Spatial-angular characteristics analysis of ion beam profile on ion implanter wafer

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Ion implantation is a basic semiconductor doping technology and imposes increased demands on the uniformity and reproducibility of ion beam parameters. The final acceleration/deceleration system plays a determining role in shaping the spatial and angular characteristics of the ion beam. As part of the TM-200T medium-current ion implanter development, numerical simulation of the ion-optical system (IOS) was performed to assess the compliance of beam parameters with modern requirements. Numerical simulation of the ion-optical system (IOS) was performed in COMSOL Multiphysics. The model accounted for space charge and ion scattering on residual gas for Ar^+ beams in the range of 0.2–270 keV, 0.04–1 mA, and pressures of 5×10^{-7}–1×10^{-5} Torr. The beam spot size on target remains below 20 mm at 80–270 keV, ensuring doping uniformity. Reducing energy to 40 keV and below broadens the spot to over 30 mm and increases angular divergence to 2–10°, exceeding the $\leq 0.5°$ requirement. Optimizing the deceleration system (80→10 keV) with additional electrodes reduced beam angular spread to 0.1° and provided spot sizes of 6–26 mm at currents up to 230 μA. Pressure increase raises ion losses from 2–8% to 26–35%. The IOS meets spatial profile requirements but shows angular uniformity limitations at low energies, defining optimal operating modes.