Research activity related to the INFN national project "SPARX"

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The research activity carried out in 2009-2010 at the Radiation Physics Laboratory of the Physics Department is strongly related to the national project "SPARC-SPARX "financed by INFN. The main objective of the project is the production of laser radiation in the X-ray range (1.5-13.5 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 RF photo-injectors 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, Lead and Magnesium Ref.[1–4]. Copper is the metal most used since long time as source for photoelectrons in RF-guns. That choice is principally due to the fact that a photocathode based on this metal is, in principle, easy to be prepared. Moreover, the chemical reactivity of the Cu with residual gases is quite low and thus the stability of its photoemissive properties should be preserved at the operational vacuum level of RF-guns (10^{-8} Pa). Such type of cathode was successfully operated during the commissioning of SPARX photo-injector. Nevertheless, the quantum efficiency (QE) of such metal is quite low, about 10^{-5} at 266 nm of wavelength. The main advantage of photocathodes based on Magnesium with respect to those based on Lead, Copper and Yttrium lies with the higher QE that they offer. In particular recent results show that QE higher than 10^{-3} can be obtained in low DC electric field with photons at 266 nm Ref. [5]. On the contrary, the very low value of yttrium work function (2.9 eV) makes this material very interesting because the extraction of photoelectrons may be achieved even with photons at 400 nm (3.1 eV). This wavelength corresponds, in fact, to the 2^{nd} harmonic of a Ti:Sapphire laser. The opportunity to drive the photoemission in RF guns by the 2^{nd} harmonic, instead of the 3^{rd} one, presents obvious advantages in terms of the final energy deliverable to the cathode even after spatio-temporal manipulation. Another advantage of Y-based photocathodes consists on reducing the thermal emittance increasing the brightness of the electron beams. In this biennial report, detailed experimental results on the emission properties of Y-based photocathodes prepared in Lecce by PLAD are presented and discussed Ref.[6,7]. Figure 1 shows the collected-charge-data as a function of the laser energy with a drive Ti: Sapphire laser operating at 3^{rd} harmonic (266 nm). It is straightforward to notice that the emission curve has a nonlinear behaviour. This is an evidence of oxidation of the Y cathode surface which is responsible of a photoemission induced by the absorption of two photons. Laser cleaning process of the cathode surface is able to remove the contamination layers. The collected-charge-data as a function of the laser energy show a linear trend typical of photoemission induced by single photon absorp-

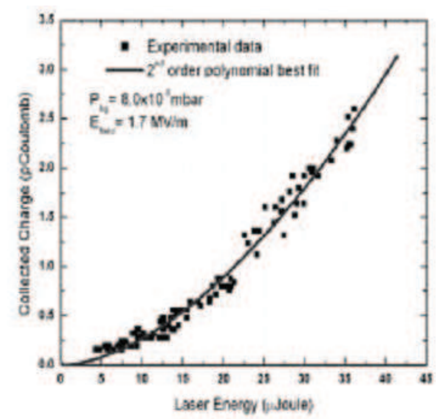

Figure 1. Emission curve characteristic of Y based photocathode. It is evident the non linear correlation between bunch charge and laser energy due to the non negligible contribution of the two-photon electron emission process.

tion (see Fig. 2). The QE value improves from 1.1×10^{-6} to 3.3×10^{-4} after in-situ-laser-cleaning procedures.

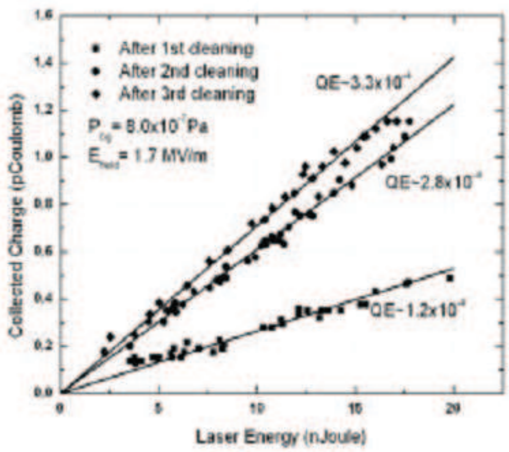

Figure 2. Collected charge as a function of the laser energy after different in-situ laser cleaning processes.

Interesting results have been carried out in 2009 and 2010 testing the Y thin film based photocathodes by CW laser diode in the blue region of 406 nm. Figure 3 shows the photoemitted current as a function of the laser power. Also

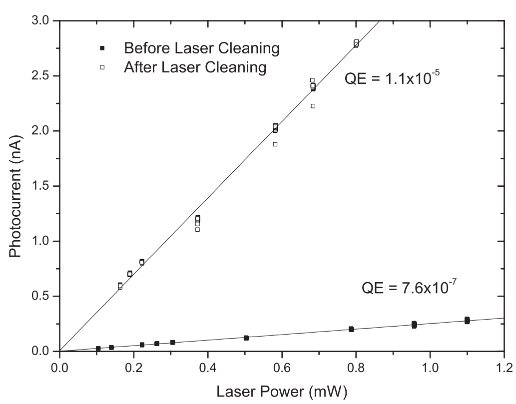

Figure 3. Photocurrent as a function of laser power before and after in-situ laser cleaning treatment.

in this case the laser-cleaning-process is mandatory in order to remove the oxidized layer. QE changes from 7.6×10^{-7} to a value of 1.1×10^{-5} after the laser cleaning. In 2010 important parametric studies have been also carried out to optimize the deposition process of Y thin film on Cu flange with the challenge to test it in the RF gun. The optimization of the laser irradiation conditions was necessary in order to reduce the density of droplets on the surface of the Y films. Mass spectrometric measurements have been also performed during the deposition in order to obtain Y thin films as much as possible pure from the chemical point of view. In light of our achievements on photocathodes based on Mg and Y thin films, we assume that sources of electron beams based on Pb thin film should be even more promising for its chemical stability and, hence, for its longer lifetime. So for the next year we have planned the preparation, characterization and testing of photocathodes based on Pb thin films deposited by PLAD technique.

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