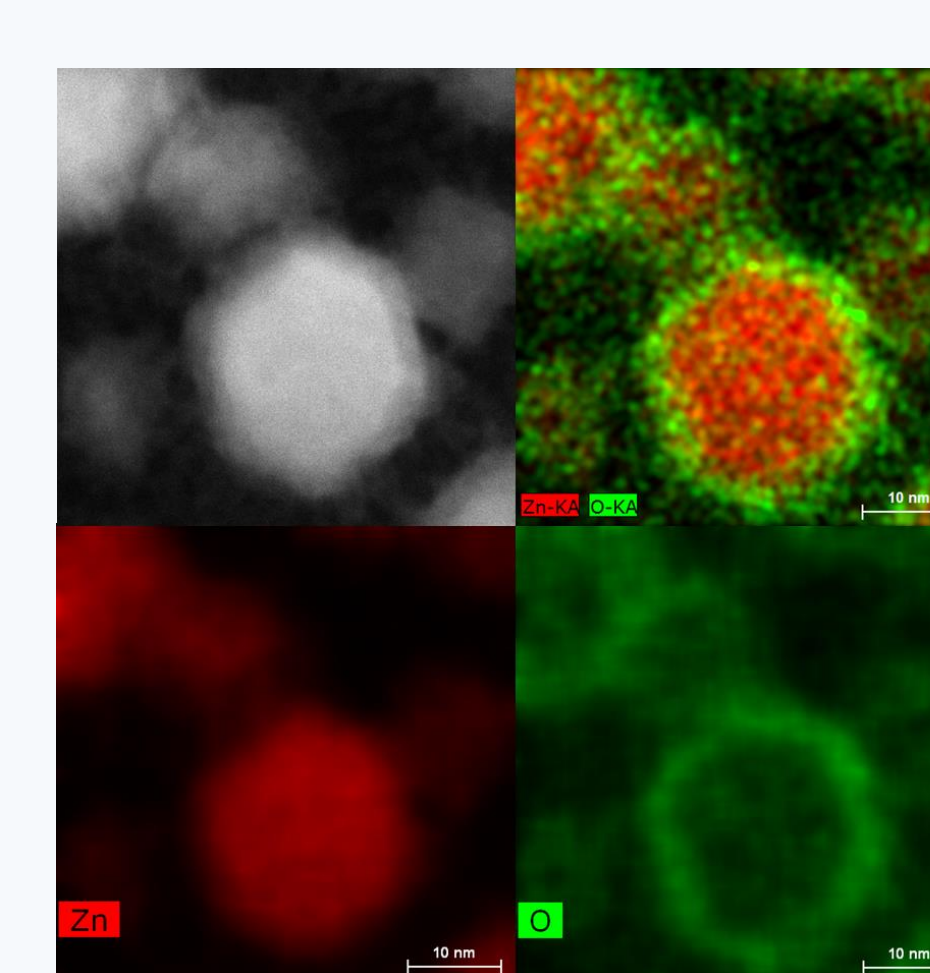


Thickness dependence multi-sliced simulations demonstrate irregular morphologies of the nanoparticles.

