Surface characterization of GaAs photocathodes and high current operation experience

Degradation of the photocathode materials employed in photoinjectors represents a challenge for sustained operation in high power Free Electron Lasers (FEL) and proposed high duty cycle fourth generation light sources. Photocathode quantum efficiency (QE) degradation is due to residual gasses in the electron source vacuum system being ionized and accelerated back to the photocathode. This work attempts to characterize the nature of the photocathode degradation, and employ multiple surface and bulk analysis techniques to investigate damage mechanisms including sputtering of the Cs-oxidant surface monolayer, other surface chemistry effects, and ion implantation. Surface and bulk analysis studies were conducted on two GaAs photocathodes, which were removed from the JLab FEL DC photoemission gun after delivering electron beam, and on two control samples. The analysis techniques include Helium Ion Microscopy (HIM), Rutherford Backscattering Spectrometry (RBS), Atomic Force Microscopy (AFM) and Secondary Ion Mass Spectrometry (SIMS). It was found that heat cleaning the FEL GaAs wafer introduces surface roughness, which seems to be reduced by prolonged use. The bulk GaAs samples retained a fairly well organized crystalline structure after delivering beam but shows evidence of Cs depletion on the surface. Within the precision of the SIMS and RBS measurements the data showed no indication of hydrogen implantation or lattice damage from ion back bombardment.

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