Summary Report for the Workshop on
Understanding Condensed Matter Dynamics at the Microscopic Level
Advanced Photon Source, Argonne National Laboratory (June 23-24, 2008)

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Over sixty individuals representing academia, national laboratories, and government organizations participated in the workshop held at the Advanced Photon Source (APS). Scientists from the U.K. and Japan were also present. Twenty-three talks and sixteen posters were presented during the 1.5 day meeting. Excellent scientific discussions took place throughout the workshop including considerable interactions at the working lunch and dinner on the first day.

Session I consisted of overview talks that set the stage for the workshop. Talks by senior managers from DOE/NNSA and DOE/BES pointed out that the workshop topic was extremely relevant to the DOE needs both in national security and energy areas. The need for establishing meaningful partnerships between the DOE Laboratories and Offices, DoD Laboratories, and academic institutions to address the workshop objectives was an important theme of the Session I talks.

Session II consisted of scientific presentations that provided overviews of particular topics. An excellent overview of the current status and future outlook of "light sources" to examine in-situ material response started the session. The two talks on dynamic compression studies captured very well the need to understand condensed matter dynamics, at the microscopic level, over a broad range of loading conditions: very high pressures and short time scales (ps-ns) and high stresses and longer time scales (ns-μs). The need for time-resolved, in-situ microscopic measurements in single event experiments was emphasized in all the talks. In particular, time-resolved measurements were deemed essential for understanding the physical processes that govern structural transition mechanisms and kinetics under dynamic loading.

The static pressure talk in this session provided an excellent overview of the elegant and meaningful scientific achievements that have been possible in the static pressure field due to in-situ, microscopic measurements. A key aspect of this talk was the recognition that a large number of the research achievements at the High-Pressure Collaborative Access Team (HP-CAT) sector were not predicted when these beamlines were first designed and built. Similarly, a proposed Dynamic Compression CAT (DC-CAT) sector will lead to unprecedented scientific achievements that cannot be foreseen at present.

The next three sessions consisted of theoretical and experimental presentations that provided overviews and topical research developments. These talks emphasized the need for an experimental facility dedicated to time-resolved, in-situ microscopic measurements under dynamic loading. Such a facility, to undertake measurements routinely under dynamic compression, does not currently exist anywhere. DC-CAT, proposed for the APS, would be the first of its kind. Senior managers from LANL and LLNL in their presentations pointed out the complementary nature of DC-CAT to other facilities being envisioned by these two laboratories.

Theoretical talks emphasized the need for time-resolved, in-situ microscopic measurements because current computational capabilities are far ahead of present measurement capabilities. Confidence in multiscale modeling requires time-resolved experimental measurements at comparable length scales; otherwise, the validity of theoretical/computational predictions cannot be firmly established. Two of the experimental talks described scientific needs that build on, but are complementary to, the NNSA activities: planetary science research for NASA; and materials science needs for the thermomechanical conditions of interest to the DoD. Both of these scientific talks emphasized the need for time-resolved, in situ microscopic measurements that extend to microsecond time scales under dynamic loading.

Based on the talks in Sessions III to V, representative of the broad scientific interests in dynamic compression research, a strong need exists for a dedicated facility like DC-CAT. Such a facility will lead to revolutionary scientific developments and advances in the field.

A key element of the final Session, focused on a path forward, was the talk on conceptual design and requirements for the proposed DC-CAT beamlines at the APS. The pulse structure at the APS is uniquely suited to undertake time-resolved measurements, which are necessary for understanding condensed matter processes under dynamic loading. Using fairly conservative standards and utilizing current technologies, it was clear that the scientific objectives to be addressed in single event experiments at DC-CAT were technologically achievable. During this presentation, it was also pointed out that the establishment of DC-CAT would spur new technical advances related to beamline upgrades and detector development resulting in orders of magnitude enhancements to current capabilities for single event measurements. The proof-of-concept measurements under shock compression, using current capabilities, were demonstrated at the HP-CAT sector of the APS in August 2007. These experiments constituted the first such measurements, and provided the impetus for establishing DC-CAT.

The discussions during the final session were stimulating. Technical needs were outlined for developing a successful facility dedicated to dynamic compression experiments. Strong support existed for moving forward with the proposed facility, DC-CAT, by the workshop participants. A senior manager from AWE (U.K.) voiced strong interest in the proposed facility development because of its importance to both fundamental and programmatic research needs in the U.K.

In summary, the meeting was extremely successful in addressing the scientific objectives of the workshop. Time-resolved measurements at the microscopic length scales constitute the most important scientific need for achieving a fundamental understanding of condensed matter phenomena (and governing mechanisms) under dynamic loading. There was a clear consensus to move forward with DC-CAT. The formal Letter-of-Intent (LOI), submitted in the spring to the APS, is being reviewed and preparations of a formal proposal will be initiated after getting a formal response from the APS. Washington State University will lead a consortium (consisting of NNSA Laboratories, academic partners, DoD Laboratories, and AWE) to prepare the requisite proposal.

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