

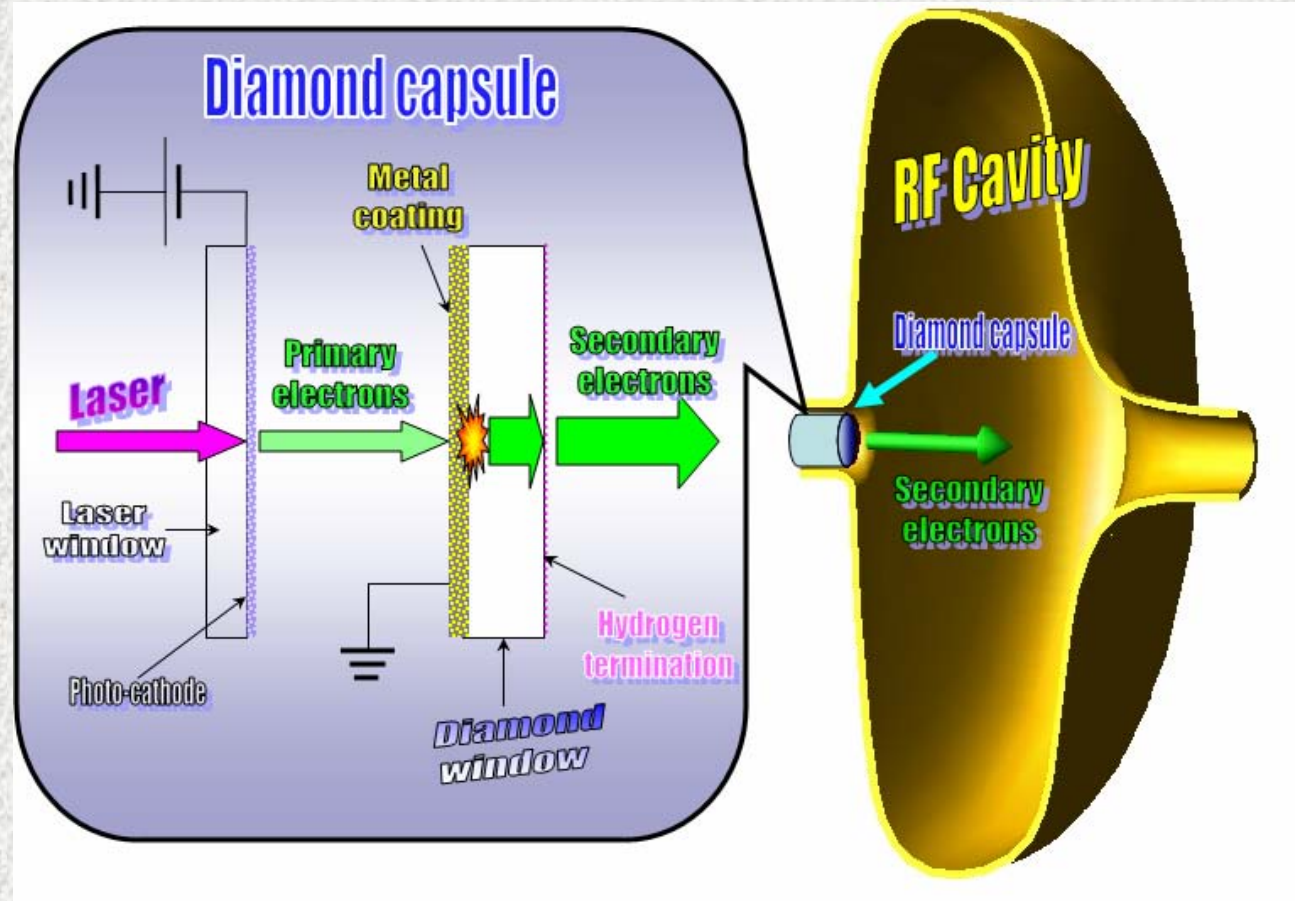
*Recent progress on the Diamond
Amplified Photo-cathode experiment*

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The Diamond Amplified Photo-cathode (DAP) concept

- I. Primary electrons are generated by the conventional photo-cathode and are accelerated to about 10keV energy.
- II. Primary electrons penetrate the metal coating and generate electron-hole pairs.
- III. Electron-hole pairs are separated by the RF electric field at the right phase.
- IV. Secondary electrons drift through diamond.
- V. Secondary electrons are emitted from the hydrogenated Negative Electron Affinity (NEA) surface.



Schematic diagram of the DAP

Issues related to each of the steps

Step 1: primary electron generation and acceleration

Metallic cathode:

low QE, less vacuum requirement.

Can be used for most of the applications due to the low primary electron current.

Semiconductor photo-cathode:

High QE, ultra-high vacuum.

