Mg photocathode grown by PLAD technique and tested in the PEGASUS RF gun of UCLA

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The research activity carried out in 2008 at the Radiation Physics Laboratory of the Physics Department is strongly related to the national project "SPARC" financed by INFN. The main objective of the project is the production of laser radiation in the visible range (500 nm) by SASE-FEL technique. The research group is involved in the production and developing of metallic photocathodes prepared by pulsed laser ablation deposition (PLAD). The metallic photocathodes based on thin film will be installed in SPARC RF photo-injector to produce high brightness electron beams. Based on the results since now obtained worldwide in different laboratories, the most promising metals that can be used as sources for primary electron beam in RF photo-injector are Copper, Yttrium and Magnesium [1–3]. Copper is the metal that mostly has been used for long time as source for photoelectron in RF-gun. The choice of using this metal is principally due to the fact that a photocathode based on this metal is in principle easy to be prepared. Moreover, the reactivity of the Cu with residual gases is quite low and thus the stability of emission properties of Cu photocathode should be preserved at the operational vacuum level of RF-gun. Such type of cathode was successfully operated during the commissioning of SPARC photo-injector. The very low value of Yttrium work function makes this material very interesting because the extraction of photoelectron may be achieved even with photons at 400 nm. This wavelength correspond in fact to the $2^{\rm nd}$ harmonic of a Ti:Sa laser. The opportunity to use the 2nd harmonic instead of the $3^{\rm rd}$ presents obvious advantages in terms of the final energy deliverable to the cathode even after space-temporal manipulation. Unfortunately, at the present, the knowledge on the emission properties of Yttrium is limited [3] and only in a future, with a dedicated R&D activities, is reasonable to imagine the use of this material as photocathode in the SPARC RF-gun. The main advantage of photocathodes based on Magnesium with respect to those based on Copper and Yttrium lies with the higher quantum efficiency (QE) that they offer. In particular recent results showed that QE as higher than 10^{-3} can be obtained in low DC electric field with photons at 266 nm [1]. In this annual report, detailed experimental results on the emission properties of a final Mg-based photocathode prepared in Lecce and installed inside the PEGASUS RF gun at UCLA are presented and discussed [4]. Figure 1 shows the charge collected by the Faraday cup as a function of the launch phase with respect to RF field inside the gun cavity. The focusing solenoid field was fixed at 1.15 kGauss and the laser energy per pulse was set at about 2 μJ. The emission curve of the cathode, reported in figure 2, was obtained by correlating the Faraday cup charge read out with the input laser energy. The launch phase of the laser beam was set at 25^o.

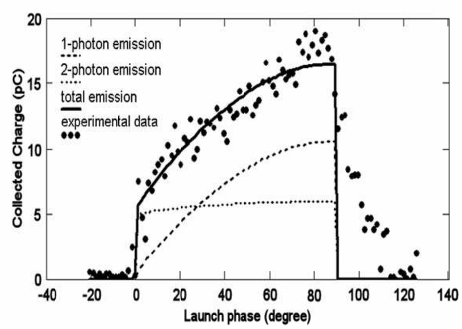

Figure 1. Electron bunch charge vs. launch phase: in the graph are reported the experimental data, and the emitted charge simulated by considering both one and two photoemission processes.

It is straightforward to notice that the emission curve has a nonlinear behaviour. This is an evidence of oxidation of the Mg cathode surface. The QE value deduced by this curve is about 10^{-5}. This low value is essentially due to the thin oxide layer formed on the Mg film in open air. A

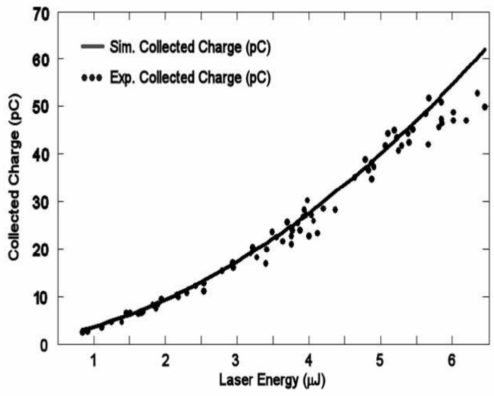

Figure 2. Emission curve characteristic of Mg based photocathode. It is evident the non linear correlation between bunch charge and laser energy due to the non negligible contribution of the two-photon electron emission process.

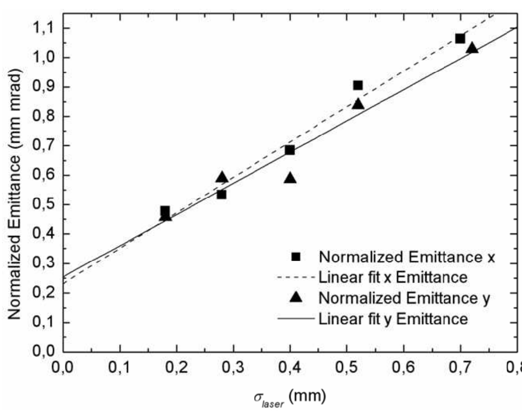

Figure 3. Linear relationship between normalized emittance and laser spot size: experimental data and best fit.

laser cleaning process is expected to improve significantly the emission performance of the photocathode. Low dark current values of some μA have been measured at 100 MV/m. Finally, the normalized emittance as a function of laser spot size has been reported in figure 3. Measurements held 0.85 and 0.75 mm mrad, respectively, for horizontal and vertical emittance. A similar value of emittance has been measured for Cu cathodes (0.93 mm mrad). This is justified by the similar values of the work functions of Cu and our Mg sample surface.

The main result of the research activity of the present group, carried out in 2008, was the successful testing of a PLAD grown film used as photocathode in the PEGASUS gun of UCLA. The electric field gradient in the gun was brought up to 100 MV/m. SEM and EDX analyses indicate that the film was not damaged. After conditioning, the gun was used during several months for experiments requiring very short (50 fs) low charge (20 pC) bunches. More power tests are needed on thicker films (few microns) and with laser cleaning before using it in the SPARC RF gun of Frascati.

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