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## Enhanced Nb/Cu Film Morphology via HiPIMS for Superconducting Accelerators

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The efficacy of superconducting radio-frequency cavities in particle accelerators is predicated upon the quality of thin niobium films deposited onto complex copper substrates. Conventional direct-current magnetron sputtering (DCMS) often yields sub-optimal, porous columnar morphologies on intricate 3D geometries due to line-of-sight limitations. High-power impulse magnetron sputtering (HiPIMS, generating highly-ionized fluxes steerable by electric fields) presents a compelling alternative for achieving conformal coatings. We employed a synergistic approach, combining classical molecular dynamics simulations with experimental validation, to scrutinize Nb film growth dynamics on Cu under both DCMS and HiPIMS conditions. Our findings definitively demonstrate that HiPIMS facilitates the deposition of markedly denser and more uniform films. This enhancement is primarily attributable to a confluence of factors: the preferential arrival of ions closer to the substrate normal, energetic particle bombardment disrupting non-ideal crystalline growth, and dynamic atomic rearrangement coupled with thermal annealing effects. Furthermore, we elucidate the profound influence of these processes on nascent epitaxial alignment at the film-substrate interface, offering valuable insights for optimizing deposition strategies on convoluted cavity structures.

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