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Pressure-driven assembly of nanoparticle arrays and nanostructures

Hongyou Fan

Sandia National Laboratories,

The University of New Mexico, Albuquerque, NM

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Outline

I. Introduction - Nanoparticle assembly at ambient pressure

- Synthesis of nanocrystals
- Van der Waals interaction.
- DNA programmable assembly.
- Dipole-dipole interactions and chemical reactions

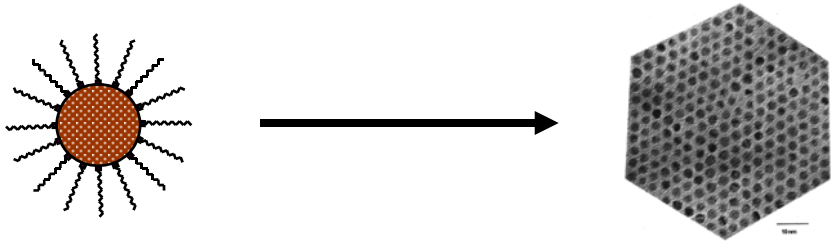
II. Nanoparticle assembly under pressure

III. Summary

Applications of Nanocrystals and Nanocrystal Arrays

1. Size-dependent and collective optical, electric, and magnetic properties.

e.g., tuning refractive index for optical coatings, tuning dielectric constant, QD/solar cells, electron transport/conductance, magnetic memory, etc.



Heath, et al *Science*, 1997

2. Chemical and biological sensor & imaging.

e.g., Surface enhanced Raman scattering (**SERS**) based chem-/bio-sensor systems, killing cells using external stimulates such as magnetic field, light etc.

3. Catalyst arrays for orientated growth of nanomaterials films/arrays.

e.g., carbon nanotube arrays/films, nanowire arrays, etc

(CdSe) Semiconductor size increase

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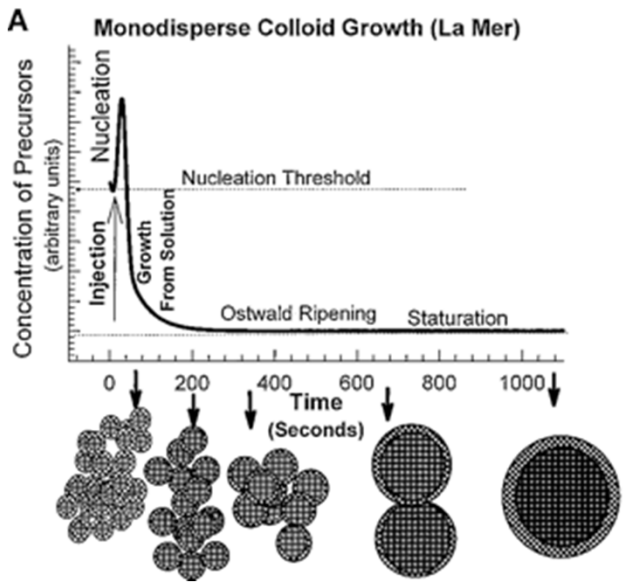
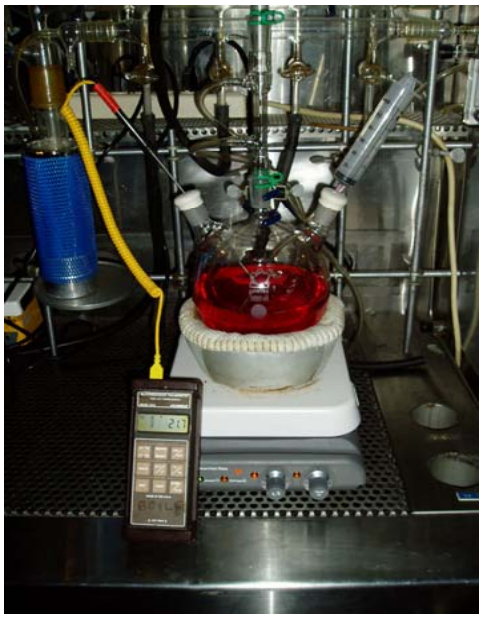
Synthesis of Hydrophobic Nanoparticles Stabilized by Organic Monolayers

(1) Nucleation and growth at high temperature





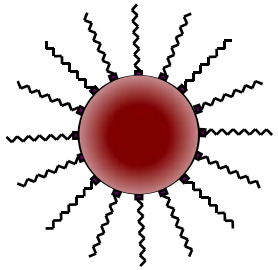
Semiconducting and magnetic nanocrystals
e.g., CdSe, FePt, $FeMnO_4$

Organic ligands:
Trioctylphosphine
Trioctylphosphine oxide
$CH_3(CH_2)_nNH_2$
$CH_3(CH_2)_nCOOH$

Murray, CB *et al*. *Annu. Rev. Mater. Sci*. **2000,** *30,* 545-610.

(2) Synthesis of metal nanocrystals in reverse micelles at room temperature

***$HAuCl_4$**
$CH_3(CH_2)_nSH$
$(CH_3(CH_2)_7)_4N^+Br^-$
$NaBH_4$



Metal nanocrystals
e.g., gold, silver, etc.

* Brust, M., *et al*. *J. Chem. Soc.-Chem. Comm*. 7, 801 - 802 (1994).

