An experimental design to determine iron melting at the Earth’s core conditions via in-situ X-ray diffraction technique at high power laser facility

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Phase diagram of iron at the Earth’s core conditions is mandatory for determining the states at the core boundaries and the crystal structure of the solid core. Up to date, the iron phase diagram at high pressure has been investigated experimentally by both static compression (diamond-anvil cell) and dynamic compression (shock wave) techniques. However, the discrepancies among different researches on melting line of iron are still irreconciled. Combining in-situ transient X-ray diffraction and laser compression technique, we propose an investigation which could determine the melting line of iron or the high-pressure high-temperature phase from the lattice level. In this research, high power lasers are applied to drive the iron into melting state. X-ray diffraction pattern interpretation and the criteria for judging iron melting are of great importance. Traditionally, the existence of diffraction peak is used as the only criteria to determine if melting occurs. Nevertheless, this is not enough for shock loading with high heating rate, where the pre-melting or superheating phenomenon occurs. Under these conditions, the diffraction peaks could either disappear at temperature below the melting line or remain even above the melting line. This could lead to misinterpretation for melting temperature. However, the two-dimensional shape of diffraction pattern will change. When melting initiates, the shear modulus of the highly stressed material disappears and the diffraction pattern changes into an ideally circled shape. Therefore, with the information of two-dimensional diffraction pattern, we can make the melting criteria, from the lattice level, more sound and clear. This method could provide experimental judgment with higher precision, which might reconcile the discrepancies on melting temperature of iron at the Earth’s core conditions.

Keywords: laser shock, in-situ x-ray diffraction, iron melting, earth core