Study of Secondary Emission Enhanced Photoinjector

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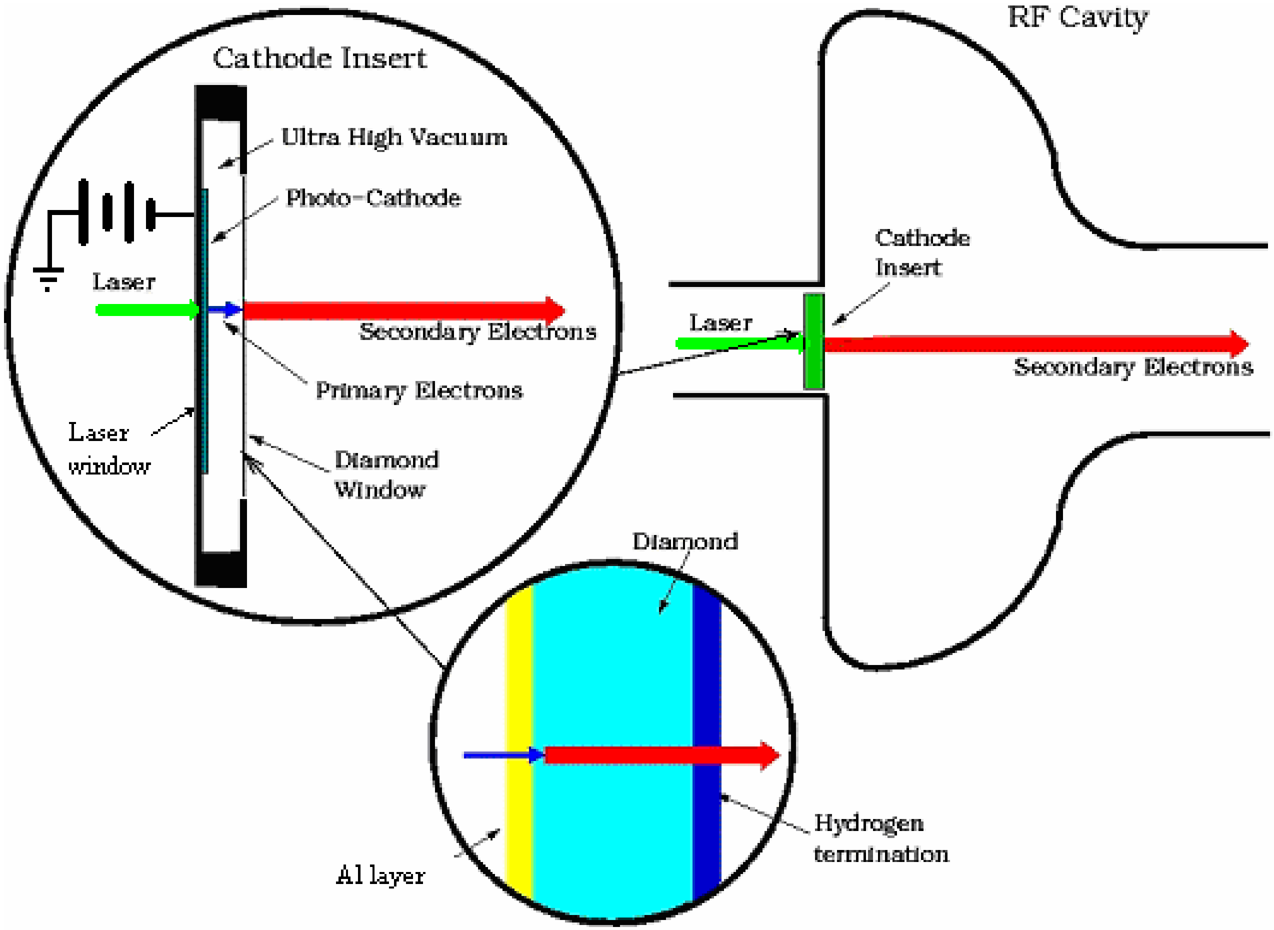
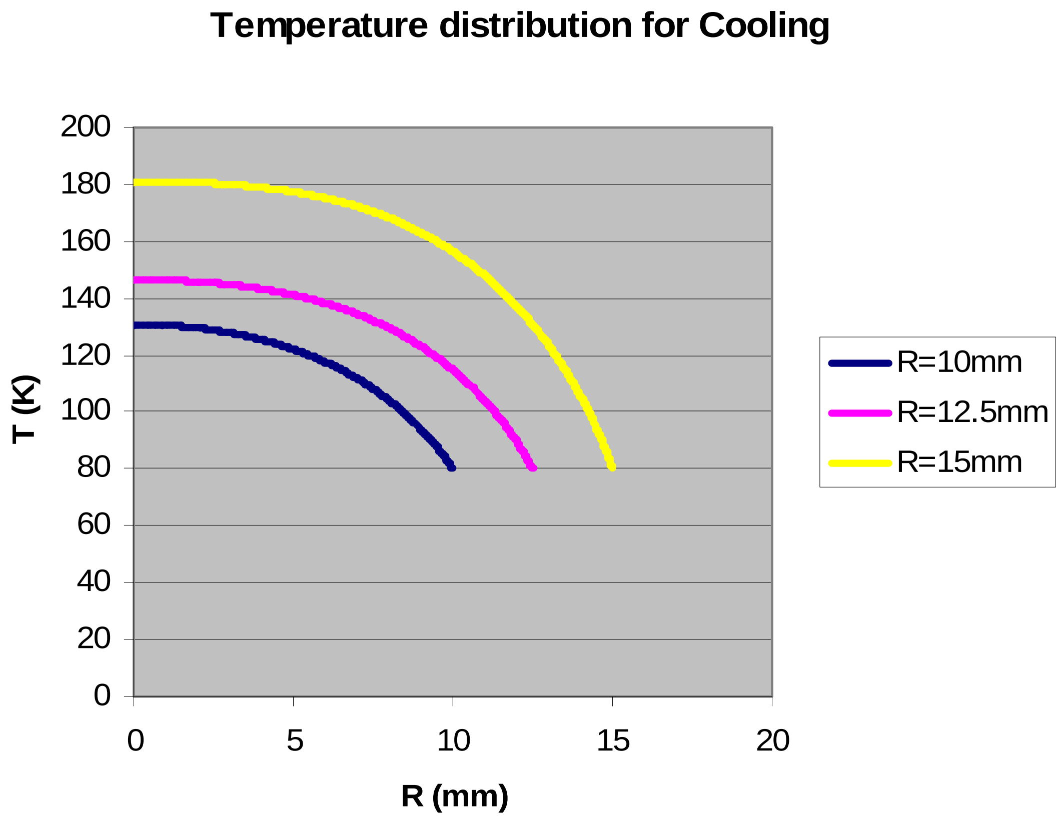
Introduction