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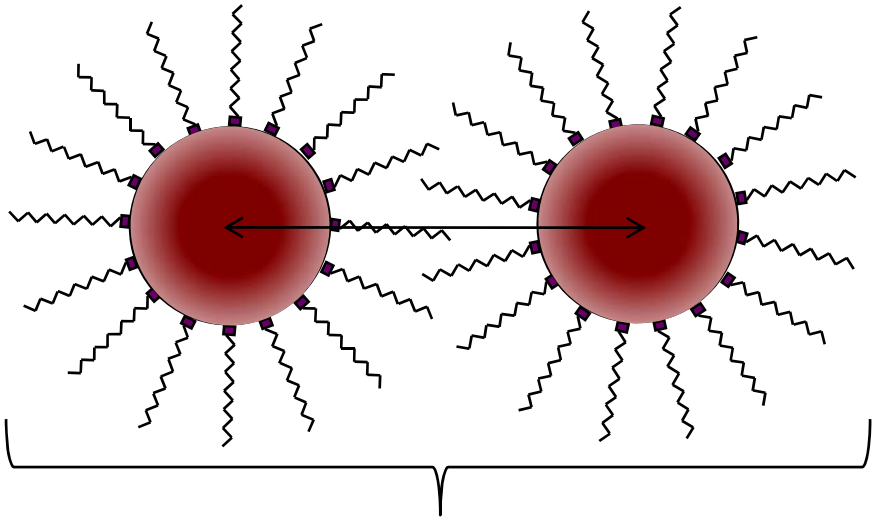
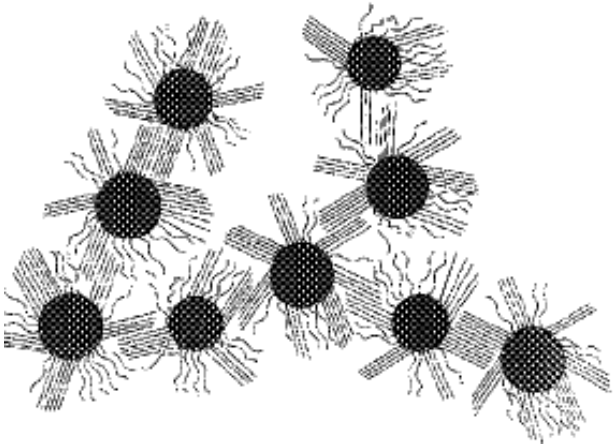
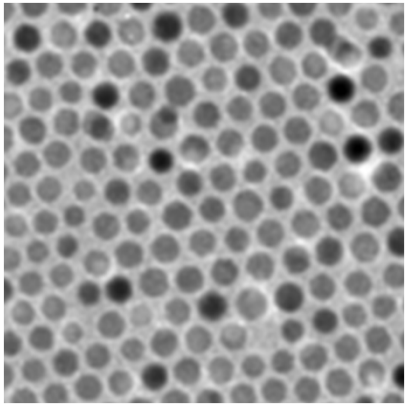
Nanoparticle Assembly at Ambient Pressure:
1. Balanced Interparticle Interactions



Balanced interparticle interactions





Lennox, R.B. *et al. Chem. Eur. J.* 1996, Vol. 2, 359-363.

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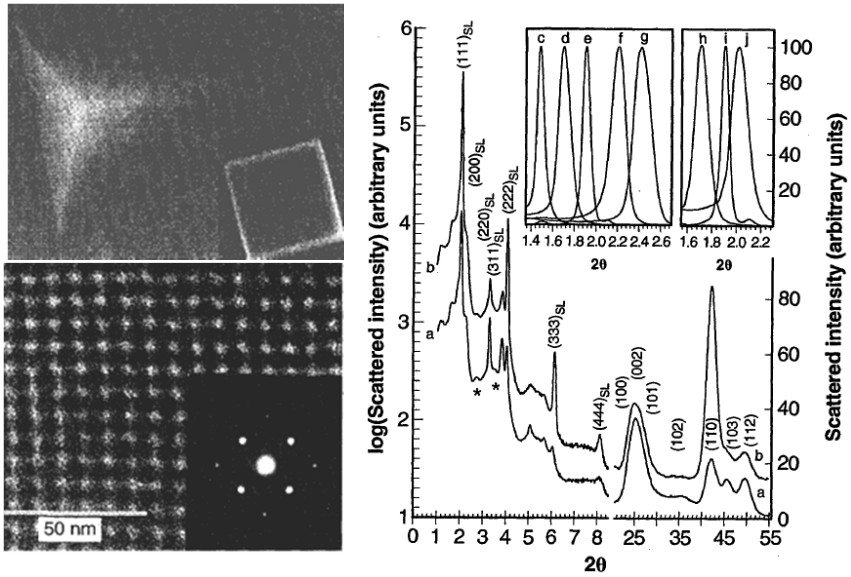
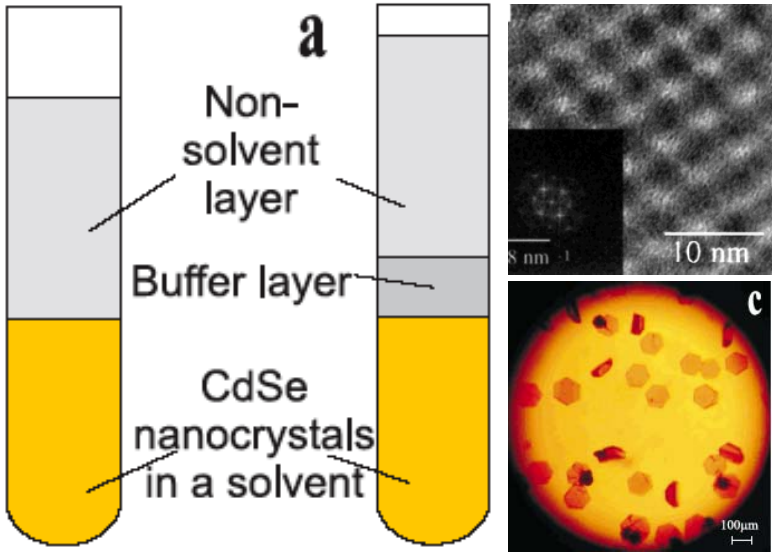
Nanoparticle Assembly at Ambient Pressure:
1. Balanced Interparticle Interactions

