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My research involves studying catalyst nanoparticles using quantitative ADF EDS and EELS signals in STEM.

ADF: Annular Dark Field
EDS: Energy-dispersive X-ray Spectroscopy
EELS: Electron Energy Loss Spectroscopy
STEM: Scanning Transmission Electron Microscopy

The overarching aim of the project is to link catalytic activity to key parameters such as size, shape, surface-str and composition. Using STEM, it is possible to routinely measure these parameters simultaneously from a nanoparticle. The ADF signal can be used to can be used to obtain atomic positions as well as the size and sha of the nanoparticle, whereas EDS and EELS can be used to obtain high resolution composition information.

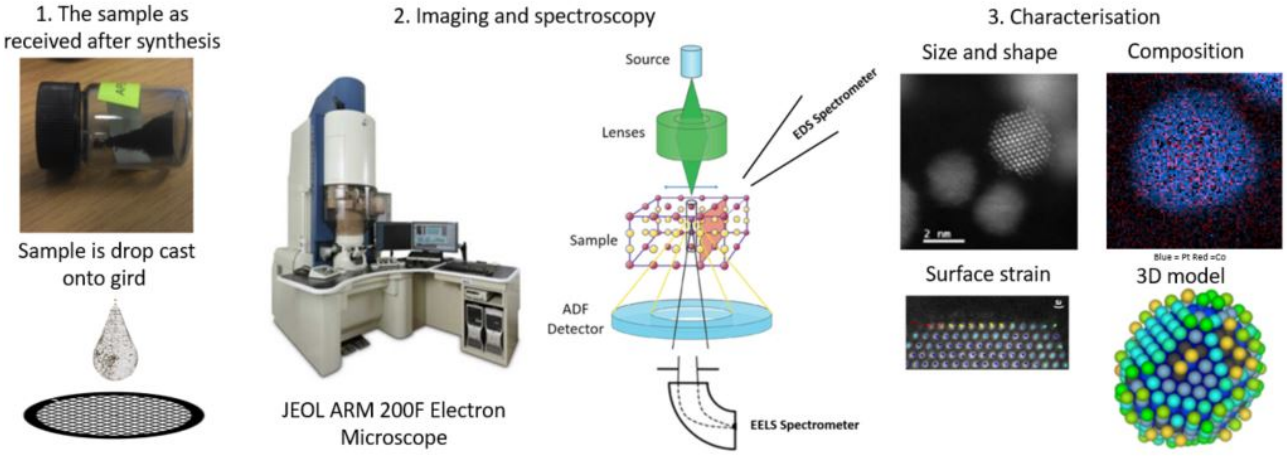

Figure 1. Combining synthesis, microscopy and characterisation for rational catalyst design. STEM schematic source: Prof David Muller, https://www.nature.com/articles/nmat2380

One of the aims of the project is to obtain three dimensional models from two-dimensional projection images obtained from the STEM with high throughput. By utilising careful calibrations and simulation matching techniques, developed within the group, routine atom counts from a broad range of nanoparticles with reliable accuracy can be obtained. In one particular case, the atom counts from pure Pt nanoparticles were converted i three dimensional models by Dr. Lewys Jones (http://lewysjones.com) and used as an input to DFT simulations Dr. Jolyon Aarons. For further details on this see: http://pubs.acs.org/doi/abs/10.1021/acs.nanolett.6b04799

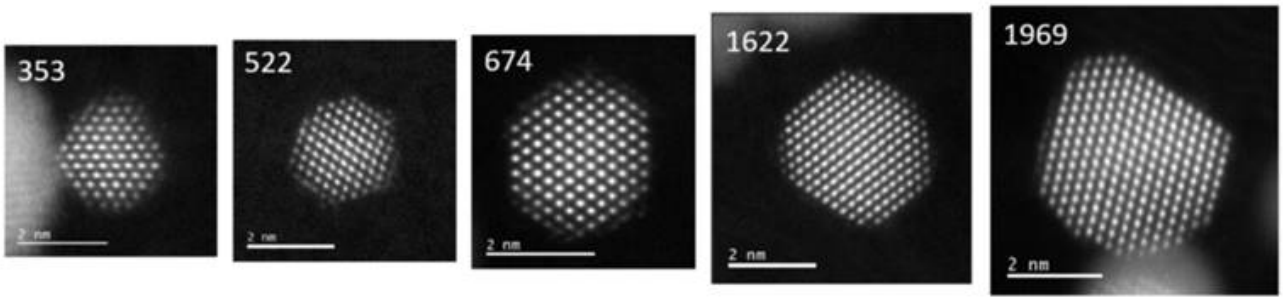

Figure 2. Atom counted nanoparticles from a size selected distribution of 1341 nanoparticles.

Whilst quantifying pure element catalysts using ADF STEM is a well-established technique, it is not suitable for quantifying bimetallic nanoparticles. To decouple composition effects, simultaneous ADF, EDS and EELS signa acquisition is required. In this technique, the spectroscopic signal from pure element standards, such as needle or nanoparticles, is required. The aim is then to use these cross-sections to atom count bimetallic nanoparticles a routine manner similar to the pure element ADF quantification.

