Synthesizing Nanoparticles via Atomic Layer Deposition to Elucidate the Haber-Bosch Process

BSc/MSc Project

Motivation

The Haber-Bosch Process is one of the greatest scientific accomplishments of the 20th century. It was developed by Nobel-Laureate Fritz Haber to produce fertilizers in 1913 and was one of the main proponents of preventing world hunger. Today, this industrial process alone accounts for 2% of the entire world's energy supply. While the process is of utmost importance to society, it is not well understood due to the lack of spectroscopic techniques capable of operating at industrially relevant conditions. As a result, scientists have little understanding of the reaction. We aim to understand this process under industrially relevant conditions by developing state-of-the-art spectroscopic methods. Since the reaction utilizes structure-sensitive materials, a method must first be created that allows atomic-level control of particle sizes.

Project

We will prepare industrially relevant iron oxide nanoparticles of various sizes via atomic layer deposition (ALD). During the ALD process, gaseous precursors are sequentially pulsed over a substrate under sensitive reaction conditions. These gas phase reactants interact with the substrate to cause particle formation. Precise control over the temperature, pressure, pulsing time, number of cycles, and gas flow rate affords atomic-level control of particle sizes. The particles will be analyzed by TEM, SEM, XPS, XRD, and ICP-OES. The project is in collaboration with Charlotte Vogt's group. A student will have the chance to visit the group to analyze particles via novel spectroscopic techniques.

Contact

We are looking for a motivated and assertive student to join the group. If you are interested, please contact Dr. Saeed Saedy (s.saedy@tudelft.nl) or Prof. Ruud van Ommen (J.R.vanOmmen@tudelft.nl) for further information.

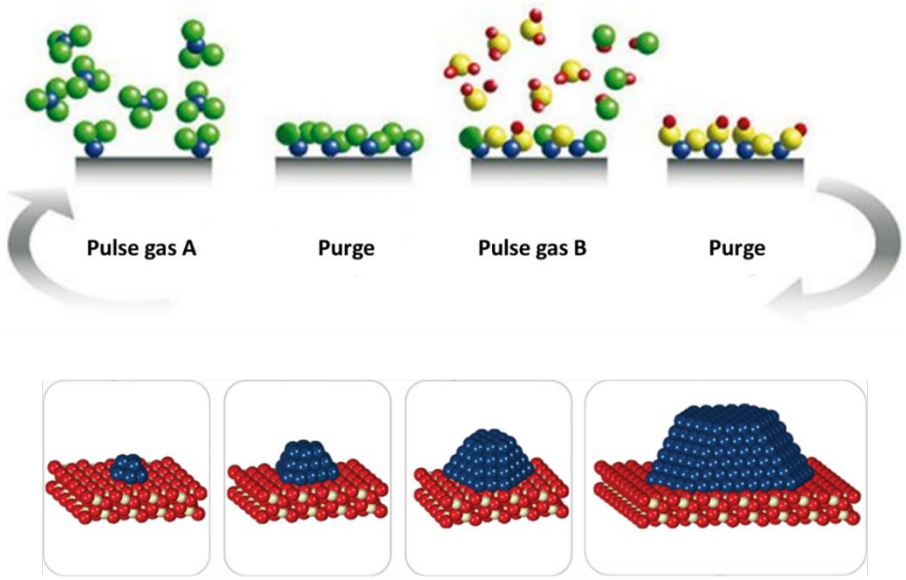

Figure. (Top) Schematic illustration of a typical ALD cycle consisting of two half-cycles. Gaseous species A and B are pulsed and then purged to induce particle formation.[1] (Bottom) Example of various-size nanoparticles achievable via ALD.[2]

1. How ALD works. Beneq. (n.d.). Retrieved September 6, 2022, from https://beneq.com/en/technology/ald/
2. Y. Lykhach et al., (2015). Counting electrons on supported nanoparticles. Nature Materials, 15(3), 284–288. https://doi.org/10.1038/nmat4500

Suggested reference to read:

https://pubs.acs.org/doi/10.1021/cs501862h

https://www.sciencedirect.com/science/article/pii/S1872206714601182