

Dynamics of Thin-Film Deposition

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Achieving the ultimate levels of performance will require atomic precision in the fabrication of the smallest structures in devices. Developing our abilities to manipulate and to characterize materials on atomic length- and time-scales is a key first step in the process.

For over a century, our fundamental understanding of the atomic-scale structure of materials has been advanced primarily by direct structural measurements of periodic materials using x-rays. However, matter is not static and the interesting cases are not, in general, periodic. Coherent, hard x-ray techniques have expanded the reach of x-ray structural studies to finite size objects and non-periodic systems.

The characteristic time for atomic rearrangements in matter is set by the characteristic vibrational period of an atom, which can be estimated to be

$$T_{vib} = 2\pi(k/m)^{1/2} \approx 1ps$$

where we have assumed a spring constant $k \sim eV/a^2$, an atomic spacing $a = 3\text{\AA}$, and mass $m = 10^{-25}$ kg. Thus, atomic rearrangements during chemical reactions, phase transitions, and in response to external stimuli are expected to occur on time scales in the picosecond range.

Thus, in principle, time-resolved, coherent x-ray techniques using hard x-rays with pulse widths in the (sub) picosecond range have the potential to characterize “interesting” materials and heterostructures on both atomic length- and time-scales. This talk will explore potential applications of such a source to the study of non-thermal processes occurring during thin film deposition.