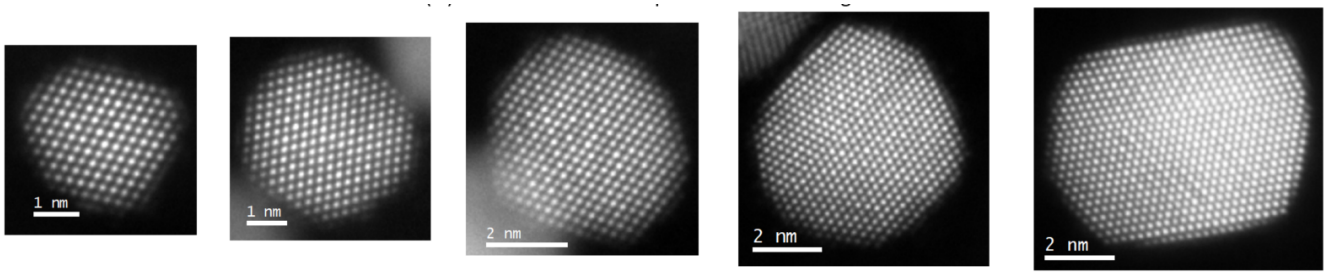

Figure 3. Size selected Pt-Co bimetallic nanoparticles, the size, structure and relative atomic displacements ca be measured from the ADF image, whereas the composition can be measured using the EDS and EELS signal

Upcoming conferences where you can find me

Electron Microscopy of catalysts

Johnson Matthey Academic Conference

Travel grants and awards won

EMAT Workshop 2015 Mansfield Travel Grant
EMCat 2016 Mansfield Travel Grant
EMAG 2016 RMS Travel Grant
EMC 2016 EMS and RMS Travel/Student award
MSA, M&M 2017, Invited talk and Young Scholar Award
Electron Microscopy of Catalysts 2017, invited talk

Publications list

"Predicting the oxygen binding properties of platinum nanoparticle ensembles by combining high-precision electron microscopy & DFT",Jolyon Aarons, Lewys Jones, Aakash Varambhia, Katherine E. MacArthur, Dogan Ozkaya, Misbah Sarwar, Chris-Kriton Skylaris, Peter D. Nellist, Nano Letters, 17(7) (2017), DOI:10.1021/acs.nanolett.6b04799.

"Quantifying a Heterogeneous Ru Catalyst on Carbon Black Using ADF STEM", A. M. Varambhia, L. Jones, A. Backer, V. T. Fauske, S. Van Aert, D. Ozkaya and P. D. Nellist, Particle & Particle Systems Characterization 33: (2016), DOI:10.1002/ppsc.201600067.

“Electrochemical CO Oxidation at Platinum on Carbon Studied Through Analysis of Anomalous In Situ IR Spectra”, Ian McPherson, Philip Ash, Lewys Jones, Aakash Varambhia, Robert Jacobs, and Kylie Vincent, Jou of Physical Chemistry C (in press), DOI:10.1021/acs.jpcc.7b02166.

“A combined approach for deposition and characterization of atomically engineered catalyst nanoparticles”. Q Yang, DE Joyce, S Saranu, GM Hughes, A Varambhia, MP Moody, , PAJ Bagot. Catalysis, Structure & Reactivi 1 (3), 125-131

“An optical configuration for fastidious STEM detector calibration”
Lewys Jonesa*, Aakash Varambhiaa, Hidetaka Sawadab, Peter D. Nellista, in press, Journal of microscopy

“Observation of metal nanoparticles at atomic resolution in Pt-based cancer chemotherapeutics”
Sheader A. A., Varambhia A.M., Fleck R. A., Flatters S. J. L. and Nellist P. D. In press, Accepted, Journal of microscopy.

“Revealing more while damaging less: exploiting multi-frame EDX & EELS spectroscopy acquisition and post-processing tools”
L. Jones, A. Varambhia, Sergio Lozano-Perez and P. D. Nellist. EDGE, In press

Conference Proceedings

“New Opportunities in multi-frame STEM Spectroscopy & Fractional Beam-current EELS”, Lewys Jones, Aakas Varambhia, Demie Kepaptsoglou, Quentin Ramasse, Robert Freer, Feridoon Azough, Sergio Lozano-Perez, Richard Beanland, and Peter Nellist, 16th European Microscopy Congress (2016)

“Nano-scale strain measurements from high-precision ADF STEM”, Lewys Jones, Aakash Varambhia, Sigurd Wenner, Magnus Nord, Per Harald Ninive, Ole Martin Løvvik, Randi Holmestad, and Peter Nellist, 16th Europe Microscopy Congress (2016)

“Experiment design for quantitative dark field imaging and spectroscopy of catalyst nanoparticles using Scannir Transmission Electron Microscopy (STEM)”, Aakash Varambhia, Lewys Jones, Annick De Backer, Vidar Fausk Sandra Van Aert, Dogan Ozkaya, Sergio Lozano-Perez, and Peter Nellist, 16th European Microscopy Congress (2016)

“Atomic resolution electron microscopy of cobalt ferrite nanoparticles”, Dominique Piché, Juan G Lozano, Aaka Varambhia, Frank Dillon, Lewys Jones, Peter D Nellist, Nicole Grobert, 16th European Microscopy Congress (2016)

“Quantification of ADF STEM Image Data for Nanoparticle Structure and Strain Measurements”, Peter Nellist, Lewys Jones, Aakash Varambhia, Annick De Backer, Sandra Van Aert, and Dogan Ozkaya, Microscopy and Microanalysis, 22(S3) p.896-897 (2016)

“Quantification of a Heterogeneous Ruthenium Catalyst on Carbon-black using ADF Imaging”, Aakash Varambhia, Lewys Jones, Peter Nellist, Sergio Lozano-Perez, and Dogan Ozkaya, Journal of Physics: Conference Series 644:012035 (2015)