PROGETTO SPARC:

MAIN RESULTS OBTAINED IN LECCE

METALLIC PHOTOCATHODES

- METALLIC PHOTOCATHODES FOR CONVENTIONAL RF GUNS;
  (Mg, Y, Cu, Zn...);

- METALLIC PHOTOCATHODES FOR HYBRID SUPERCONDUCTING RF GUNS.
  (Nb, Pb...)

Mg THIN FILMS-BASED PHOTOCATHODES PREPARED BY PLD TECHNIQUE

- Mg THIN FILMS DEPOSITED ON DIFFERENT SUBSTRATES;
- CHARACTERIZATION AND TESTING OF PHOTOCATHODES IN PHOTODIODE CELL;
- FINAL TESTING IN A REAL PHOTOINJECTOR GUN.

Y THIN FILMS-BASED PHOTOCATHODES PREPARED BY PLD TECHNIQUE

- Y THIN FILMS DEPOSITED ON DIFFERENT SUBSTRATES;
- CHARACTERIZATION AND TESTING OF PHOTOCATHODES IN PHOTODIODE CELL;
- FINAL TESTING IN A REAL PHOTOINJECTOR GUN.

MAIN RESULTS

1. QEs of metallic thin films (Mg, Y) are comparable to those of the bulk;

2. Surface contamination is a big problem even with metallic films though less drastic than that observed with semiconductor cathodes;

3. H_2 chemisorption is the main process responsible of surface contamination at vacuum levels less than 10 Pa;

4. H_2O chemisorption is the main surface process in the SPARC gun due to the soft baking procedure (temperature <120 °C);

5. Protective coating is needless; the native metal oxide forms in open air becomes the natural protecting coating of the film surface;

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SUPERCONDUCTING RF GUNS

- ADVANTAGES
- HIGHER ACCELERATING GRADIENT
- LOWER DISSIPATED POWER
- LOWER THERMAL EMITTANCE

- DRAWBACKS
- LOW QE OF Nb CATHODE
- EXPENSIVE SYSTEM
- HIGH TECHNOLOGY IS REQUIRED

PROPERTIES OF CATHODES FOR SRF-GUNS

- HIGH QUALITY FACTOR OF SC CAVITY;
- RESPECTABLE QE;
- HIGH SUPERCONDUCTING TEMPERATURE.

- PROBLEMS

TO ADDRESS THIS CONCERN...

- PHOTOCATHODES BASED ON Pb THIN FILMS DEPOSITED ON Nb BY PLD TECHNIQUE.

- WHY Pb?
- HIGH SUPERCONDUCTING TEMPERATURE;
- RELATIVELY HIGH QE;
- GOOD CHEMICAL STABILITY.

- WHY PLD?
- FILMS ADHERENT TO THE SUBSTRATE

APPROACH TO THE PROBLEM

- THREE DIFFERENT STEPS

1. OPTIMAZATION OF DEPOSITION PROCESS OF Pb THIN FILMS BY PLD;

1. MEASUREMENT OF THE PHOTOEMISSIVE PROPERTIES OF Nb/Pb PHOTOCATHODES;

1. INSTALLATION OF THE PHOTOCATHODES IN A REAL SRF CAVITY.

CONCLUSION SO FAR

- METALLIC PHOTOCATHODES SUFFER THE SURFACE CONTAMINATION;
- LASER CLEANING PROCESS IS MANDATORY TO RECOVER PHOTOCATHODES;
- PHOTOCATHODES BASED ON Y THIN FILM SEEM TO BE THE MOST PROMISING;
- IT HAS BEEN SHOWN, **DEFINITIVELY**, THAT THE MOST SUITABLE FILM DEPOSITION TECHNIQUE IS THE PLD TECHNIQUE;
- THE PREPARATION OF CATHODES IS THE WEAK POINT OF SRF-GUNS.

Do ut des

- LASER Nd:YAG E BANCO OTTICO;
- 3 ASSEGNI DI RICERCA;
- 1 BORSA BIENNALE PER RICERCATORE STRANIERO.

- 22 ARTICOLI PUBBLICATI IN RIVISTE INTERNAZIONALI DAL 2005;

- 12 PRESENTAZIONI A CONFERENZE INTERNAZIONALI.