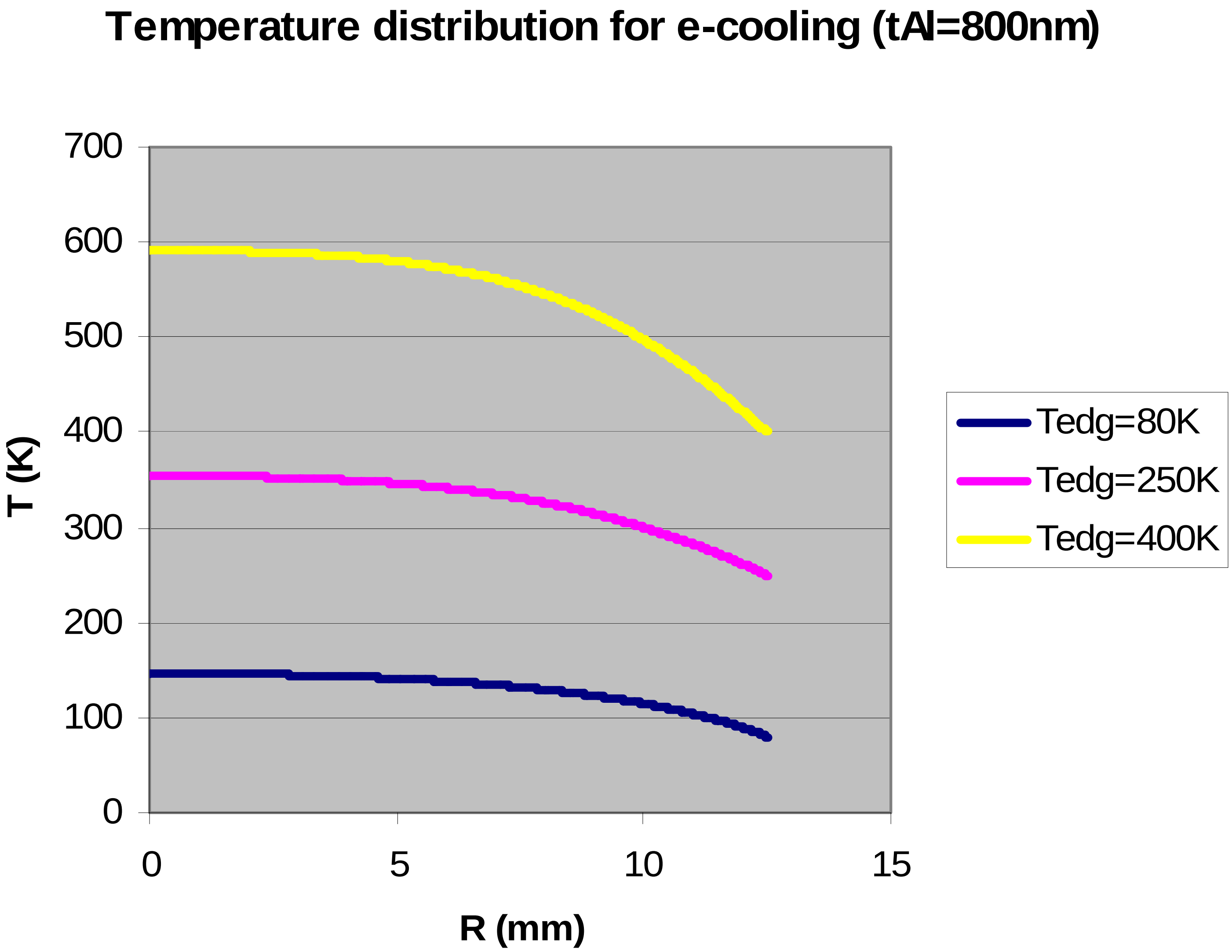
Schematic diagram of a secondary emission enhanced photoinjector