1. Slow solvent evaporation



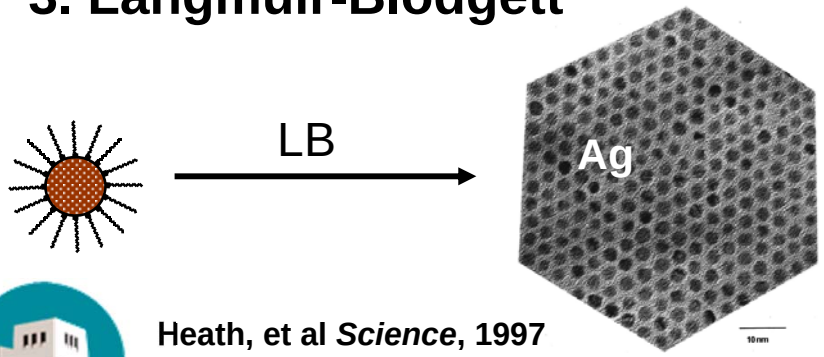
Murray, et al., *Science*, 1995

2. Heterogeneous nucleation



Talapin, et al., *Adv. Mater*. 2001

3. Langmuir-Blodgett



Heath, et al *Science*, 1997

4. Others:

- **Break figure**
- **Biotemplating**

Han YC *et al*.
Russell, T *et al*.
Korgel B. *et al.*

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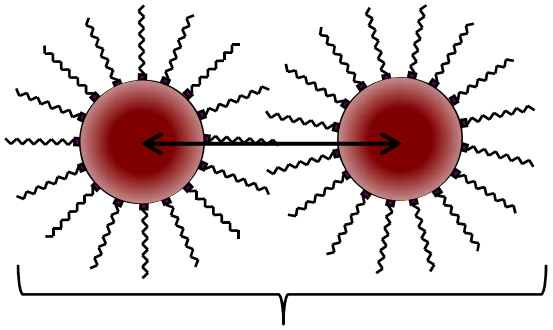
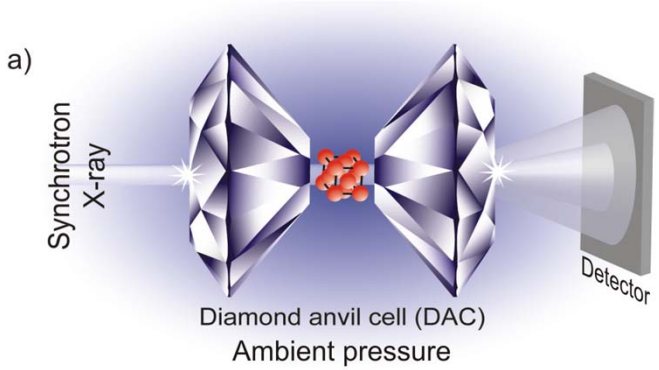
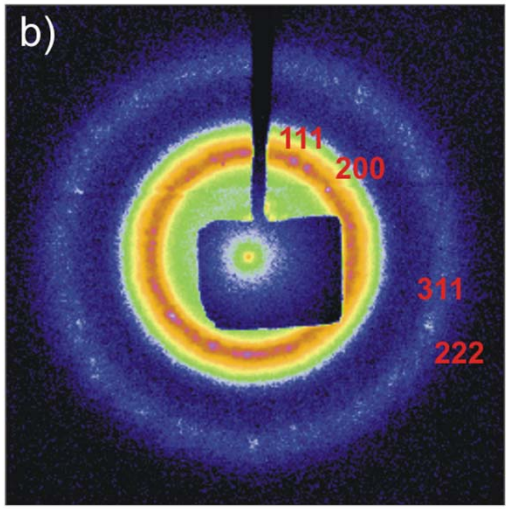
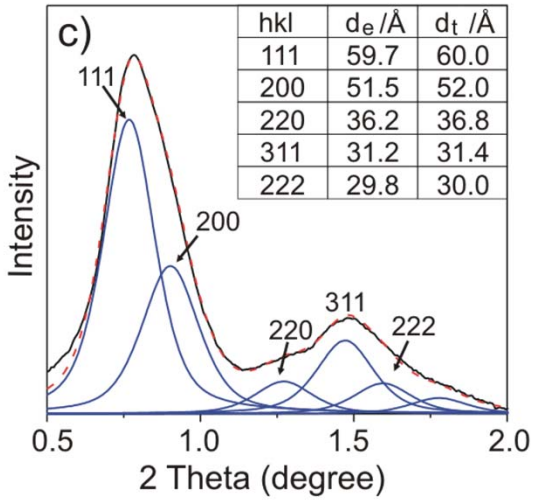
II. Nanoparticle Assembly under Pressure:

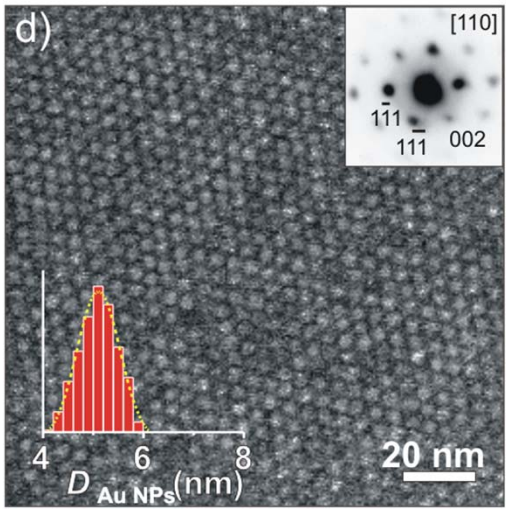


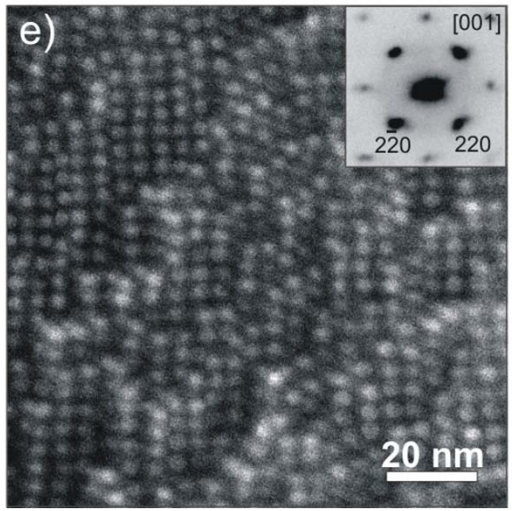
Balanced interparticle interactions











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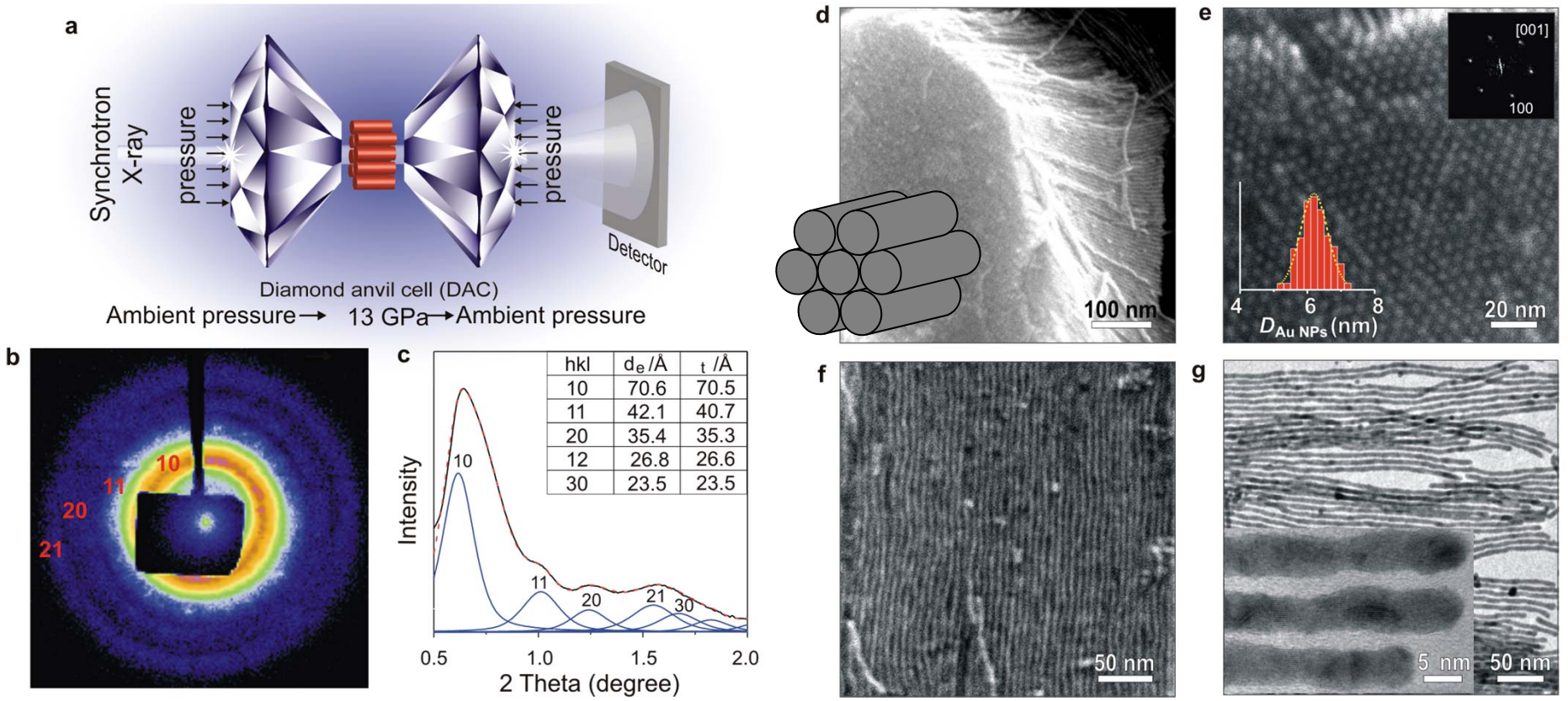
High Pressure Driven Formation of 1D Nanowires



Angwandte Chemie Int. Edit., accepted.

