On Diamond-Like Carbon (DLC)-based radiation hard contacts for diamond detectors

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Motivation

- Optimisation of the contact properties is quite essential for development of high resolution and radiation hard DDs
- Deterioration of commonly used metallic contacts under high intensity radiations might contribute noticeably to degradation of DDs
- Some novel DLC materials seem to be promising candidates as radiation hard contacts

What is diamond-like carbon?

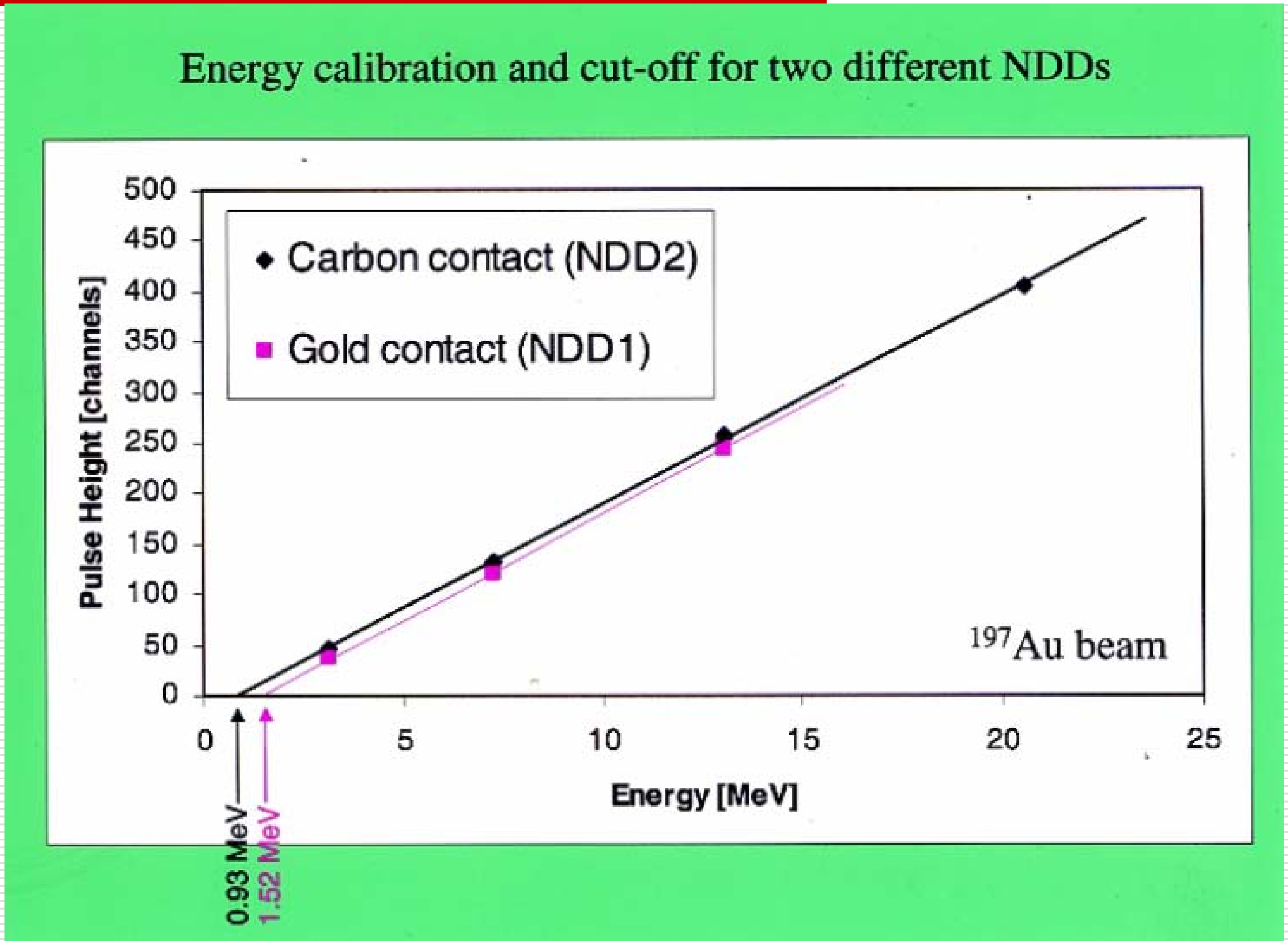
- Diamond-like carbon (DLC) is a metastable form of amorphous carbon, containing significant portion of sp^3-bonded atoms in the matrix. In general, DLC is a wide band (1.5-2.5 eV) semiconductor with an optical transparency, mechanical hardness, and chemical inertness approaching those of crystalline diamond.
- Owing to these unique properties, DLC films are not only being investigated extensively, but have widespread applications as protective layers to different materials
- Electronic properties of DLC films including electrical resistance, can be heavily modified by proper element (i.e Boron) doping, ion implantation and intermixing

