Introduction

Next generations of high energy light source and electron colliders need compact and efficient processes of initial particle sourcing, that idea has been already described [1]. Standard photocathodes with powerful RF guns deliver MeV beams, which are accelerated to GeV (light sources) and more (colliders) thanks to continuous, and guided with electron optics. However, to overcome the performances of the couple photo-cathode/RFgun, a completely different concept is proposed: a low energy Field Emission Array (FEA), running in transient photo-field mode, associated with nanostructures of Laser Dielectric Accelerators (DLA).

The figure 1. standard sources, and 2. Laser Dielectric Laser driven. Illustrate these two different approaches:

II First simulations with Abinit

1. Ground State on bulk copper

A serial version of Abinit by debian packet was installed on a single machine and also a compiled parallel version for future work. That last result is reported by [7] for two single machines, tuned with throttling. Installation of those version has been asked to L3 central machines. The GS of copper are reported not to exactly converge, as simple metals [1], but are not too far from few electron approximation calculation. [7]. I started from tutorial with AlA*, and modified the script. Those I finally choosed, with a simple LDA approximation are:

1. reduced lattice, with 3x3x78 mesh, nband 4, oct 7, tomear 0.08
2. esct 100, nstep 40, tolvrs 1e-8

The simulations lasts 18 minutes, and result is NLSIPE 0.16, ETSOT = 142.49[0]40(0)3146, 0.98 = 2.048 - 0.064

2. Dynamic matrix responses

Following again tutorial, I tried to compute the entire response simulation. For the moment, only frozen phonons at q = 0 is available. The code included automatically 10 bands, it did not parallelized 0-band and was not multiplied. The results are in course.

3. Vacuum emission and laser interaction (planned)

Emission probably happens predominantly for a layer at some cm from the surface. Next step will be to develop the interface Cu-Ni, (Ni thickness ~100µm suggesting a bulk behaviour). The Cu-Ni bounding will depend on the nature of the tip.

The next step is to simulate the tip-vacuum transition. In a 1D formulation, the Fowler-Nordheim(-Forbes) theory [8], applied to plane cathode, gives us the current density given the electric field F:

\[ J = \frac{eF}{\sqrt{2\pi m^*}} \delta \exp\left(\frac{\delta}{\sqrt{\frac{2eF}{\pi m^*}}}ight) \]

where e is the elementary charge, \( F \) the electric field, \( m^* \) the effective mass of the electron, \( \delta \) the escape depth, \( \delta = \frac{\sqrt{2m^*eF}}{\pi} \). The value of \( \delta \) is very sensitive to the value of the escape depth, \( \delta \).

Finally the laser interaction may be qualitatively described by the 3-step process, figure 7.4:

1. nanostuctured photocathodes

1. Choice of FEAs

We propose to benchmark two candidates for the ideal FEA photo-field performances (fig 3 and fig 4):

1. Spinodi-like metallic cathodes, tips array made in Targenton, on a Ni support.
2. Monolayer Carbon Nanotubes, also in array, on a (monolayer) graphen, which is put down a Ni support.

2. Logical steps for Abinit simulations

The logical flow progresses from electrical cascaded pushing of cathode-holder to the transport inside individual tips, and finally in vacuum emission. 4. A biographical study concluded to

1. low influence of pulsed Electrical field inside Cu bulk, 2. metal influence on GS of Bulk Cu
2. 1. low influence of copper metallurgy

1. Laser-matter interaction and DLAs

To illustrate laser-matter coupling, you find here two major schemes, fig 8 and 9 of the today developments in DLAs arrays [7].

1. Laser-plasma buncher

In the first case, laser radiation goes through the material, with interactions expected during the transmission. In the second case, there is a vacuum path for laser and electron beams.

The (multi-)bunches should raise the bunch energy, from some tens of keV to some relativistic MeV energy ranges. Demonstrating experiments are in the field and... 1. as was laser-plasma a ten years ago, the in-chip accelerator technology is nowadays rapidly expanding.

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Finally the laser interaction may be qualitatively described by the 3-step process, figure 7.4:

IV SUMMARY

1. New compact and performant electron in-chip Dielectric Laser Accelerator (DLA), need a first non-relativistic stage driver, from 0keV to relativistic MeV energy ranges; the proposed system is a photocathode Field Emitting Array (FEA), combined with a first stage DLA.

2. The blocks which should be studied are tied to the photo-cathode and the DLA 1-stage module. For the photo-cathode, we show that a logical approach consists to simulate the electron-photon and electric response inside bulk of cathode-holder, then to study vacuum emission through tip.

3. The other scope of study concern laser-matter interaction inside the DLA. In this case, the TDDFT is envisaged to render the photo-field emission. The scope for our appliance, will be a photon and electron field perturbative approach, because of moderate laser flux and energy, comparati-vely to bandgap of usual dielectrics materials of DLAs.

The goal should be to contribute to nano-engineering domain, applied to photo-cathode physics, and design a new family of electron sources

Références