Nucleation of gold nanoparticles on graphene from Au_{144} molecular precursors

Andrei Venter[1], Mahdi Hesari[2], M. Shafiq Ahmed[1], Reg Bauld[1], Mark S. Workentin[2] and Giovanni Fanchini[1,2]

Department of Physics and Astronomy[1] and Department of Chemistry[2]
Western University
London, Ontario, N6A 3K7, Canada

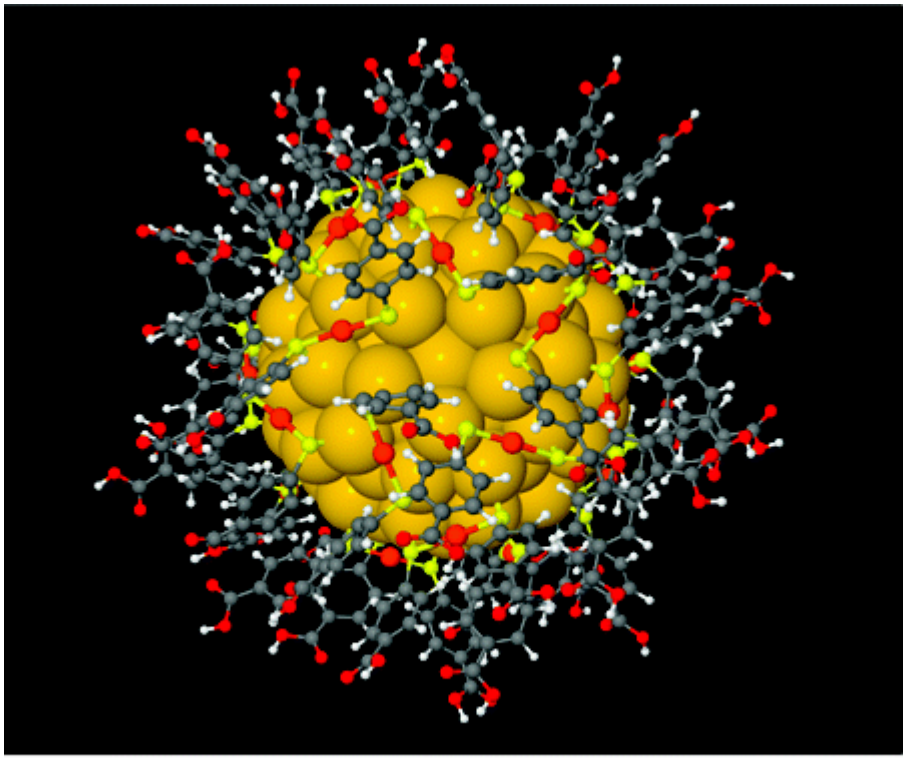
Western

Physics Astronomy Western

Outline

- Au_{144} Structure
- Graphene Preparation
- Au_{144} Nanoparticle Layer Fabrication
- Controlling Particle Size
- Optical Properties and Plasmonics
- Advantages of this method