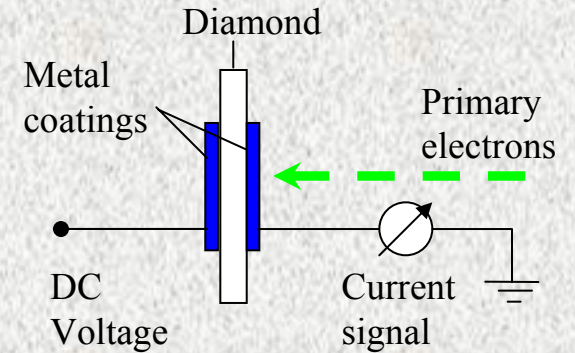
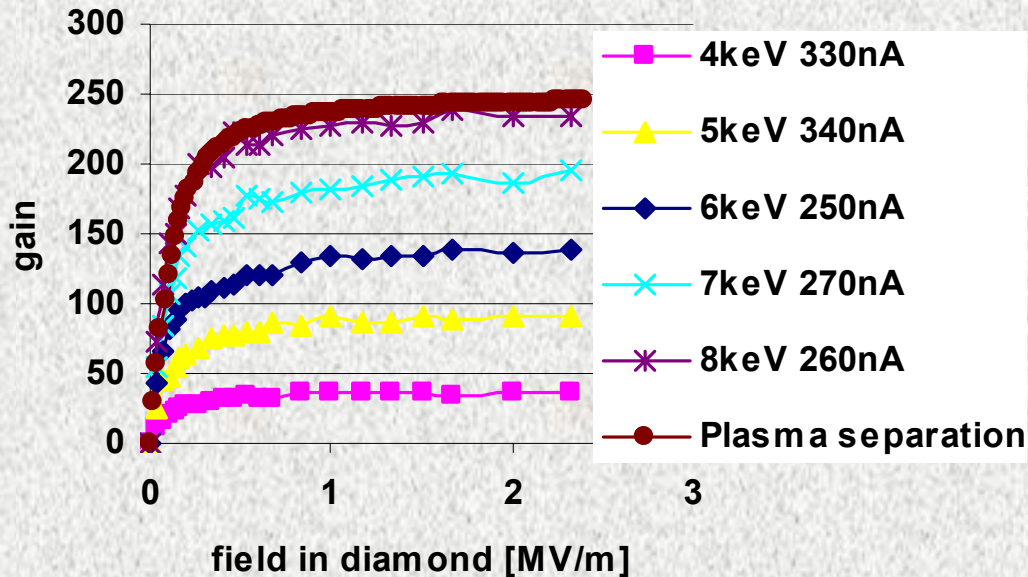
The capsule design is being studied to provide the required vacuum.

Step 2: electron-hole pair generation

Optimize the metal coating thickness.

- Step 3: electron-hole pair separation

Need to study the electron-hole recombination during its separation.



Transmission mode circuit

The charge separation model:

The recombination rate is proportional to the product of the electron density and the hole density.

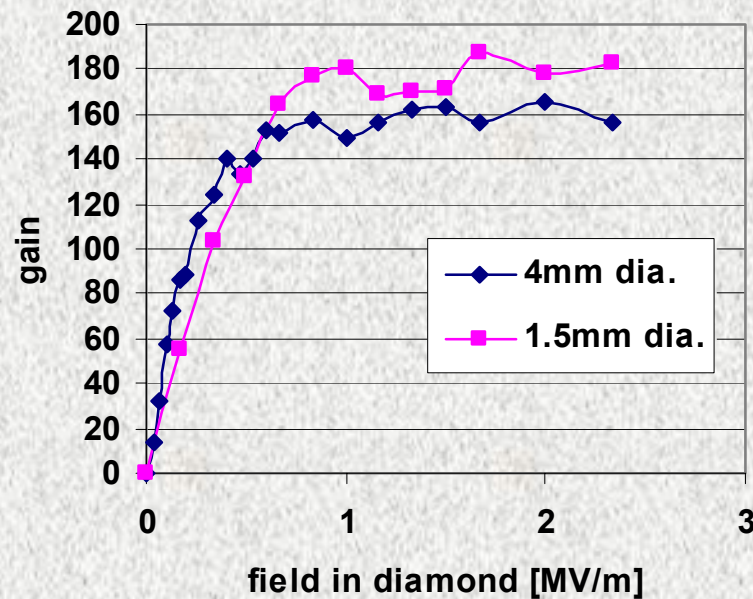
The charge separation model describes very well the single primary electron case, which will apply to very high current density.

Each charge separation event can be as short as a few ps: $L \sim$ a few hundred nm.

Drift velocity $\sim 10^5$ m/s

Transverse size \sim a few hundred nm.

>> Hence, unless the primary electron current densities is $\gg 10\text{mA/mm}^2$, the secondary charge clouds from individual primary electrons do not overlap and the gain curve should be independent of the current density.



Gain vs. field curves with one order magnitude difference of primary electron densities

- Step 4: charge carrier transport through diamond.

Requires high purity single crystal diamond or polycrystalline diamond with large grains.

Synthetic diamonds meeting these criteria are now grown by the CVD technique and are readily available commercially.

