Solar Induced Growth of Silver Nanocrystals

VINÍCIUS DAMASCENO COSTA

Solar induced growth of silver nanocrystals

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Introduction

- Metallic nanocrystals increase the absorption and the eficience of solar cells.

- Silver nanocrystals is cheap and easy to produce.

- Instability with the heat.

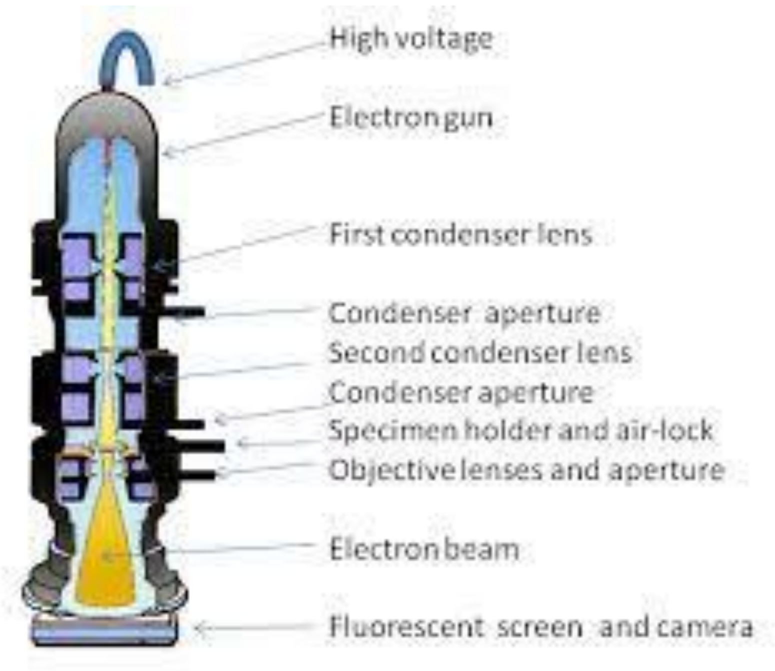
Objective

The paper study the the effect of solar irradiation on Ag nanocrystals on a carbon film, and investigate the growth rate and particle distribution with solar irradiation in different times.

Experiment: Nanocrystals

- 0.6 mM $AgNO_3$ solution.
- deionized H_2O + 1.2 mM aqueous $NaBH_4$ solution.
- Adding drop by drop in the continuously stirred solution.
- They used a a $AgNO_3/NaBH_4$ molar ratio of 2/25.
- Finally they put one drop of the final solution in a carbon film.

Experiment: Transmission Electron Microscopy (TEM)



- What is a TEM?
- 5 of the TEM samples are placed under a Xenon lamp.
- Temperature: 55.7◦C after 15 min to 64.3◦C after 240 min.
- Lamp was placed 35 cm from the TEM sample grids.
- Sample 2 after 15 min; sample 3 after 30 min; sample 4 after 60 min; sample 5 after 120 min; and sample 6 after 240 min.
- High-Resolution Transmission Electron Microscopy was used to see the nanocrystals.

Theory: Ostwald Ripening

- Ostwald ripening
- First they described the process by the LSW model.
- The correction:

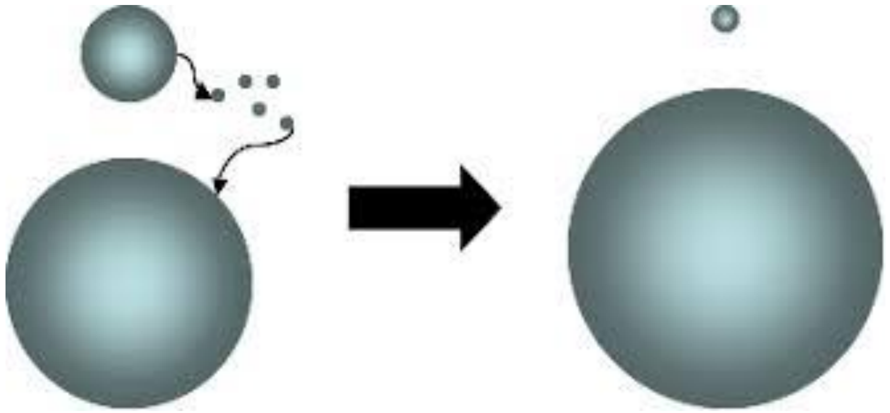
$$\langle R \rangle^3 = \langle R_0 \rangle^3 + k_\phi t$$

- But some particles become aspherical over time:

$$\langle d \rangle^3 = \langle d_0 \rangle^3 + 8k_\phi t.$$

$$A = \pi (d/2)^2$$

$$k_{0.25} \approx 0.810,\ k_{0.5} \approx 2.548,\ k_{0.75} \approx 8.207,\ k_{0.9} \approx 24.487.$$



Theory: The log-normal Distribution

- Provide a close fit with the experimental observations of the particle sizes.