Au_{144} Structure

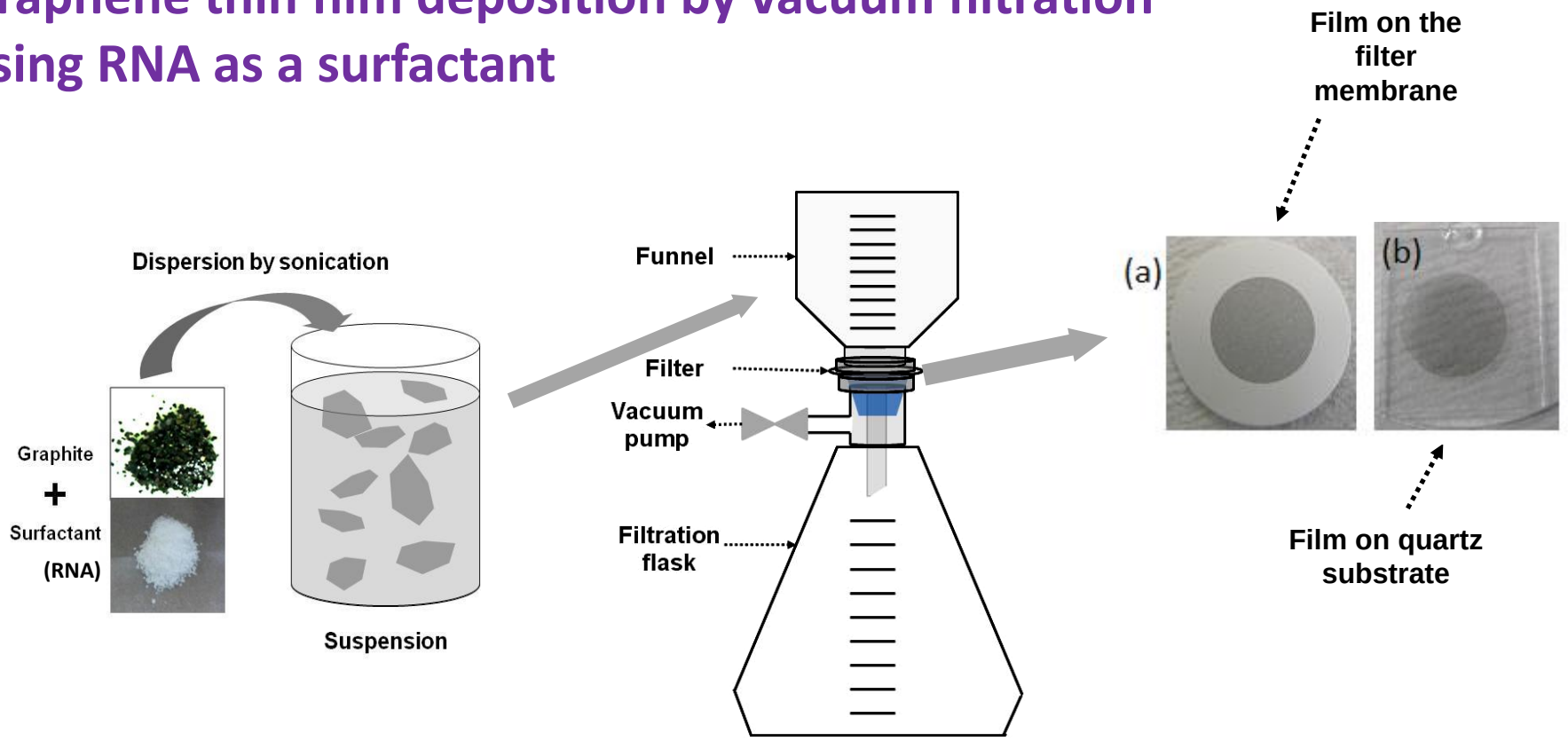


$Au_{144}(SR)_{60} = Au_{114}(RSAuSR)_{30}$

- Core composed of structured Au atoms
- Outer shell covered in stabilizing ligands
- Au-NPs have plasmonic resonance properties