Charge=20nC/bunch
Repetition frequency=9.4MHz
Radius R>10mm
Primary electron energy EPri=10keV
Diamond thickness rDmd=30 μ m
Al thickness tAl=800nm
Peak RF field on cathode
E0=15MV/m
SEY=300
Temperature on diamond edge
Tedge=80K
Primary electron pulse length
PlsPri=10deg

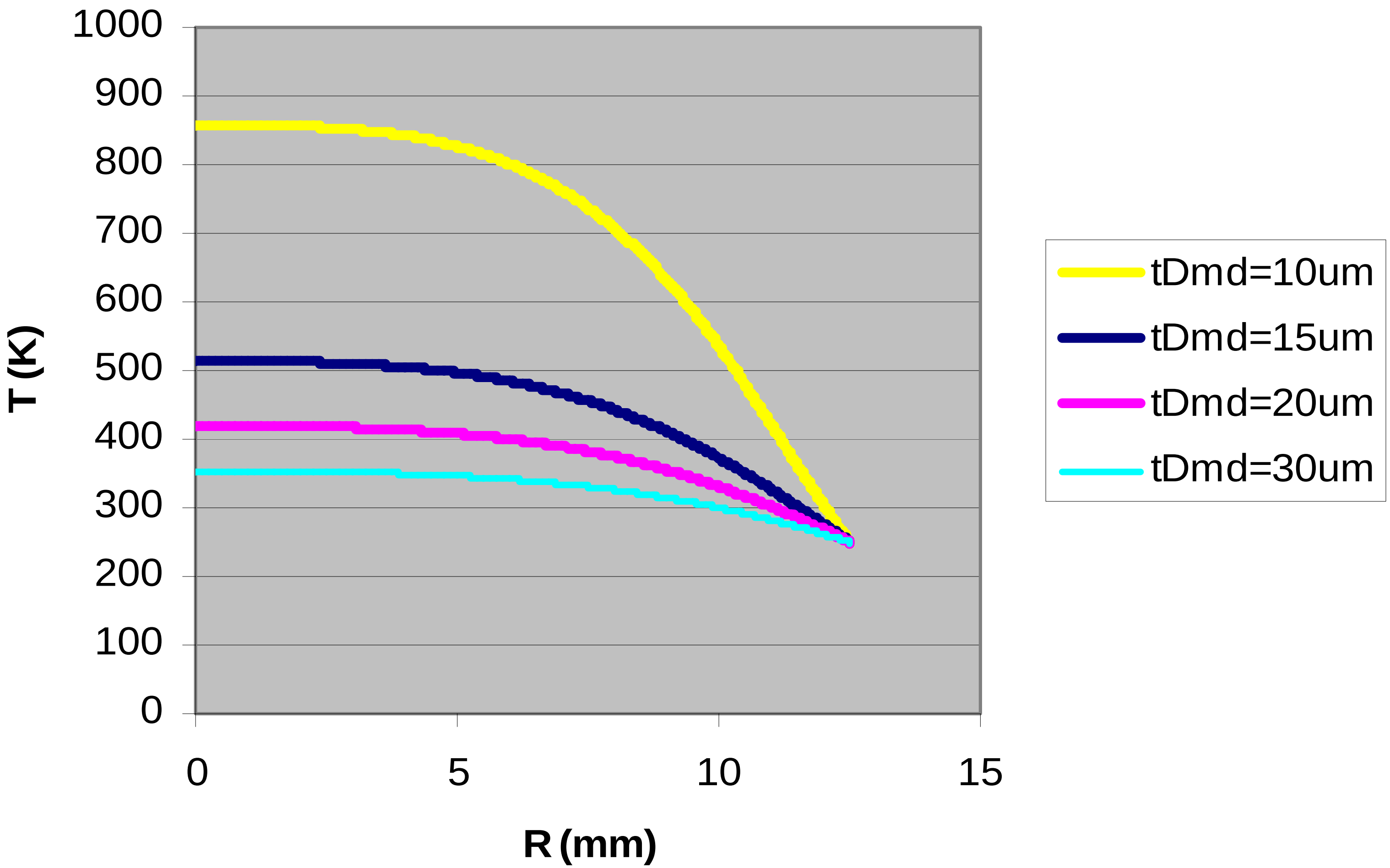


R		10mm	12.5mm	15mm
Primary	power=	6.3(W)	6.3(W)	6.3(W)
Secondary	power=	7.6(W)	7.6(W)	7.6(W)
RF	power=	7.5(W)	20.0(W)	48. 6(W)
Replenishment	power=	0.04(W)	0.05(W)	0.05(W)
Total	power=	21.4(W)	33. 9(W)	62. 5(W)