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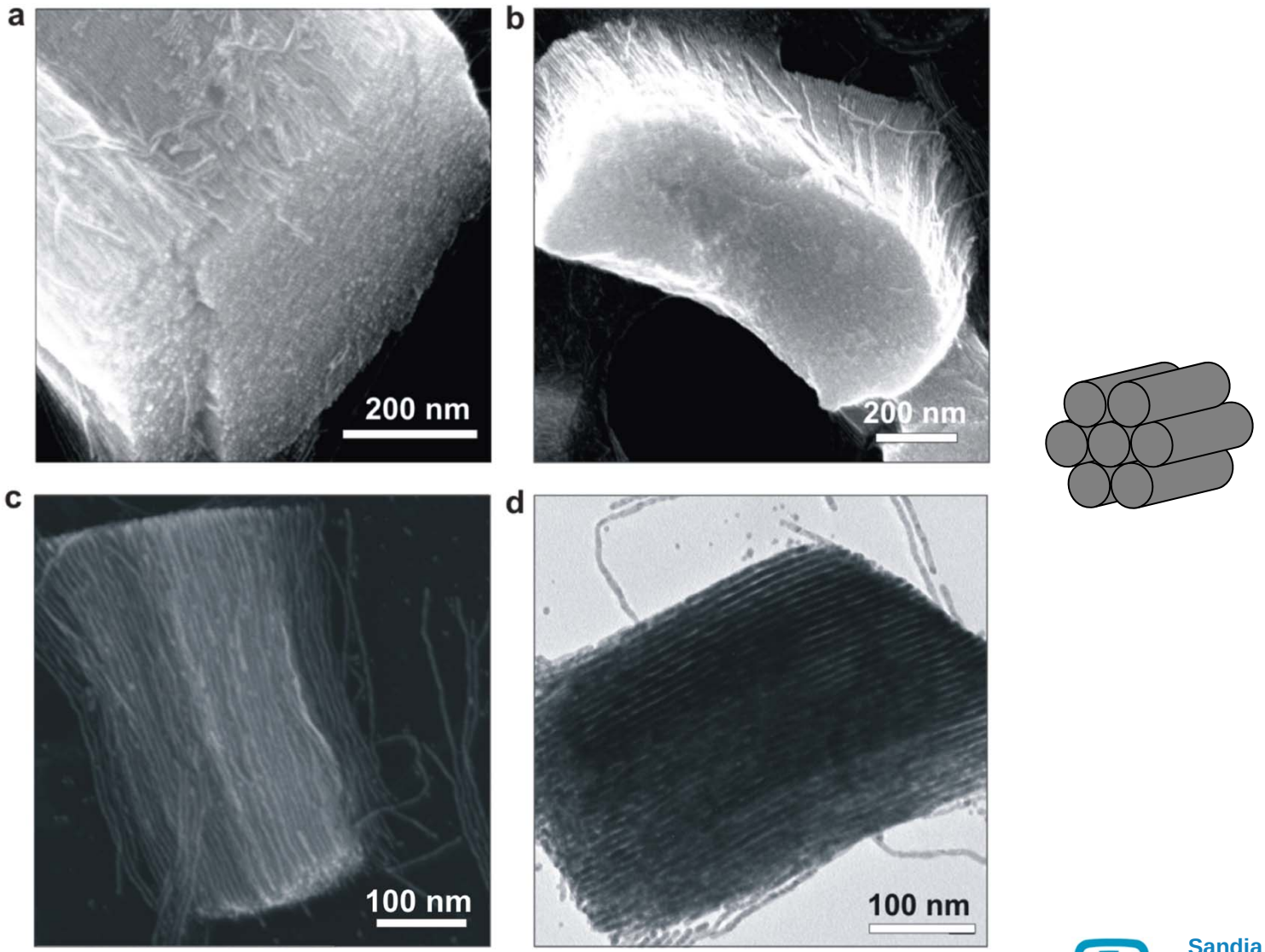
