



HAL
open science

Nucleation of nanocrystals in solution: confinement by the amorphous networks

Jens Baumgartner, Alexy Freitas, Blaise Fleury, Raj-Kumar Raamoorthy, Marie-Alexandra Neouze, Mathieu Bennet, Damien Faivre, Thierry Gacoin, David Carriere

► **To cite this version:**

Jens Baumgartner, Alexy Freitas, Blaise Fleury, Raj-Kumar Raamoorthy, Marie-Alexandra Neouze, et al.. Nucleation of nanocrystals in solution: confinement by the amorphous networks. Cristal 9 - 2019, May 2019, Nancy, France. cea-02329638

HAL Id: cea-02329638

<https://hal-cea.archives-ouvertes.fr/cea-02329638>

Submitted on 23 Oct 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Nucleation of nanocrystals in solution: confinement by the amorphous networks

Jens BAUMGARTNER¹, Alexy FREITAS^{2,3}, Blaise FLEURY², Raj-Kumar RAAMOORTHY³, Marie-Alexandra NEOUZE², Mathieu BENNET¹, Damien FAIVRE¹, Thierry GACOIN² et **David CARRIERE**³

¹*Department of Biomaterials, Max Planck Institute of Colloids and Interfaces, Germany*

²*Laboratoire de Physique de la Matière Condensée, École polytechnique, CNRS, France*

³*LIONS, NIMBE, CEA, CNRS, Université Paris-Saclay, France*

david.carriere@cea.fr

RÉSUMÉ

Recent advances show that nucleation of crystalline phases from dilute solutions often involves the formation of intermediate disordered states: clusters, droplets, amorphous nanoparticles, polymorphs etc [1]. It remains unclear how the intermediate states affect the predictions of the classical single-step nucleation theory, in terms of activation barrier, rate of nucleation, or critical cluster sizes. Progress is hampered by the difficulty to reach sufficient resolutions ($<1\text{nm}$, $\ll 1\text{s}$), without perturbing the metastable process.

Here, we overcome this issue using in situ x-ray scattering, and report nucleation rates upon formation of different nanocrystals in solution (luminescent $\text{YVO}_4:\text{Eu}$, magnetite Fe_3O_4), where an intermediate nanostructured amorphous network is evidenced [2,3]. We find how the amorphous precursor impedes nucleation at the nanometer scale, and limits the size of the nanocrystals. The clarification of the role of the intermediate nanostructure clarifies why the predicted nanocrystal sizes are overestimated by several orders of magnitude by classical theories.

MOTS-CLÉS

Nucleation/growth, X-ray scattering, co-precipitation in solution, magnetite, luminescent nanoparticles

REFERENCES

- [1] J. J. D. Yoreo *et al.*, Crystallization by particle attachment in synthetic, biogenic, and geologic environments. *Science*. **349**, aaa6760 (2015).
- [2] B. Fleury *et al.*, Amorphous to Crystal Conversion as a Mechanism Governing the Structure of Luminescent $\text{YVO}_4:\text{Eu}$ Nanoparticles. *ACS Nano*. **8**, 2602–2608 (2014).
- [3] J. Baumgartner *et al.*, *under review*