Edge Temperature effects



diamond thickness effects



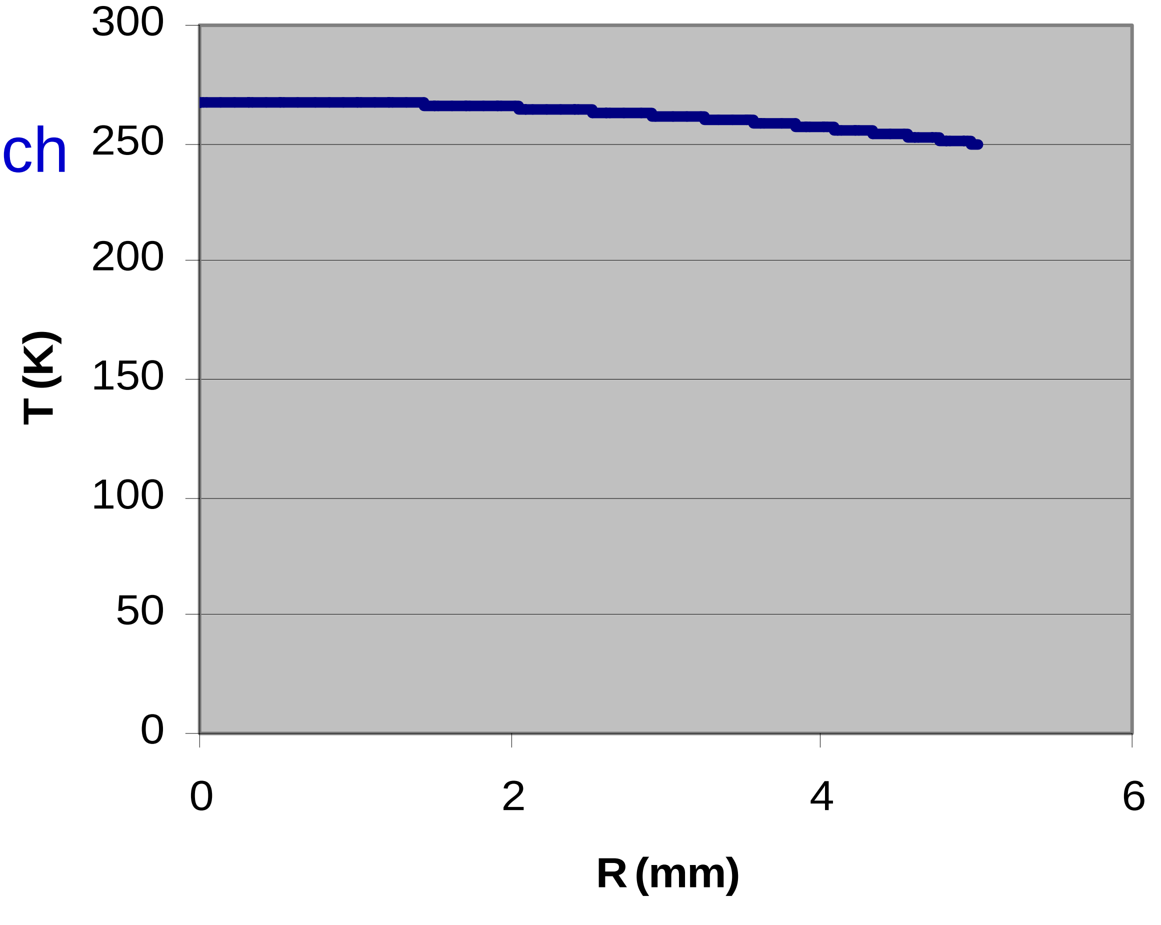
Charge=0.14nC/bunch