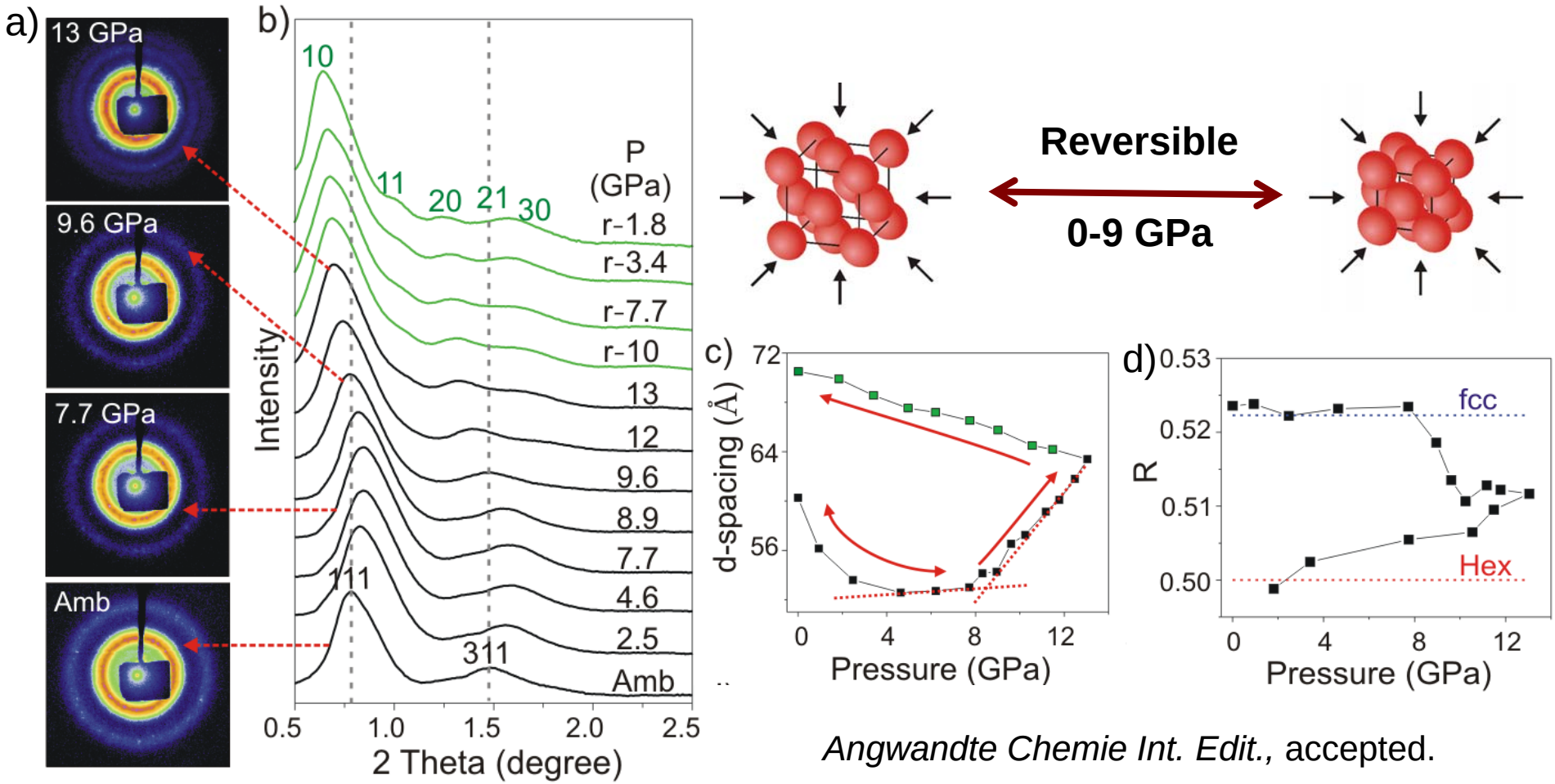
1D nanostructure arrays