- Step 5: electron emission from diamond surface.

Needs to hydrogenate the sample carefully to produce NEA surface.

We've observed evidences of electron emission from our hydrogenated diamond surface but it's clear that the trapping of the electrons near the hydrogenated surface is significant.

Possible reasons of the electron trapping:

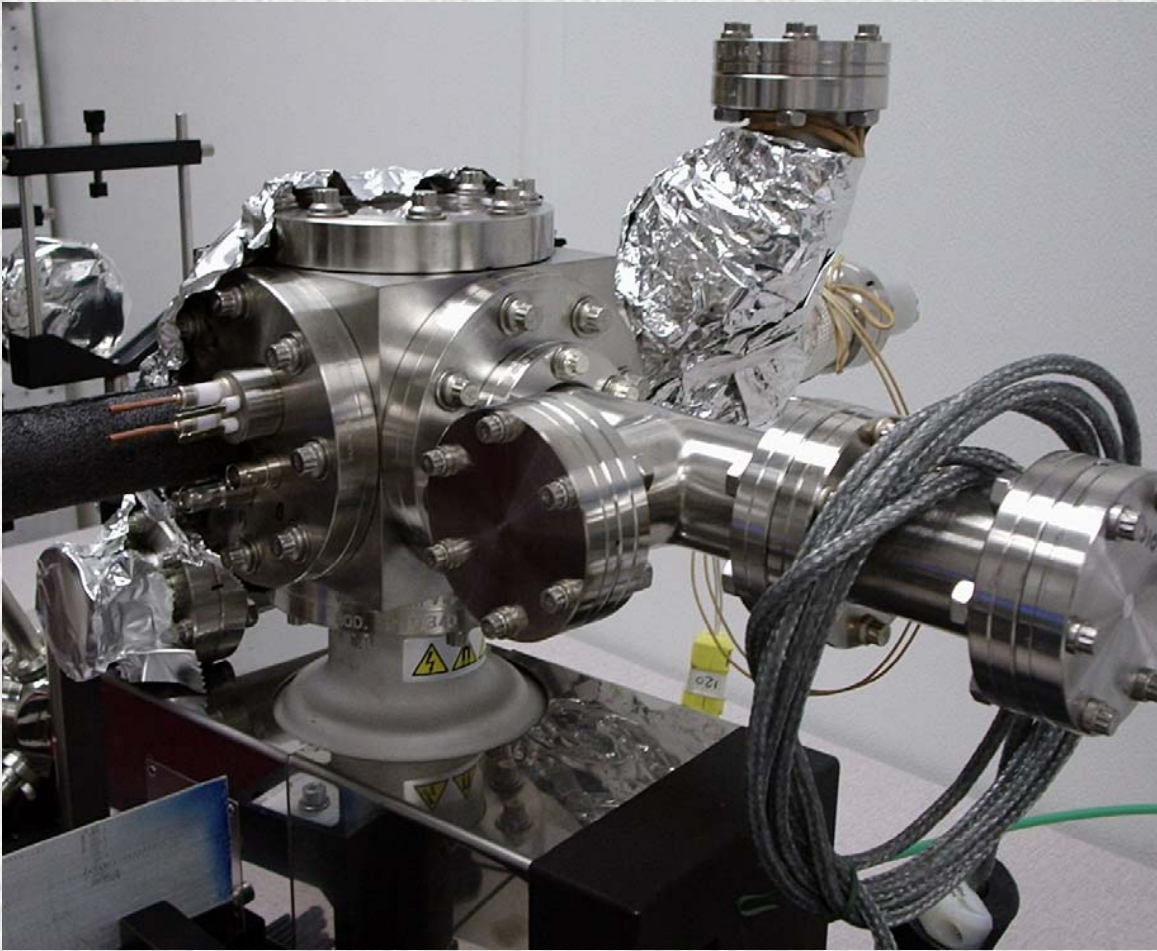
Slightly Positive Electron Affinity surface of the <100> lattice surface-normal orientation diamond.

Surface states caused by the lattice discontinuity near the surface.

Possible ways to overcome the trapping problem:

- *Working at cryogenic temperature which can greatly reduce the probabilities of the electrons being trapped.*
- *Use $\langle 111 \rangle$ orientation single crystal diamond to give a real Negative Electron Affinity surface.*
- *Terminate the surface with alkali elements such as sodium or even potassium instead of the hydrogen.*
- *Gently treat the surface by the ion etching or laser ablation techniques.*
- *Use low energy laser to detrap the trapped electrons.*

The new test chamber



Capable of:

- *Working at cryogenic or high temperatures*
- *Emittance measurement*
- *Laser related measurements*

Conclusions

- *Among the 5 sub-processes of the DAP operation, Only the fifth step process needs further investigations and we've proposed many possible solutions.*
- *The capsule design and DAP emittance measurement are studied in parallel with the other studies.*
- *This novel new type of photo-cathode is very promising!*