f_{Rep}=703MHz

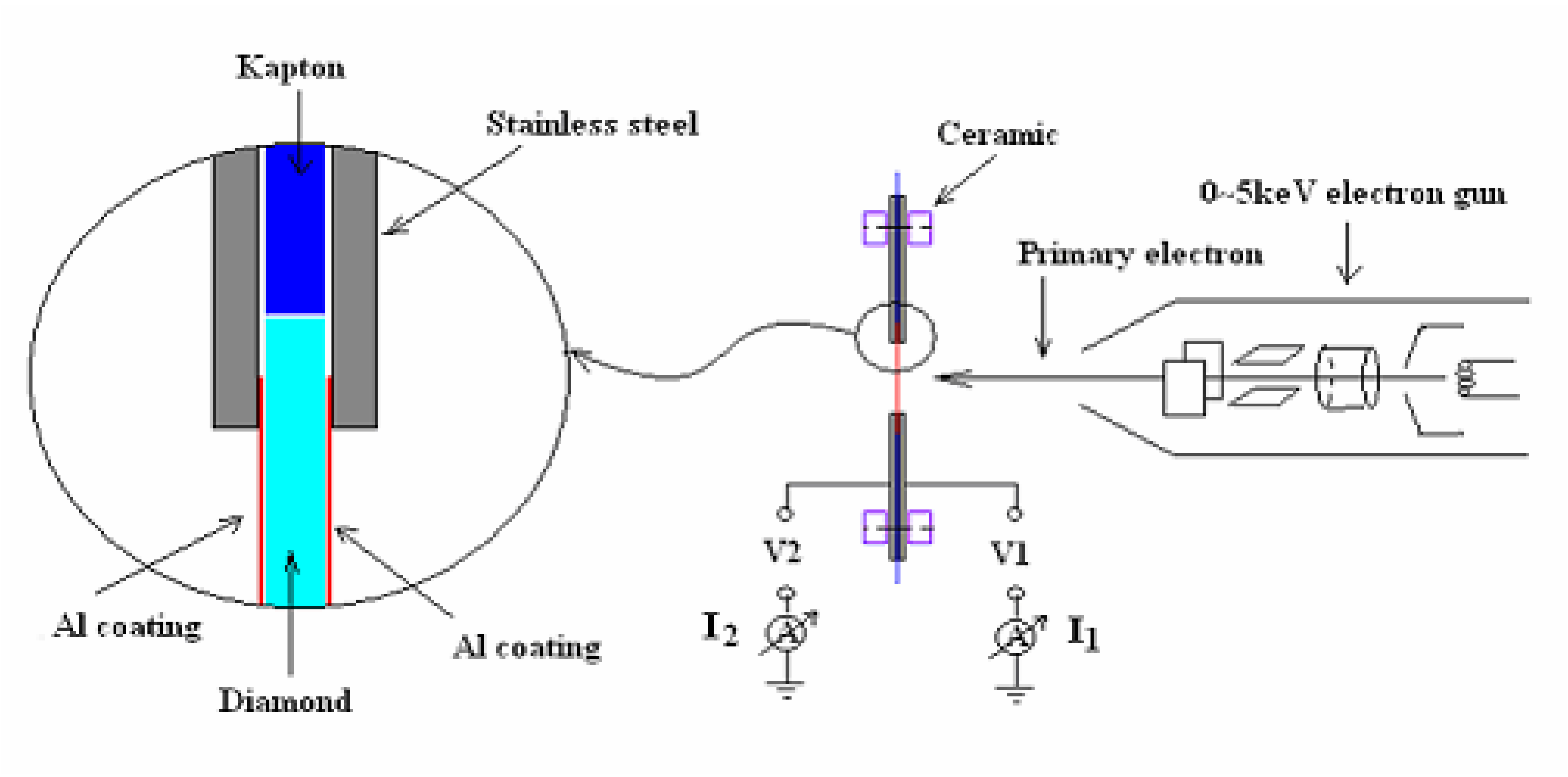
I=100mA

Radius R=5mm

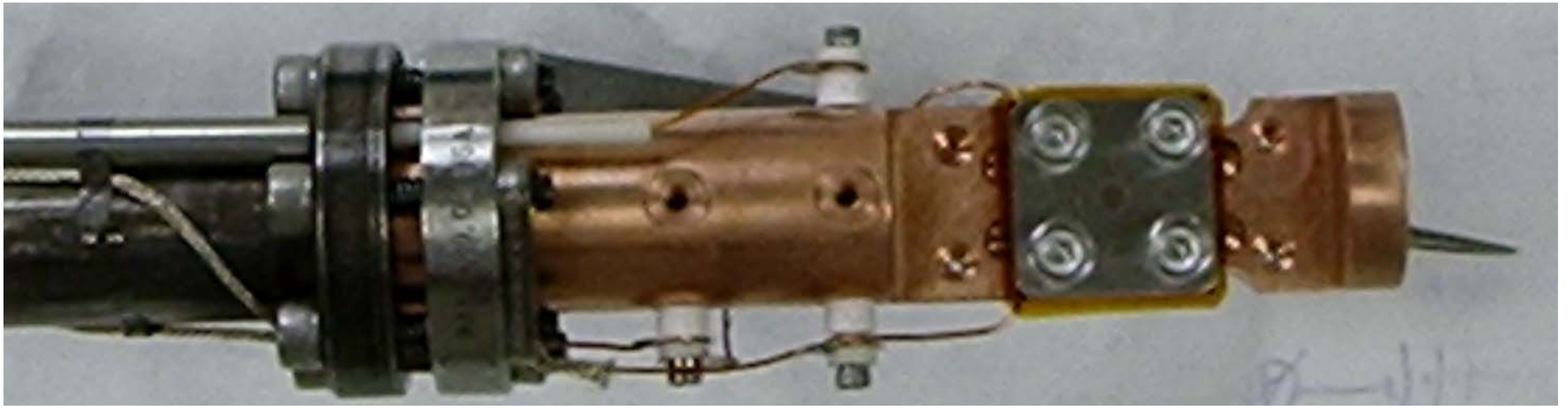