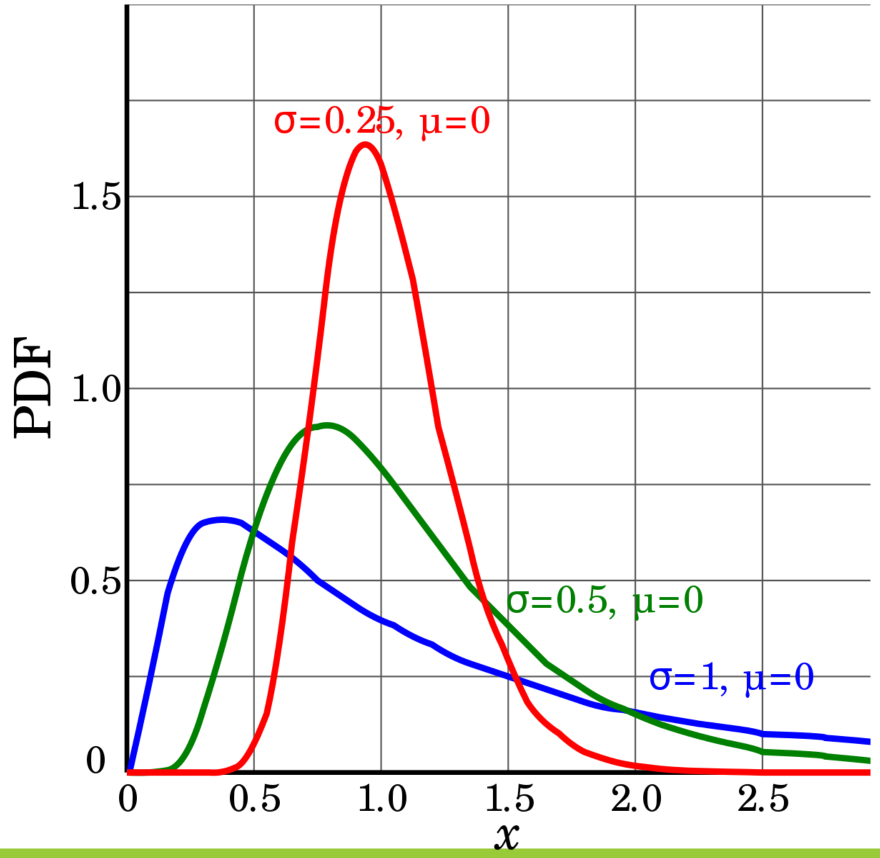
$$p(x;\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln x-\mu)^2}{2\sigma^2}}$$

- The mean of the particles sizes:

$$m = e^{\mu+\sigma^2/2}$$

- The standart deviation:

$$sd = e^{\mu+\sigma^2/2}\sqrt{e^{\sigma^2}-1}$$



Theory:Parameter Estimation

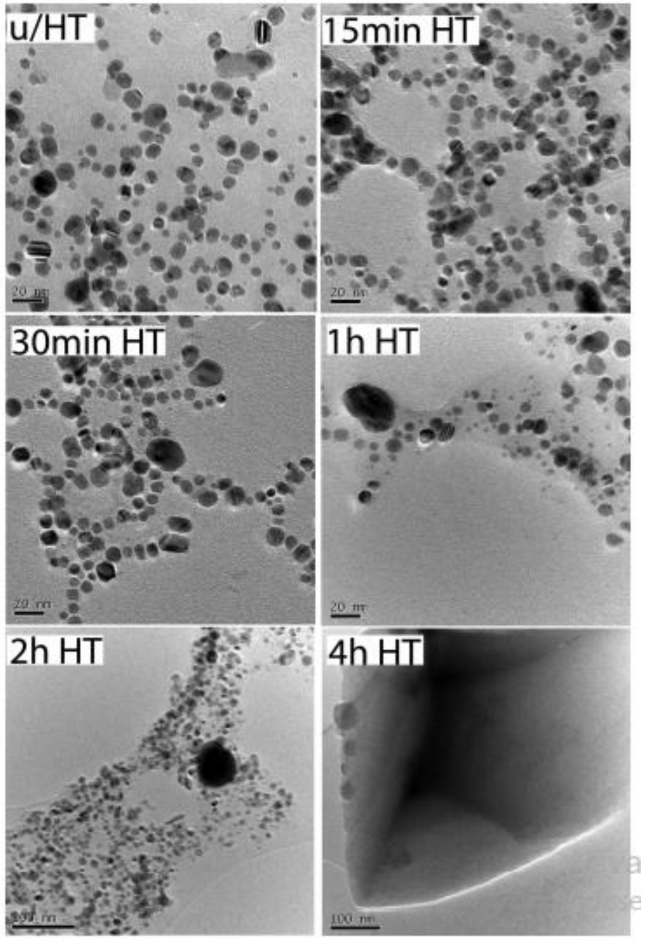
- The probability that the random variable X assumes a value between d − 1/2 and d + 1/2

$$P_{d;\mu,\sigma} := \int_{d-1/2}^{d+1/2} p(x;\mu,\sigma)\mathrm{d}x$$

- Sample i comprises Ni particles of which Ni,d are of size between d−1/2 and d+ 1/2.