Advantages of DLC -based contacts

- Significantly increased (~10times) resistance against irradiation damages & sputtering → - **radiation hard contacts**
- Ultra-thin & continuous contacts---**minimized dead layer & low energy cut-off** **(see next slide)**
- Good adhesion to diamond--**simpler fabrication of DDs**
- Availability of both ohmic and "blocking" contacts---**reduced polarization effects**

Low energy cut-off vs contacts

(V.Liechtenstein, 2nd NoRHDia Workshop)



Disadvantages of DLC contacts

- Ultimate time resolution of DD might be worse then that for DD with metallic contacts due to higher resistance of DLC contacts
- Limited thermal stability (T max~800 C)
- Slightly more expensive as compared to metallic ones

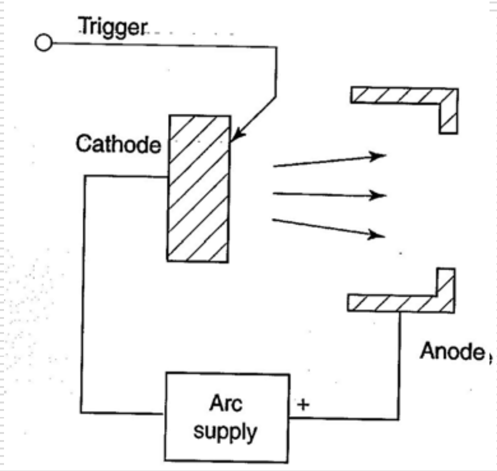
Preparation of DLC films

Unlike ordinary carbon films, DLC film is grown when carbon is deposited under energetic (10-100 eV) bombardment. The instantaneous local high temperature and pressure induce a proportion of carbon atoms to bond as diamond. These conditions are obtained during a variety of methods, including CVD, laser ablation, magnetron sputtering, cathodic arc, and ion beam deposition. Of these methods, unbalanced magnetron and cathodic arc deposition techniques seem mostly suitable to fabrication DLC contacts for DDs.

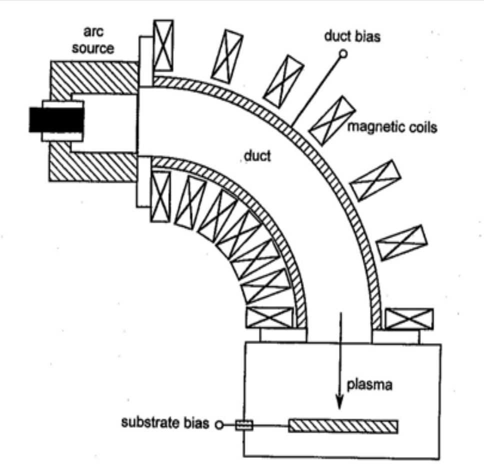
As magnetron sputtering is well known technique , let me touch on cathodic arc deposition in this talk.

Concept of cathodic arc deposition of DLC films (from Aksenov, et al, 1982)

Carbon ions are produced in a high current arc discharge between graphite cathode and metallic anode The plasma beam ejected from the cathode is then guided to the substrate by a curved magnetic filter/duct to eliminate plasma contamination by macro particles and to achieve a pure carbon beam. As the ~100 A arc is localized on the cathode spots of several um in diameter, current density lies in the range 10^6-10^8 A/cm2.



In these conditions, dense carbon plasma with an average ion energy of ~30eV is created, resulting in extremely hard DLC films with sp3 fraction up to 85%. Addition of a proper biasing enables fine tuning of main deposition parameters, while doping is also feasible by either gas introduction or adding the dopant to the cathode.



Along DLC, metallic and component films can be produced by this way using commercially available systems

Conclusions

- DLC films seem to have potential as advanced radiation hard contacts for DDs
- To implement this potential, a proper R&D is needed, may be, in the framework of the FP7 activity

THANK YOU VERY MUCH FOR YOUR ATTENTION !