Tedge=250K



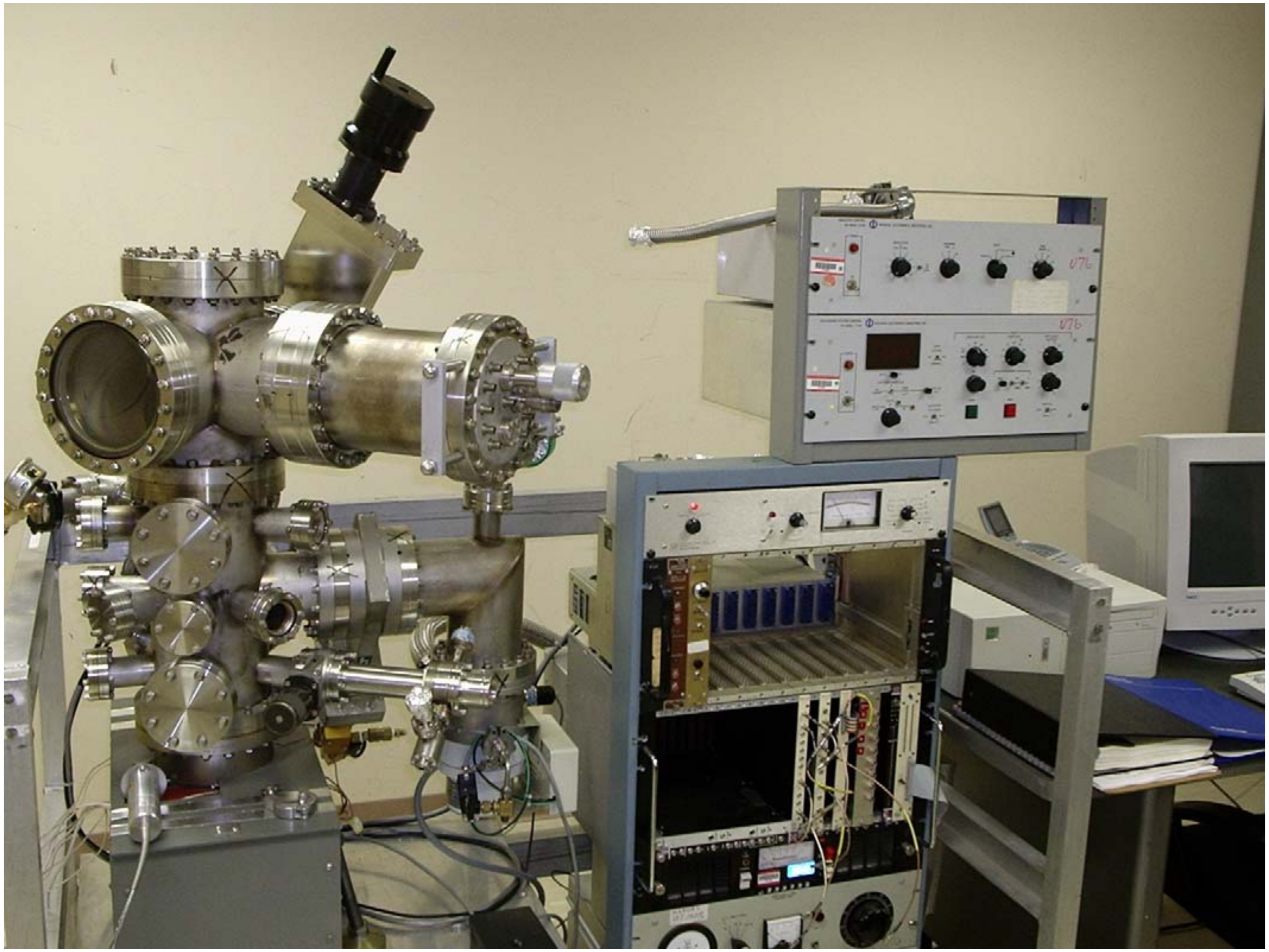
Electron and hole transmission measurements



