Irradiations at the INFN-LABEC facility in Florence

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ELectrostatic DEFlector (DEFlettore ELecttrostatico): the chopped beam line of the Tandem accelerator at INFN-LABEC
Capabilities of the DEFEL beam line

- Pulsed bunches of:
  - *Duoplasmatron*: p (and α)
  - Cs-ion sputtering source: p, Li, C, O, Si, Ti, Fe, I
- Energy:
  - 1÷6 MeV for protons;
  - 1÷few tens MeV (heavier ions)
- Bunch frequency:
  - up to ~10kHz
- Average ion multiplicity:
  - hundreds particles and more
Ions are deflected from the beam line axis for most of the time (PreDeflector). For time windows of ~ 1μs, ions are allowed to enter the main Deflector.
From a continuous to a pulsed beam

During the transition of the applied voltage, the beam spot moves transversally from a steady state B to A.
Few examples - I

10.035 MeV $^{12}$C$^{3+}$ ions

11.235 MeV O$^{3+}$ Ions

1 MeV protons

fit function $= \frac{e^{\mu k}}{k!}$

Fit Parameters

$\mu = 2.988 \pm 0.006$

$k = 398300 \pm 1300$

$\chi^2/\text{ndf} = 26.64/8$
Few examples - II

3 MeV Protons beams of different intensities
The role of the final slits S3

Aperture of slits on y axis →
- number of transmitted ions per pulse (it also depends on beam current – once voltage steps, deflector plates length and deflector-to-slits distance are fixed)
- spatial resolution

Aperture of slits on x axis →
- spatial resolution

Typically, 4-independent sectro slits (by Fischer Gmbh) →
- 30-50 μm spatial resolution
- ~50 μm uncertainty on aperture size
→ Not suitable for precision applications!
Our new slits

- Aperture formed by 4 independent blades
- 30 mm x 30 mm maximum size
- 1 μm resolution
- Designed for high vacuum applications
- Tungsten carbide blades with a 0.5° knife-edge
How to look at the beam

- Typical devices:
  - Beam profile monitor
  - Luminescent quartz
- Downstream the final slits, \textit{transmitted beam intensity too low}
- Need of a new visualisation system
The Aptina camera

- 752 x 480 pixels
- Pixel dimensions 6x6 μm
- Programmable through serial interface
- Images acquired using services added to Linux kernel

(MT9V034)
Here is the beam

Slits aperture 1mm x 400 μm
Here is the beam

Slits aperture 200 x 200 μm
Here is the beam

3 MeV protons

A new sensor (Aptina, 5M pixels, 2x2 μm pixel size) is going to be tested...
State of charge = Si$^{3+}$

Energies = 8 – 11 MeV

Probe size = 0.2 to 1 mm wide ($x$ and $y$)

Implantation times ranging from 100 µs (pulsed) to 1 h (continuum)

Fluences = $\sim 10^9$ - $\sim 10^{16}$ cm$^{-2}$
Results

5.6 \times 10^{13} \text{ cm}^{-2}
1.1 \times 10^{13} \text{ cm}^{-2}
2.3 \times 10^{12} \text{ cm}^{-2}
3.7 \times 10^{11} \text{ cm}^{-2}

5 \times 5 \text{ mm}^2

6 \times 10^{14} \text{ cm}^{-2}

10^{16} \text{ cm}^{-2}

Mono-INFN

H-Al\text{max}

6 \times 10^{15} \text{ cm}^{-2}
 applications

**energy losses and straggling**


**Characterization of detectors**


**Time resolved ion beam induced luminescence**

- C. Czelusniak, *PhD Thesis*, ongoing
Microbeam line

Beam trajectory in horizontal plane

Beam trajectory in vertical plane
The set-up for ultra-low intensity measurements
Refractive index control

- 2 and 3 MeV proton implantation in the low damage regime
- fluences ($\Phi = 10^{13} - 10^{17} \text{ cm}^{-2}$) measured at the Florence microbeam
- refractive index variation OPD = $(n-n_0)$ of implanted diamond measured at the Florence INOA
Experimental data: OPD vs. Fluence

- linear trends
- different trends for 2 & 3 MeV implantations
Evidence of Light Guiding in Ion-Implanted Diamond

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Controlled variation of the refractive index in ion-damaged diamond

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IBIC study of a CdS/CdTe solar cell

3 MeV He

lighting direction
IBIC study of a CdS/CdTe solar cell

• 3 MeV He ions

• the set-up for beam current control allowed an easy and fast intensity reduction down to $10^3$ particles per second injected directly into the solar cell

• charge collection efficiency (CCE) maps show inhomogeneous response due to the polycrystalline nature of the CdTe bulk material
radiation resistance

- average pulse height decrement of 20% for fluences up to $2 \cdot 10^{10}$ alpha/cm$^2$
- maps show non-uniform decrease of CCE: large grains with higher efficiencies more sensitive to radiation damage
Thank you for your attention!


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