Kelvin Probe Studies of Cesium Telluride Photocathode for the AWA Photoinjector

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Abstract. Cesium telluride is an important photocathode as an electron source for particle accelerators. It has a relatively high quantum efficiency (> 1%), is robust in a photoinjector, and long lifetime. This photocathode is fabricated in-house for a new Argonne Wakefield Accelerator (AWA) beamline to produce high charge per bunch (~50 nC) in a long bunch train. We present some results from a study of the work function of cesium telluride photocathode using the Kelvin Probe technique. The study includes an investigation of the correlation between the quantum efficiency and the work function, the effect of photocathode aging, the effect of UV light exposure on the work function, and the evolution of the work function during and after photocathode rejuvenation via heating.

A proven high-charge electron source for particle accelerators, Cesium telluride (Cs_2Te) photocathodes have many distinguishing characteristics including high quantum efficiency (10%at 4.9 eV photon energy), long lifetime (months) and survival in a high gradient environment [1]. The RF photocathode drive gun at the Argonne Wakefield Accelerator (AWA) is a new high peak-current electron beam source for the new 75 MeV linear electron accelerator. Primary application will be to create wakefields in dielectric-loaded accelerating (DLA) structures and other novel structures [2]. AWA's experimental program requires the ability to produce high-charge bunches, often in long bunch trains. This calls for a high quantum efficiency (QE) photocathode such as Cs_2Te. The AWA fabricates Cs2Te photocathodes for use in the new high-charge, 1.3 GHz photoinjector [3]. Electron bunch train of 30 bunches with up to 50 nC per bunch is planned. A thorough understanding of the photocathode and its parameters is required because of the high performance demand. The QE at a particular photon energy and the work function (ϕ) are two key parameters of electron emission. We present some results of Kelvin probe measurements of ϕ on Cs_2Te photocathodes [4]. We examined the correlation between the changes in QE and the work function; how QE and the work function evolved with photocathode aging; effects of rejuvenation of the photocathode via heating, and (iv) the effects on the work function upon exposure to UV light.

The Kelvin probe method is a non-contact, nondestructive technique that is used to measure the work function. The theory and details of the method have been described in detail elsewhere [5]. The work function is defined as the energy difference between the vacuum potential level and the Fermi level, located in the forbidden energy gap between valence and conduction bands. The photoemission threshold is defined as the difference between the vacuum level and the valence band maximum. Therefore the work function in a semiconductor is not equivalent to the photoemission threshold, unlike the case of a metal. What is measured in this experiment is work function and not the photoemission threshold.

The photocathodes studied were fabricated in the AWA photocathode laboratory using a standard recipe and procedure [6, 7]. AWA photocathodes are deposited on a molybdenum plug designed to fit into the back wall of the gun. In preparation for deposition, the plug is polished and cleaned, placed under vacuum, then heated to 120°C. A 22 nm layer of tellurium is deposited via thermal evaporation. When tellurium deposition is complete, cesium deposition commences and the photocurrent is monitored. Deposition continues for several minutes after maximum photocurrent is achieved. The result of this process is a Cs_2Te thin film photocathode on a molybdenum substrate

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