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Time-Resolved, Atomic-Resolution Imaging of Metastable Atom Configurations[1]

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In the recent past significant initiatives are dedicated to the exploration of sustainable energy solutions. Certainly, related research must address a rich diversity of challenges because it is not only the static arrangement of matter that must be understood at a single atom level but also the collective behavior of molecular assemblies that leads to functionality. Moreover, hybrid materials are commonly employed that contain hard and soft matter components to artificially stimulate complex behavior. Electron microscopy is often considered a method of choice that may address these challenges if further improved. This paper reports on the development of in-line holography for atomic-resolution electron microscopy, which makes use of dose rates as low as a few atto Amperes per square Ångstrom and of variable acceleration voltages between 20 kV and 300 kV [1]. The approach allows for enhancing resolution in radiation sensitive materials and is especially well suited to study the time evolution of nanoscale objects with single atom sensitivity. For the first time temporary displacements of single atoms from their equilibrium lattice sites into metastable sites across a projected distance of only 0.07 nm and 0.10 nm are directly captured in images with a time resolution around one second. These temporary excitations seem relevant to the irreversible transformation of graphene into carbene and to self-diffusion in catalysts. In suitable experimental conditions, however, atom displacements of 0.05 - 0.1 nm are entirely reversible. Exploiting the reversible nature of such excitations, it may become feasible to probe for conformational object changes in beam sensitive materials at improved spatial resolution.

[1] B. Barton, B. Jiang, C.Y. Song, P. Specht, H. Calderon, C, Kisielowski, Atomic-resolution phase-contrast imaging and in-line electron holography using variable voltage and dose rate, **Microsc. Microanal. 18** (2012) 982–994

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