In situ diagnosis of surface damage of plasma facing components based on laser speckle interferometry in presence of vibration

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Clean and safe nuclear fusion energy is particularly important to solve the problem of energy supply and magnetic confinement tokamak is currently the most likely method to achieve controlled thermonuclear fusion. The key factor for the high-parameter, long-pulse operation of the Tokamak device is to maintain and constrain the high-performance fusion plasma and to prevent high thermal loads from damaging the surface of the plasma-facing components (PFCs) during plasma-wall interaction. To realize the real-time, online, non-contact monitoring of the morphology damage of the PFCs, we have developed a measurement system based on laser speckle interferometry (LSI) in our laboratory. To preserve high temporal resolution, the temporal phase shifting approach which is sensitive to vibration was introduced. Considering that periodic vibration of the tokamak device itself will cause the phase shift of each step during the speckle pattern acquisition process to be not equal to \( \frac{2\pi}{N} \), which will reduce the accuracy of the morphology reconstruction. This presentation introduce a phase extraction approach based on the Least-square iteration technique to deal with the problem. We take the phase shift of each step and the phase introduced by vibration as unknown, and calibrate the phase shift by least square iteration approach. Then verify the effectiveness of the algorithm from realistic simulations and experiments. Benchmark tests are performed on the Molybdenum (Mo) tile, which is commonly used as PFCs in Experimental Advanced Superconducting Tokamak (EAST). Both the simulation results and experimental results show that the Least-square iteration approach can reduce the impact of vibration on morphology measurement effectively. The measurement accuracy can reach the order of hundreds of nanometers and the average relative error rate is less than 10%. This is of great importance for realizing real-time and online LSI measurement in EAST tokamak environment.


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