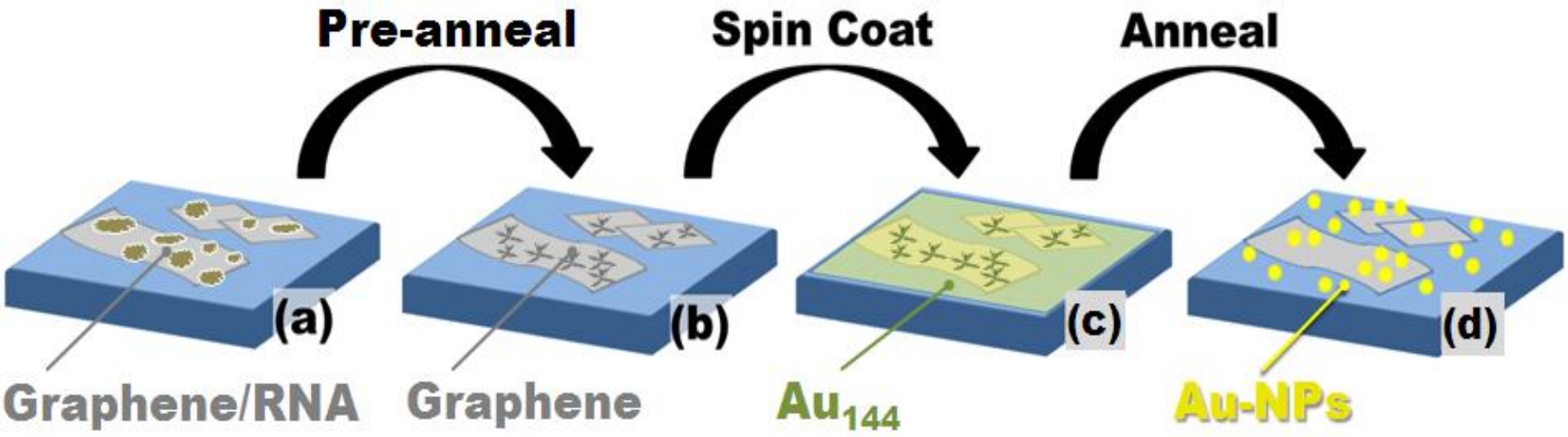
Olga Lopez et. al. *J. Phys. Chem. C*, Vol. 113, No. 13. pp. 5035-5038

