Controlled Growth of Two-Dimensional MoS_2 Films Using Nanosecond and Femtosecond Pulsed Laser for Memristor Applications

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Abstract

Two dimensional Molybdenum Sulphide (MoS_2) films were grown using pulsed laser deposition (PLD) using Nd:YAG laser operating at 266 nm wavelength and a pulse width of 10 ns. The substrate temperature was maintained at 700 °C, and depositions were carried out at a laser power of 100 mW with deposition times ranging from 100s to 1800s. Monolayer MoS_2 formation was observed for samples deposited for 100s. The films were characterised by Raman, AFM and TEM measurements. Memristor devices based on PLD grown MoS_2 were fabricated exploiting the switching behaviour of MoS_2.
Recently, high-quality MoS_2 thin films were deposited using a Coherent Astrella femtosecond laser system. Ultra-short 800nm and 35 fs pulses at 1000Hz repetition rate was used for the deposition process. The ablation process was confined to a non-thermal regime, significantly reducing particulate density and ensuring stoichiometric material transfer from the target. The high peak power and rapid pulse frequency can result in precise nucleation of MoS_2 layers with high crystalline integrity and uniform surface morphology. This ultrafast laser matter interaction provides a scalable pathway for the growth of large area transition metal dichalcogenides (TMDCs) with optimized optoelectronic properties for next generation semiconductor devices.
To complement the PLD growth, a modified mechanical exfoliation technique termed as stamp on tape method (SOTM) was implemented using blue adhesive tapes to ensure uniform pressure distribution and minimize manual transfer artifacts. To optimize the interfacial interaction between the exfoliated MoS_2 and Si/SiO_2 substrate, the silicon wafers were subjected to systematic surface treatments. It was observed that UV-Ozone treatment significantly enhanced the adhesion of MoS_2 flakes compared to untreated substrates. This enhancement is attributed to the removal of contaminants which promotes stronger Van der Waals coupling and reduces interfacial voids during the mechanical transfer process.