High Pressure GISAXS Studies of Nanoparticle Assembly under Pressure

An external pressure can be utilized to engineer nanoparticle assembly, allowing fine-tuning of lattice structure and interparticle separation distance and to fabricate new nanoparticle architectures without relying on these specific interactions.



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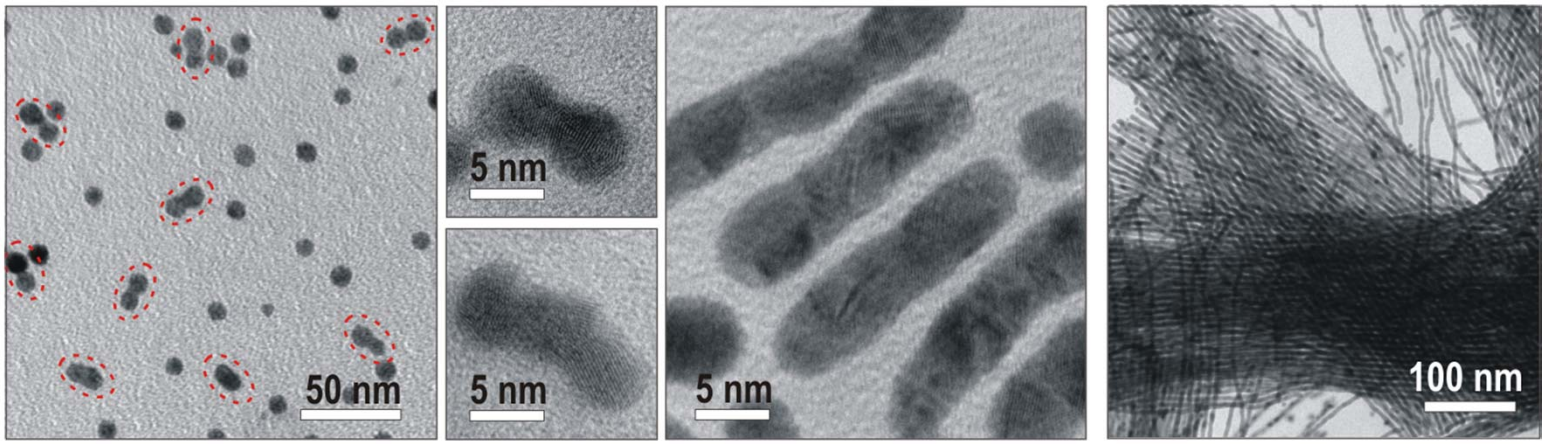
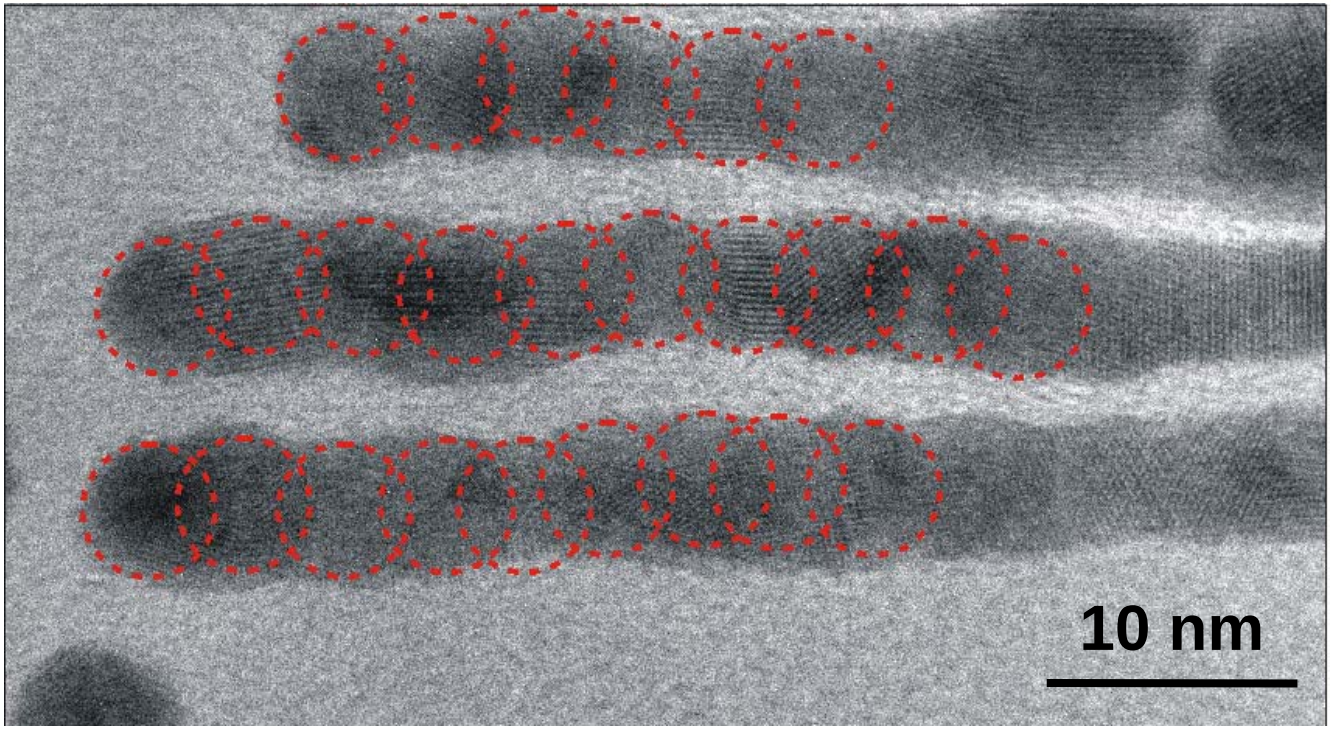
High Pressure Driven Nanoparticle Sintering and Formation of New Chemically and Mechanically Stable 1D Nanostructures