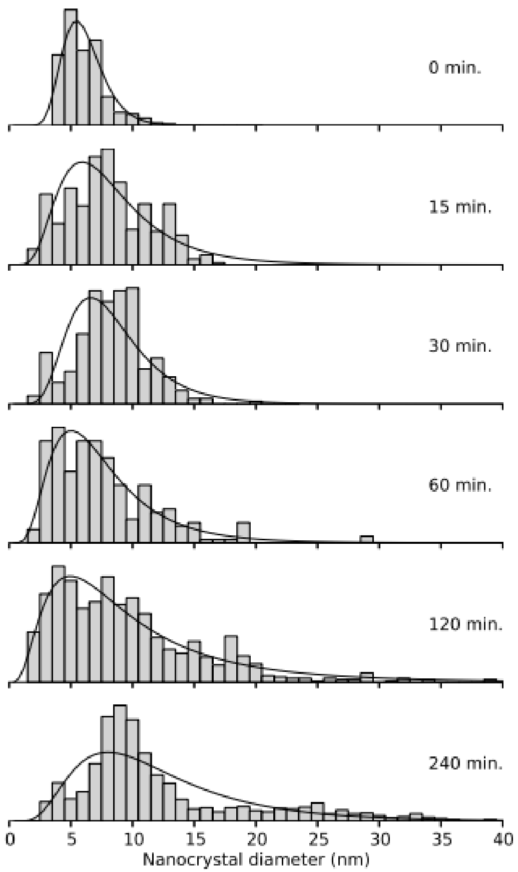
$$\sum_{d} N_{i,d} \log(P_{d;\mu,\sigma})$$

- They estimate μ, σ by maximazing the expression numerically.



i	1	2	3	4	5	6
t_i	0	15	30	60	120	240
N_i	523	425	284	257	909	1499
$\widehat{\mu}_i$	1.775	2.014	2.050	1.903	2.102	2.382
$\widehat{\sigma}_i$	0.279	0.487	0.401	0.535	0.708	0.547
m_i	6.134	8.437	8.416	7.737	10.513	12.572
sd_i	1.743	4.362	3.515	4.453	8.480	7.425

Results



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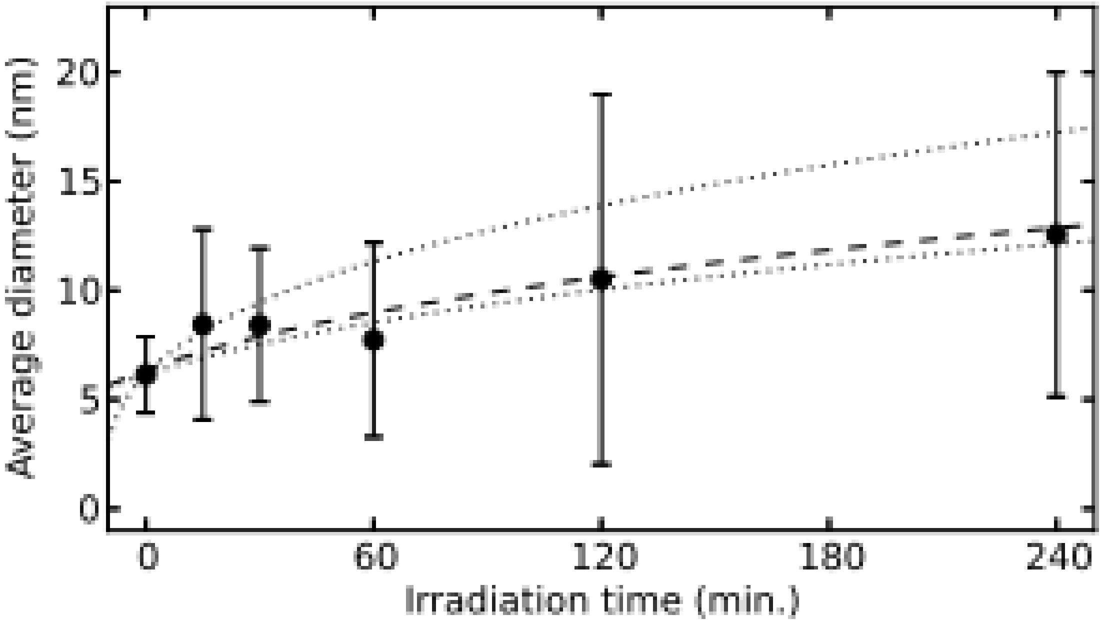
$$\langle d\rangle^3 = \langle d_0\rangle^3 + 8k_\phi t$$

$$\langle d_0\rangle = 6.429 \qquad k_\phi = 0.881$$



Results

Conclussion

After four hours of solar irradiation, the largest observed particle has a diameter of 638 nm.

The average particle diameter <d> can be approximately described by the Ostwald ripening.

The initial average diameter <d0> ≈ 6.429 and kinetic coefficient $k_\phi \approx 0.881$.

While the particle size distribution initially stays log-normal, it eventually starts to deviate from the log-normal distribution.

The resulting distribution does not fit the steady-state distributions predicted by the Ostwald ripening model .

Bibliografia das imagens

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THANK YOU!!