In-Situ Atomic Force Microscopy of Halide Salts Under X-Ray Irradiation

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Predicting material behavior under radiological conditions provides a unique challenge due to the relatively limited number of tools available for characterization. This hinders the development of a fundamental understanding and predictive models of complex processes under ionizing radiation such as those involved in the processing of legacy radioactive waste forms, long term waste storage, atmospheric particle transformations under cosmic radiation, or the stability of materials used in existing and future reactors. Typically characterization of chemical, morphological, and material properties are carried out as a comparison of changes between pre and post irradiation or as a function of bulk properties in situ. Few techniques are able to provide both local structure and in situ characterization in order to observe the evolution of radiation induced process. To this end an atomic force microscope with an integrated x-ray source has been developed, allowing for the characterization of morphological changes during irradiation with nanometer resolution. Complex growth and reconstruction behaviors of halide salts including KBr, NaCl, and KCl induced by radiolytic species were observed during gas phase x-ray irradiation under carefully controlled temperature, gas composition, and humidity. The dynamic processes involved have implications for long term radioactive waste repositories composed of halide salts, and for atmospheric reactions of halide salt particles. In addition, this work showcases a flexible new technique for understanding mechanisms of material transformation in a variety of systems.