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ABSTRACT:

Probing Energy Materials at the Nanoscale: In Situ Bragg Coherent Diffraction and Nano-Diffraction Insights

M.-I. Richard[1,2], C. Atlan[1,2], C. Chatelier[1,2], M. Grimes[1,2], E. Bellec[1,2], K. Olson[1,2], N. Vostrov[2], A. Viola[3], M. Dupraz[1,2], I. Martens[2], T. Schülli[2], F. Maillard[3] and S. J. Leake[2]
[1]Univ. Grenoble Alpes, CEA Grenoble, IRIG, MEM, NRX, Grenoble, France.
[2]ESRF - The European Synchrotron, Grenoble, France.
[3]Univ. Grenoble Alpes, CNRS, Grenoble INP, LEPMI, Grenoble, France.

The emergence of 4th generation x-ray light sources offers an unparalleled opportunity for conducting in situ and operando studies of nanoparticle structures in complex environments, especially in the field of energy materials. Gaining insights into the dynamic strain behavior of catalysts is critical for developing cost-effective, efficient, and long-lasting catalytic systems. In this talk, I will show how Bragg coherent x-ray imaging (BCDI) [1] enables three-dimensional (3D) nanoscale imaging of strain, defect dynamics, and re-faceting processes within nanoparticles during catalytic reactions.
We successfully mapped the 3D lattice displacements and strain distribution of a platinum nanoparticle under electrochemical conditions [2] and during CO oxidation [3,4]. We achieved sub-second time resolution during operando chemical reactions, detecting oscillatory strain changes with a 6.4-second periodicity, directly associated with site-specific CO adsorption during oxidation [5], with a benchmark resolution of 0.25 seconds. I will also present our latest findings on the core-shell transition in NiFe catalysts during annealing [6], discuss the potential of measuring particles as small as 20 nm [7] and demonstrate high-energy imaging of embedded materials [8] using BCDI. Finally, I will highlight how operando scanning nano-diffraction can reveal the evolution of strain and defects in nanocrystals during battery charge-discharge cycles [9,10].
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[1] I. Robinson and R. Harder, Nat. Mater. 8, 291 (2009); [2] C. Atlan et al., Nat. Mater. 22, 6 (2023); [3] J. Carnis et al., Nat. Commun. 12, 5385 (2021); [4] M. Dupraz et al., Nat. Commun. 13, 1 (2022); [5] M. Grimes et al., ACS Nano 18, 19608 (2024); [6] C. Chatelier et al., ACS Nano 18, 13517 (2024); [7] M.-I. Richard et al., J. Appl. Crystallogr. 55, 621 (2022); [8] M.-I. Richard et al., ACS Appl. Nano

Mater. (2023); [9] I. Martens et al., Nat. Commun. 14, 1 (2023); [10] I. Martens et al, ACS Appl. Mater. Amp Interfaces 15, 59319 (2023).