Graphene thin film deposition by vacuum filtration using RNA as a surfactant



Sharifi, Bauld, Ahmed and Fanchini, *Small* 8 (2012) 699

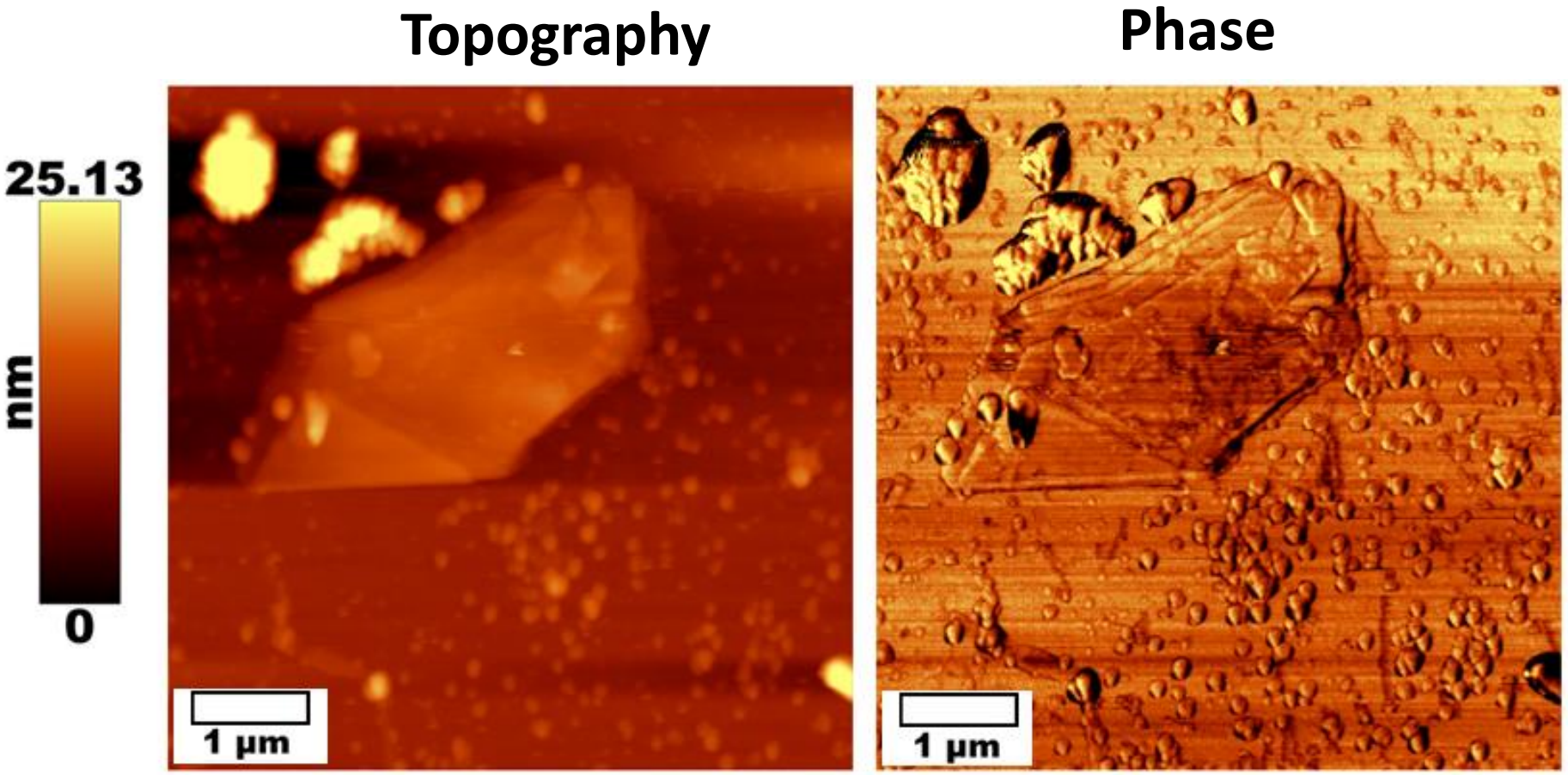
Process



a) A graphene/RNA thin film is prepared on a glass substrate
b) RNA is removed from graphene by a first annealing stage, leaving behind some defects
c) $Au_{144}(SCH_2CH_2Ph)_{60}$ molecular nanoclusters are spun on graphene thin films from solutions in toluene, and
d) the as-obtained $Au_{144}(SCH_2CH_2Ph)_{60}$ film on graphene is annealed.

Using surfactants other than RNA does not lead to Au-NP deposition on graphene

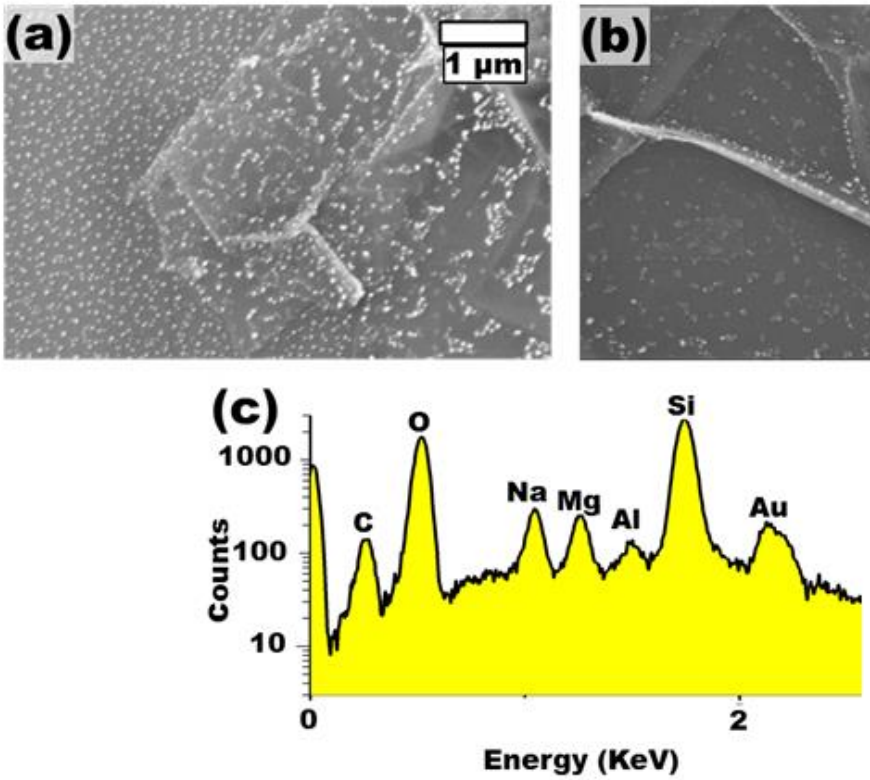
Films grown using Sodium Dodecyl Benzene Sulfonate (SDBS) as a surfactant:



Particle Structure and Composition

SEM images:

(a) spin coated 3000 rpm for 60 seconds
(b) spin coated 4000 rpm for 60 seconds
(c) EDX spectra for one of the nanoparticles in panel b.