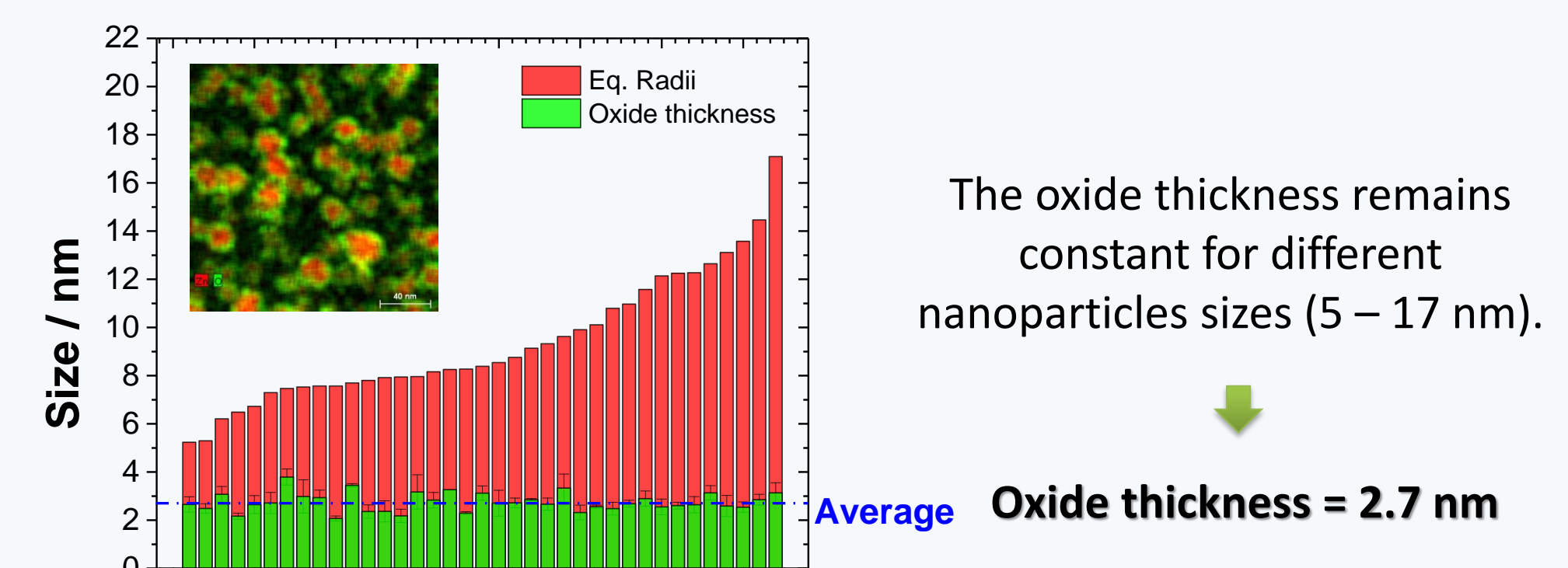


NANOPARTICLES OXIDATION

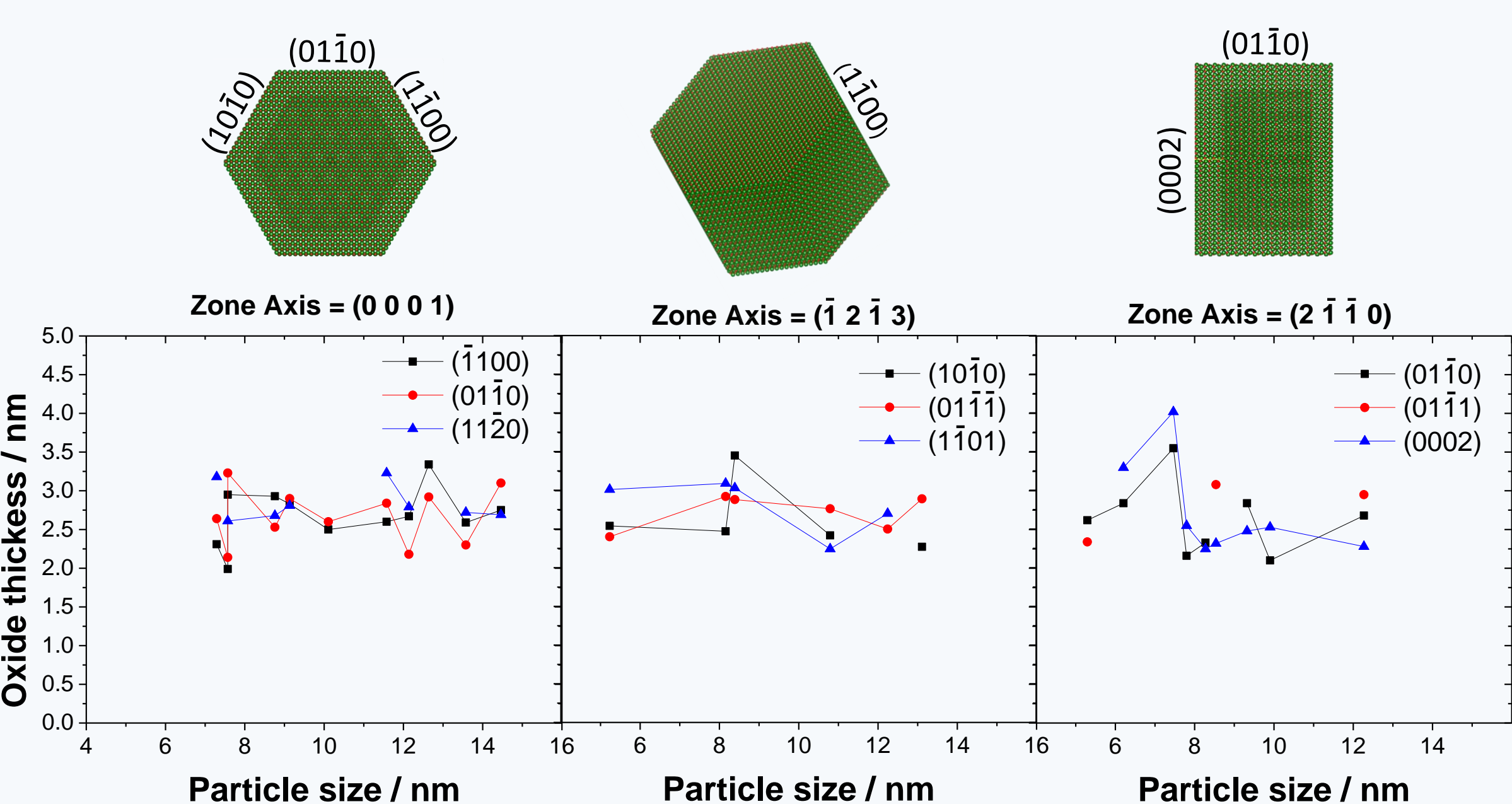
Size-dependent oxidation



The Zn nanoparticles spontaneously oxidize at room temperature and atmospheric pressure, due to the passivation of the metal surface. EDS-STEM mapping corroborates the core-shell structure of the nanoparticles.



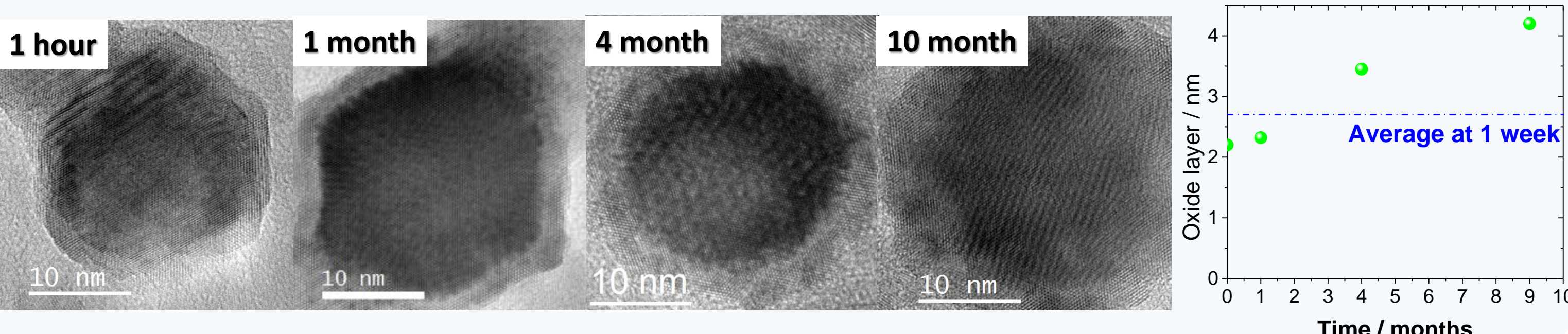
Effect of surface orientation on the NPs oxidation



The NPs oxidation seems to be independent of the orientation and the surface growth direction.

Oxidation Kinetics

After less than 1 h of deposition time, the nanoparticles are already oxidized with an oxide layer of $\sim 2 \text{ nm}$. Further oxidation occurs at very slow rates, increasing from 2 nm to 4 nm after 10 months.



CONCLUSIONS

- Zn NPs produced by pulsed-DC-magnetron sputtering can be produced in different sizes and distributions depending on the deposition conditions.
- The nanoparticles spontaneously oxidize due to the surface passivation of Zn.
- The thickness of the oxide is independent of the size of the NPs and of the growth plane direction.
- The particles seem to oxidize as a function of exposure time. However, this process is very slow after a $\sim 2 \text{ nm}$ of thickness.

ACKNOWLEDGEMENTS

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