Progress on the development of a silicon-carbon nanotube photodetector

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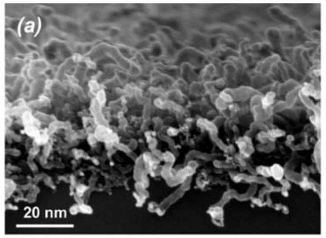
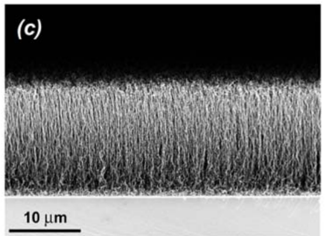
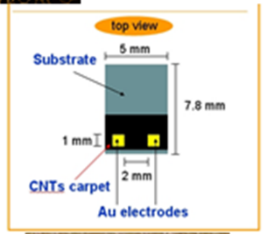
Abstract: The properties of Carbon Nanotubes (CNTs), the new allotropic status of carbon discovered in 1991, have been widely investigated in all possible application field. This new material in fact can be easily obtained chemically by CVD (Chemical Vapour Deposition) as a layer of nanotubes growth on a wide variety of materials. When growth on a silicon surface, CNTs create a semiconductor heterojunction with peculiar photoresponsivity properties. We studied this heterojunction with the purpose to realize a large photocathode with high quantum efficiency in a large wavelength range from UV to IR. Results obtained up to day allowed us to build a new kind of photodetector very cheap, stable and easy to manage. Recently this new device has been proposed as one of candidates for the beam monitor system of SuperB.

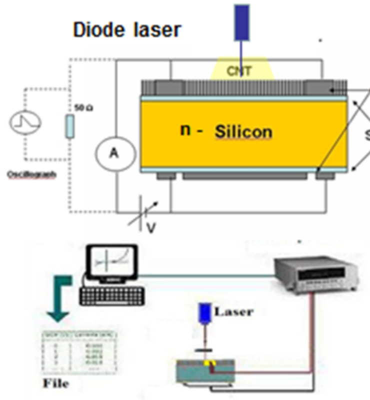
Silicon-CNT radiation detector





SEM image of CN device grown at a CVD temperature of 500 °C (a) and 700°C (b)





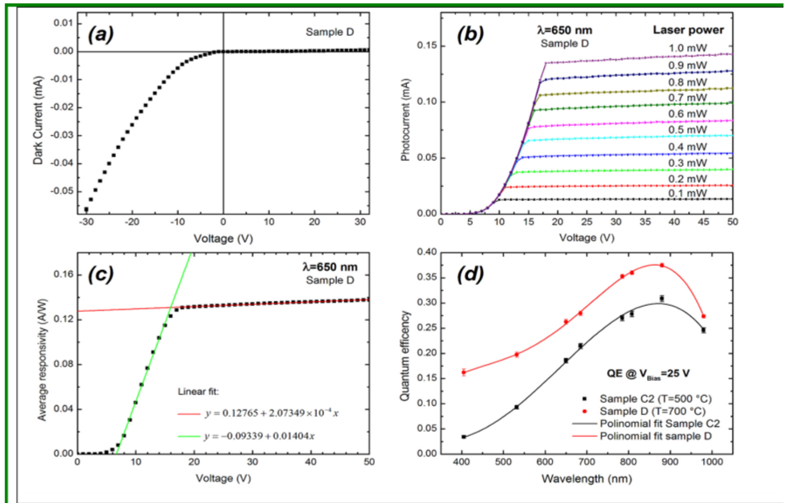


Figure 3 | Measurements performed on sample D. a, Dark current. **b**, I-V curve at λ=650 nm for various laser light intensities. **c**, Averaged responsivity at λ=650 nm. In the curves are superimposed fitting the signal rise and the current plateau. **d,** quantum efficiency as a function of the wavelength ranging from 405 to 980 nm of detector C2 compared with that of detector D fitted with a four order polynomial function.

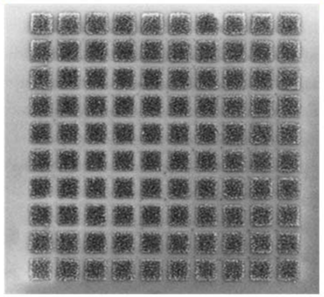


Figure 6 | 100 pixels of 4x4 μm each obtained with micro lithography.

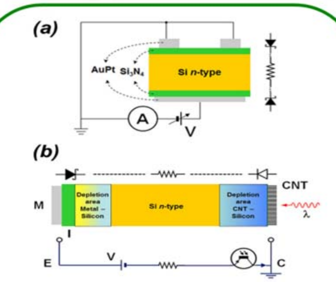


Figure 5 | Layout of CN-Si with the junctions. a, In absence of CNs the device can be schematized as a double Schottky junction polarized back-to-back. **b,** The presence of the CNs overbalances the system: a heterojunction is created between the CN layer and the silicon.

The presence of the CNs overbalances the system: a heterojunction is created between the CN layer and the silicon. The device shows the characteristics of a p-n-p photo-transistor, where the metallic contact on the back acts as the emitter, the upper CN layer is the collector and the CN-silicon depletion area plays the role of the transistor base. The performance of this detector depends on the CN morphology and ultimately on their electronic properties. We have found that MWCNT-based devices show a higher junction thresholds and a higher sensitivity to the UV radiation (Fig.3).