Particle Size

Controlling particle size is important for fine-tuning the plasmonic absorption peak and maximizing the amount of light absorbed

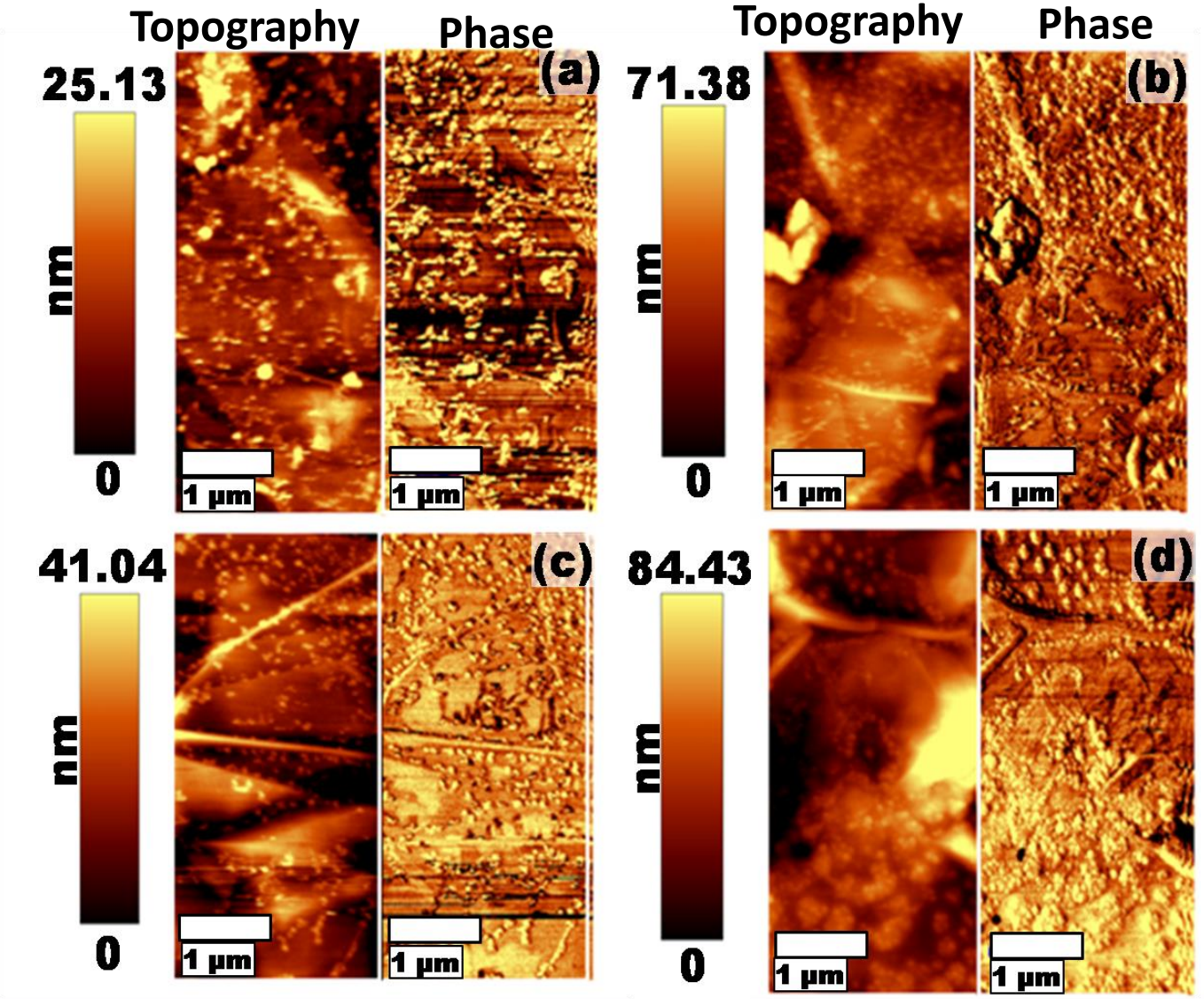
There are many ways to control the size of the nanoparticles that form, we tested 2 method:

