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SESSION 1: MODELS AND METHODS, SALON A

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Recent advances in four-dimensional studies of advanced materials and processing

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ABSTRACT

Natural and man-made materials are often made of atoms of different elements, and these elements often form clusters of different sizes and morphologies typically in nanometer-to-millimetre scale determined by the thermodynamic nature of the materials system. Understanding of those multi-length scale clusters in a material system is essential for the exploitation of existing materials, and developing new materials with innovative functionalities. Although huge technological advances have been made in this field, full length scale characterisation of materials from atomic level above are still very challenging, especially difficult for characterising materials in real-time during processing.

Recently, we used the speciality synchrotron X-ray beamlines housed at the Advanced Photon Source, Argonne National Laboratory, USA, the Diamond Light Source, UK and Swiss Light Source, Switzerland to study in-situ the dynamics of structural evolution at atomic, nano, and microscale during the liquid-to-solid phase transformation under either an electromagnetic field or rapid heating or cooling processes. Ultrafast synchrotron X-ray imaging and tomography techniques were used to reveal how exactly crystal nucleation occurs and how electromagnetic pulses or thermal shock alter the growing directions of primary dendritic phases and intermetallic phases.

The huge amount of dataset obtained from the real-time synchrotron X-ray experiments allow the time-evolved 2D and 3D phases to be studied from nanometre above, revealing many highly dynamic phenomena concerning phase changes and complex 3D morphology evolution during the liquid-to-solid transformation processes that cannot be obtained by traditional experimental methods, opening a new era for quantitative materials research in four dimensions.

KEYWORDS: synchrotron X-ray, in-situ studies