215 Invited
Reproducible pulsed laser deposition of multicomponent oxide thin films

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Pulsed Laser Deposition (PLD) is believed to be one of the best methods to grow high-quality functional oxide thin films. However, it is true that reproducing other groups' film quality is usually very difficult. Even with the same PLD system, it is not easy to obtain perfectly repeatable result over long time periods, especially if the operator is different. The purpose of this study was to identify some of the hidden growth parameters that affect reproducibility in the PLD process and to achieve high-quality oxide thin films in a reproducible fashion. As a target material system, $SrTiO_3$ homoepitaxy was chosen in view of multiple interesting properties, such as quantum paraelectricity, large permittivity, band insulator with metal phase transition at fairly low electron carrier density (10^{-18} cm^{-3}), superconductivity, etc. Ideally, there is also no lattice mismatch between the film and the substrate for crystallographic simplicity. In order to normalize growth parameters, especially laser ablation conditions, a special PLD system was constructed, which enabled us to control a KrF excimer laser energy through the entrance viewport, beam shape and area on the target, and the target-substrate distance. It was found that the transmission laser energy loss at the entrance viewport was considerable (can be up to 90% loss), and the transmission decreased exponentially with deposition runs (roughly $80e^{-0.02x}$ %: where x is run number). The real laser energy density and spot area were found to have a significant correlation with the deposition rate as well as the film properties, such as optical absorption and crystallographic constants. By controlling these two parameters accurately, fairly reproducible film growth could be achieved.

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