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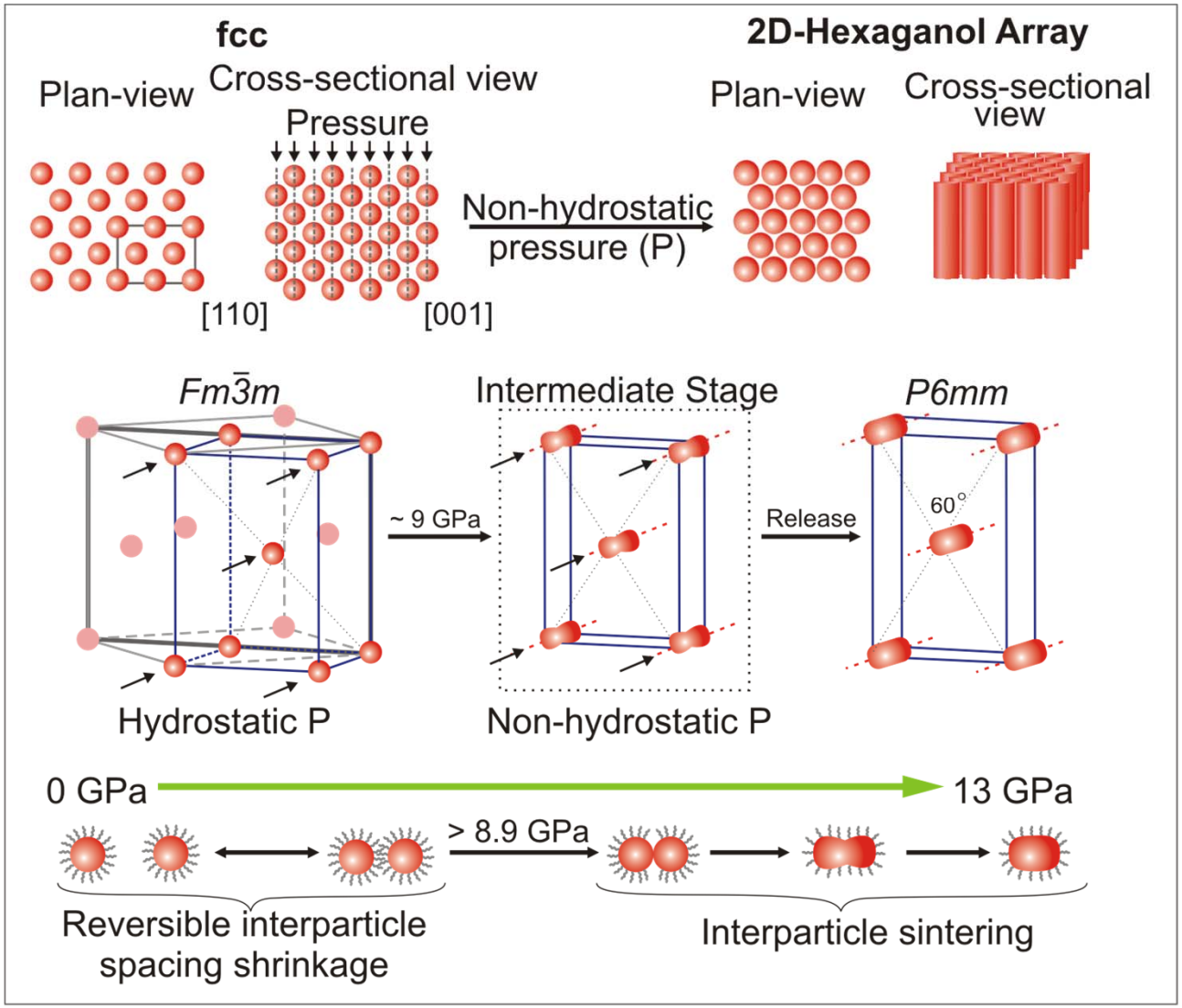
Proposed Processes for High Pressure Driven Nanoparticle Sintering and Formation of 1D Nanostructures



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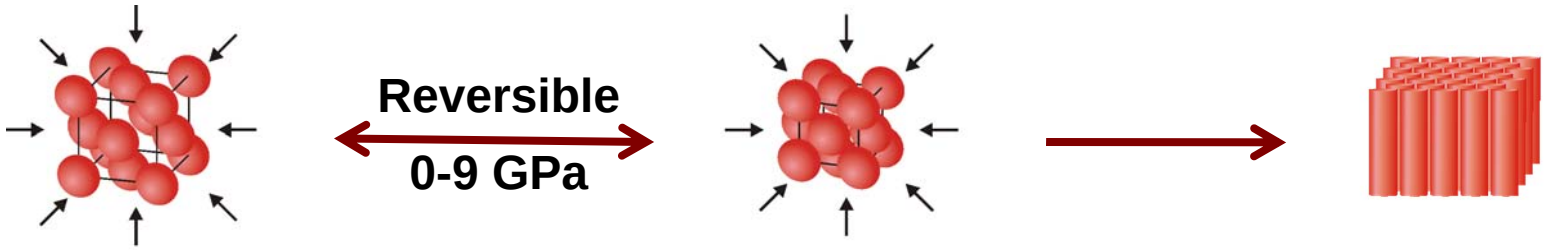
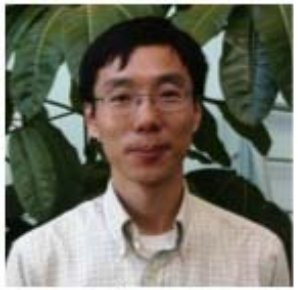
Summary

An external pressure can be utilized to engineer nanoparticle assembly, allowing fine-tuning of lattice structure and interparticle separation distance and to fabricate new nanoparticle architectures without relying on these specific interactions.



Acknowledgements:



Dr. Zaicheng Sun
UNM postdoc

Dr. Feng Bai
UNM postdoc

Dr. Huimeng Wu
SNL postdoc

Dr. Bruce Burckel
SNL postdoc

Prof. Dan Boye
Davidson College
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Adrian Rodriguez
UNM student

Adam Wright
UNM student

Eric Leve
UNM student

Samantha Schmitt
UNM student

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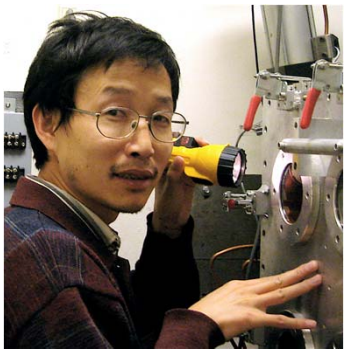

Dr. Zhongwu Wang

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Dr. Jin Wang

Advanced Photon Source

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