Pubblicazioni collegate al progetto SPARC dal 2011

1) A. Lorusso, V. Fasano, A. Perrone and K. Lovchinov, "*Y thin films grown by pulsed laser ablation*", J. Vac. Sci. & Technol. 29 (2011) 031502-5

1) A. Lorusso, F. Gontad, and A. Perrone, " *In-situ and ex-situ investigations of pulsed laser ablation of Y target*", Thin Solid Films, 520 (2011) 117 - 120

1) A. Lorusso, L. Cultrera, V. Fasano, and A. Perrone, "*Detailed studies of photocathodes based on Y thin films grown by PLD technique*", Nucl. Instr. and Meth. in Phys. Res. B, 269 (2011) 3091–3093

1) A. Lorusso, F. Gontad, A. Perrone, "*Deposition of* MgF_2 *Thin Films by Pulsed Laser Ablation Technique*", Jpn. J. Appl. Phys. 50 (2011) 08JD071-3

1) A. Lorusso, F. Gontad, A. Perrone, N. Stankova, "*Highlights on photocathodes based on thin films prepared by pulsed laser deposition*", Physical Review Special Topics - Accelerators and Beams, 14 (2011) 090401-9

1) F. Gontad, A. Lorusso, and A. Perrone, "*Structure and morphology of laser-ablated Pb thin films*", Thin Solid Films, 520 (2012) 3892-3895

1) F. Gontad, A. Lorusso, A. Perrone, *"Detailed mass spectrometric studies during laser ablation of Yttrium target in high vacuum"*, Thin Solid Films, 520 (2012) 5211-5214

1) A. Lorusso, M. L. De Giorgi, C. Fotakis, P. Miglietta, B. Maiolo, P. Miglietta, E. L. Papadopoulou, A. Perrone, "*Y thin films by ultra-short pulsed laser deposition for photocathode application*", Appl. Surf. Sci. http://dx.doi.org/10.1016/j.apsusc.2012.05.080

RF PHOTOCATHODE GUN – SLAC/BNL/UCLA/SPARC

- Maximum electric field: 120 MV/m
- RF pulse duration: 4.5 µs
- Peak power at 120 MVolt/m: 15 MW
- Operating vacuum: 10^{-7} Pa
- Operating temperature: 45 ºC
- Laser incidence angle at the cathode: 72º
- RF: 2.856 GHz
- Electron bunch energy at the exit: 5.6 MeV

DRIVE LASER SYSTEM

- Ti:Sapphire
- Wavelength: 800 nm
- Laser pulse duration: 100 fs
- Laser pulse energy @ 266 nm: 0,5 mJ
- Repetition rate: 1-10 Hz
- Pointing stability on cathode: < 0,1 mm
- Flat top uniformity (peak to peak): < 30%

LINAC

- **LENGTH: 3 m;**
- **REPETITION FREQUENCY: 100 Hz;**
- **BUNCH CHARGE: 1 nC;**
- **BUNCH CURRENT: 100 A;**
- **BUNCH DURATION: 10 ps**
- **ELECTRON ENERGY AT THE EXIT: 150 MeV.**

UNDULATOR

- Undulator period: 2,8 cm
- Undulator sections: 6
- Undulator section length: 2,16 m
- Saturation length: 12 m
- Wavelength: 500 nm
- Pulse duration: 3 ps
- Power @ saturation > 80 MW
- Bunch charge: 1 nC
- Photons/pulse: 10^{15}

ELECTRON BEAM

- Electron energy beam: 150 MeV
- Bunch charge: 1 nC
- Electric field: 120 MV/m
- Photocathode spot size: 1.1 mm
- Beam pulse duration: 10 ps
- Bunch energy at gun exit: 5.6 MeV
- Bunch peak current at linac exit: 100 A
- Normalized transverse emittance at linac exit: <2 μmrad
- Beam spot size at linac exit: 0.4 mm
- Bunch length at linac exit: 1 mm
- Relative energy spread: <0.1 %

SPARX

- **ELECTRON BEAM**
- Electron beam energy: 1.2 – 2.4 GeV
- Electron charge: 1 nC
- Peak current: 1 – 2.5 kA
- Emittance: 1 μmrad

SPARX

- **FEL RADIATION**
- Wavelength: 1.5 – 13.5 nm;
- Brillanza: 10^{32} cu (phtons/s/0,1%bw/(μmrad)^2) ;
- Potenza: 10 GW;
- Pulse duration: 0,1 ps;
- Energy: 1 mJ.