- Annealing temperature
- Spin-coat speed

Pre-Annealing Temperature

AFM micrographs at different temps

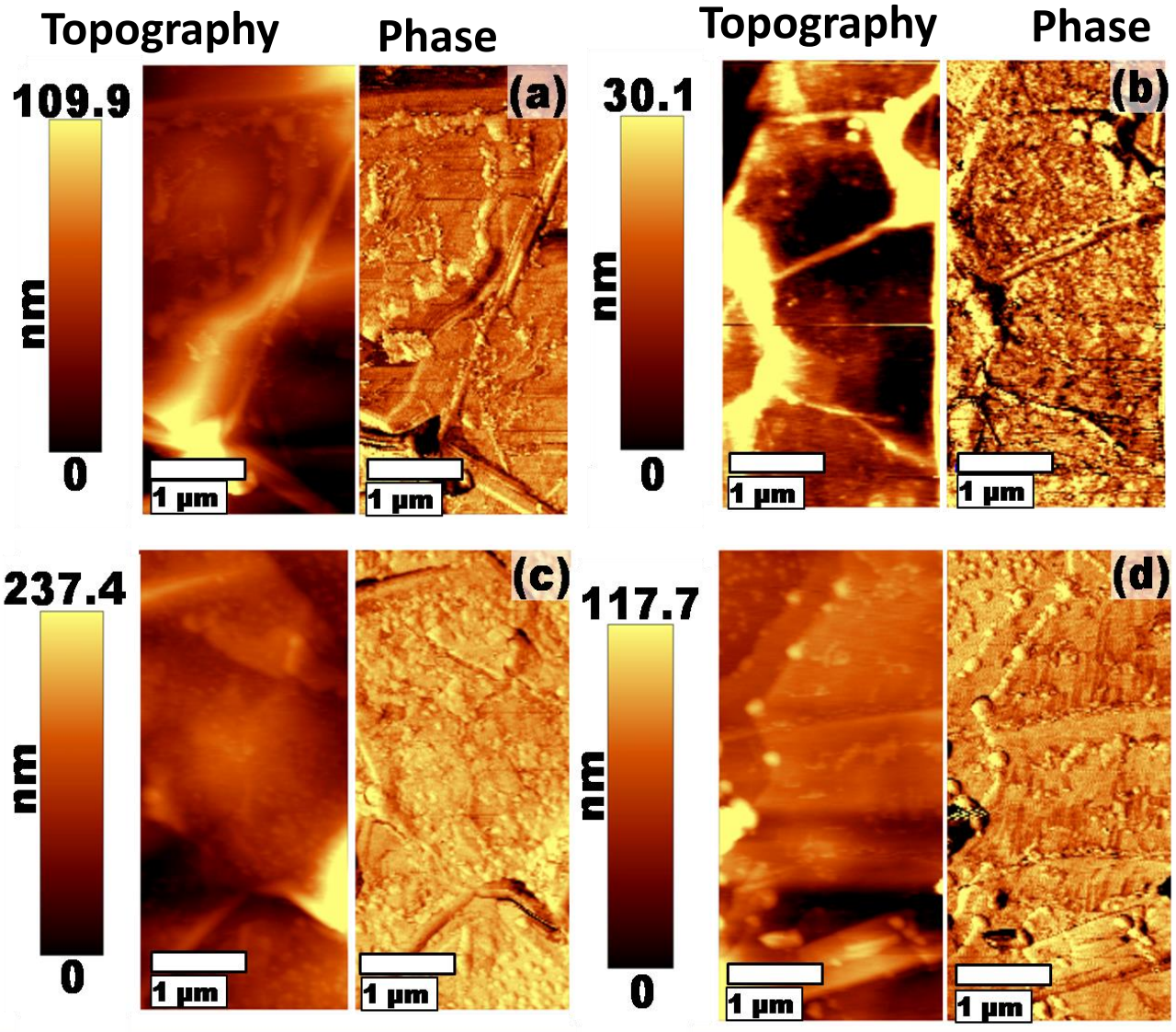
(a) 200°C
(b) 300°C
(c) 400°C
(d) 500°C



Spin-Coat Speed

AFM micrographs
at different speeds

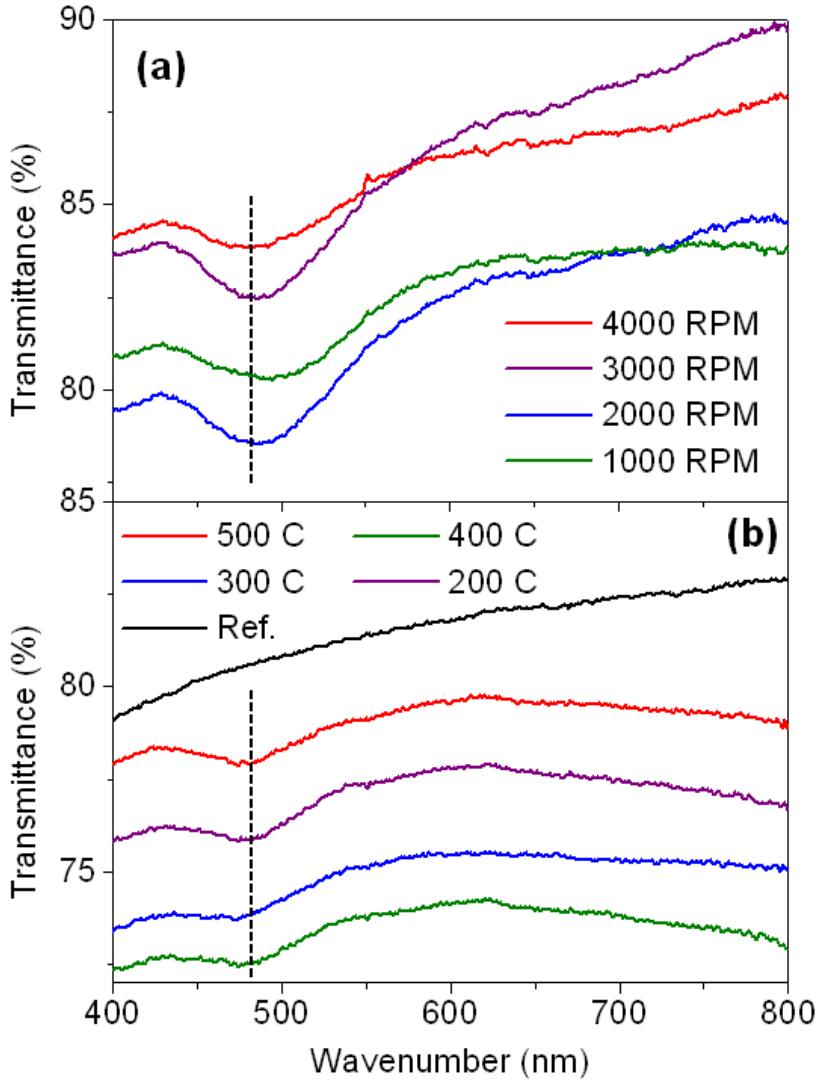
(a) 1000 rpm
(b) 2000 rpm
(c) 3000 rpm
(d) 4000 rpm



Optical Properties

UV-visible transmission spectra samples varying
(a) spinning speed
(b) pre-annealing temperature.

The dip at ~475 nm is due to plasmon-related effects in Au-NPs



Conclusion

We have demonstrated a simple method for the formation of Au-NPs

- pre-annealing is necessary
- RNA is essential
- roughly uniform in size

Controlling Particle Size

- Best results by changing spin-speed
- Changes the position of the surface plasmon peak

Applications:

- transparent electrodes in solar cells
- optical memory devices

Acknowledgements

WESTERN UNIVERSITY
CAMBR
CENTRE FOR ADVANCED MATERIALS & BIOMATERIALS RESEARCH

NSERC
CRSNG

INNOVATION.CA
CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION

Canada Research Chairs
Chaires de recherche du Canada

Thank you for listening