Comparative Wavelength Effects on the Reflectivity of Metals Under Solid-State Laser Pulses

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The reflectivity of metals under laser irradiation varies significantly with wavelength, influencing their optical and thermal responses. This study compiles research conducted over 12 years on the comparative analysis of the wavelength-dependent reflectivity of metals, including aluminum, silver, molybdenum, tungsten, tin, niobium, iron, and zinc, when exposed to laser pulses. In this research, solid-state lasers with a 50 ns pulse duration in Q-switched mode at wavelengths of 1.06 and 0.69 µm were used to study hemispherical reflectivity. Experimental measurements and theoretical modeling were performed to evaluate the reflection coefficients at these wavelengths. Additionally, the laser threshold fluences required for the onset of the material's threshold plume were estimated, and variations in the melting temperatures of the studied metals were compared with values reported in the literature. At the laser fluence corresponding to the plasma formation threshold, the total reflectivity begins to decrease. As the laser fluence increases beyond this threshold, the reflectivity abruptly drops to approximately 0.17 and 0.11 for silver and molybdenum, respectively, and then remains unchanged with further increases in laser fluence. Our calculations of the surface temperature of the irradiated samples at the plasma formation threshold fluence show that the surface temperature is significantly below the melting point. This suggests that surface nanostructural defects play a crucial role in plasma formation in real samples due to their enhanced heating caused by plasmonic absorption. Understanding these variations is essential for optimizing laser-based applications in material processing, coating technologies, and photonic device fabrication.

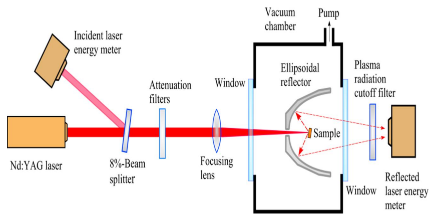

Figure 1: General experimental setup