Nanocrystals: What can we learn from them?

Seminar jointly organized by the Department of Mechanical Engineering and Department of Civil Engineering

Date: 12 January, 2024 (Friday)

Time: 2:30 p.m.

Venue: Room 7-34 / 7-35
Haking Wong Building
HKU

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Abstract:

The recent Nobel Prize in Chemistry features Quantum Dots. Quantum Dots are nanocrystals of compound semiconductors with well capped surfaces for optimum optical and electronic properties. Quantum confinements were predicted by Dr. Luis Brus in 1986 at Bell Labs. Hence, without surface defect traps, their optical and electronic properties can be tuned by controlling the crystallite-size. Today many displays employ QD's and have great commercial success.

Such detail size-dependent property study has not been extended to nanocrystals' bond-length, mechanical and thermal properties. The lattice expansion in nanocrystals of oxides and PbS is shown to be a result of surface compressive stress originated from adsorbents/surfactants, size-dependent Madelung negative pressure, and/or cation reduction. The findings open a new way to control surface/interface stress in nano-device fabrication which is important to the overall yield of manufacturing, crucial to the chip makers' profit margin and survival. For example, misfit dislocations from lattice mismatch in epi-growth of SiGe on Si have been avoided through size-control. Strained SiGe/Si enables faster transistors, an important breakthrough toward GHZ FET's and BiCOM.

In addition, stiffness (aka Bulk Modulus) also shows size-dependence in nanocrystals of ceria, MgO and PBS each with a maximum and a general decrease with decreasing crystal-size. Similarly with thermal expansion the general decrease with decreasing crystal-size is also observed in nano ceria and MgO. Together the predicted heat capacity exhibits a crucial size beyond which a general decrease with decreasing crystal-size.

In summary, we will examine how these new findings improve our control over device processing and reliability.

Size-dependent heat capacity in nano-oxide crystals
Chan, S.-W., Wang, W.
Solid State Communications 365, p. 115121(2023)

Surface stress of nano-crystals
Chan, S.-W., Wang, W.
Materials Chemistry and Physics 273, p.125091(2021)

Crystallite-size dependency of the pressure and temperature response in nanoparticles of magnesia
Rodenbough, P.P., Chan, S.-W.
Journal of Nanoparticle Research 19(7), p.241(2017)

Crystallite size dependency of thermal expansion in ceria nanoparticles
Rodenbough, P.P., Lipatov, M., Chan, S.-W.
Materials Chemistry and Physics 192, pp. 311–316 (2017)

Lattice Expansion in Metal Oxide Nanoparticles: MgO, Co3O4, Fe3O4
Journal of the American Ceramic Society (2017) DOI: 10.1111/jace.14478
Rodenbough, P.P.; Zheng, C.; Liu, Y.; Hui, C.; Xia, Y.; Ran, Z.; Hu, Y.; Chan, S.-W.

Size dependent compressibility of nano-ceria: Minimum near 33 nm
Applied Physics Letters (2015) DOI: 10.1063/1.4918625
Rodenbough, P.P.; Song, J.; Walker, D.; Clark, S.M.; Kalkan, B.; Chan, S.-W.

Size-Dependent Crystal Properties of Nanocuprite
International Journal of Applied Ceramic Technology (2016)
DOI: 10.1111/ijac.12486 Song, J.; Rodenbough, P.P.; Zhang, L.; Chan, S.-W.

ALL INTERESTED ARE WELCOME

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