The sample holder



Experiments



Main results

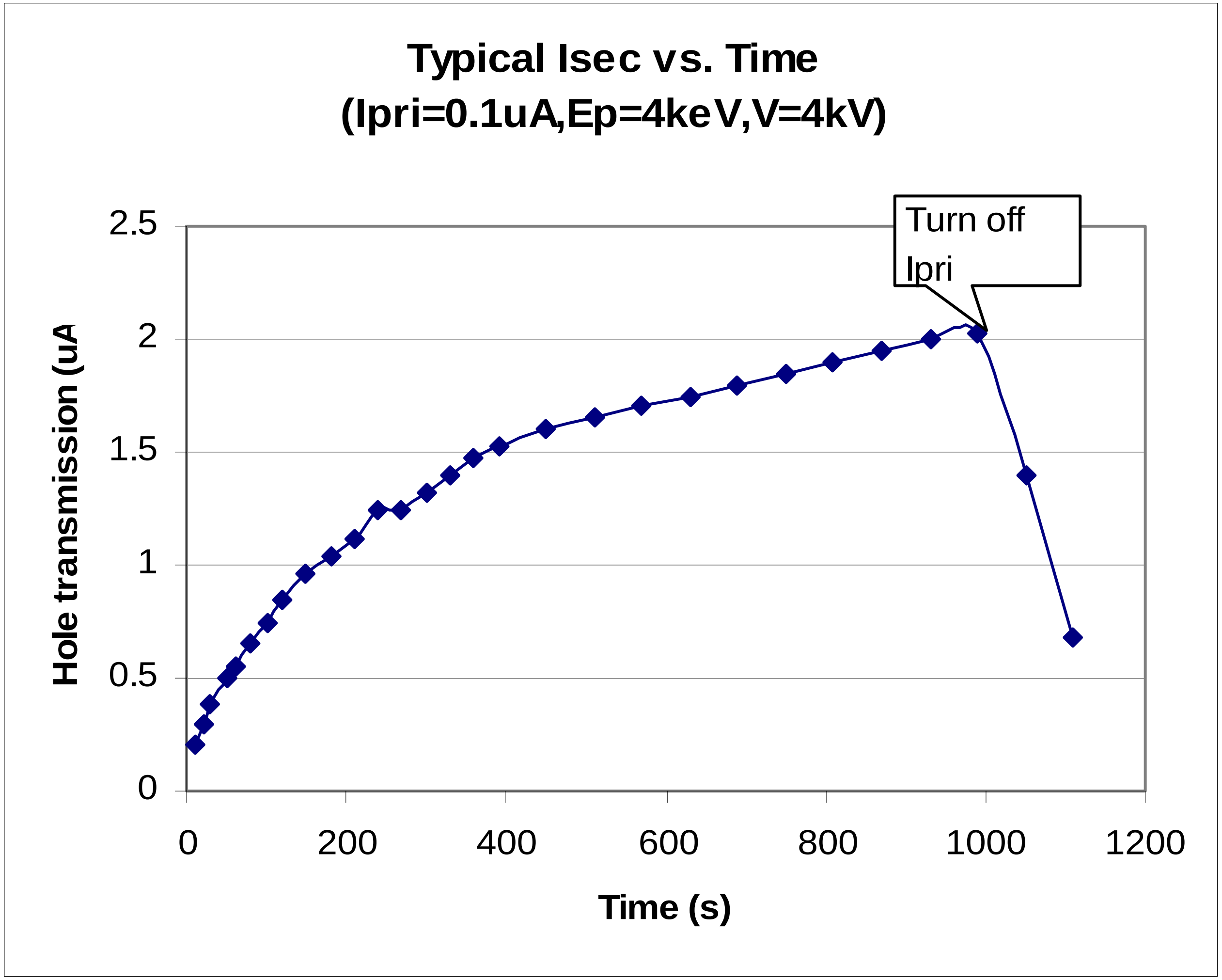
- Polycrystalline diamond ($200\mu m \times \phi 6mm$).

  0eV<Epri<6keV, 0<Ipri<5µA.

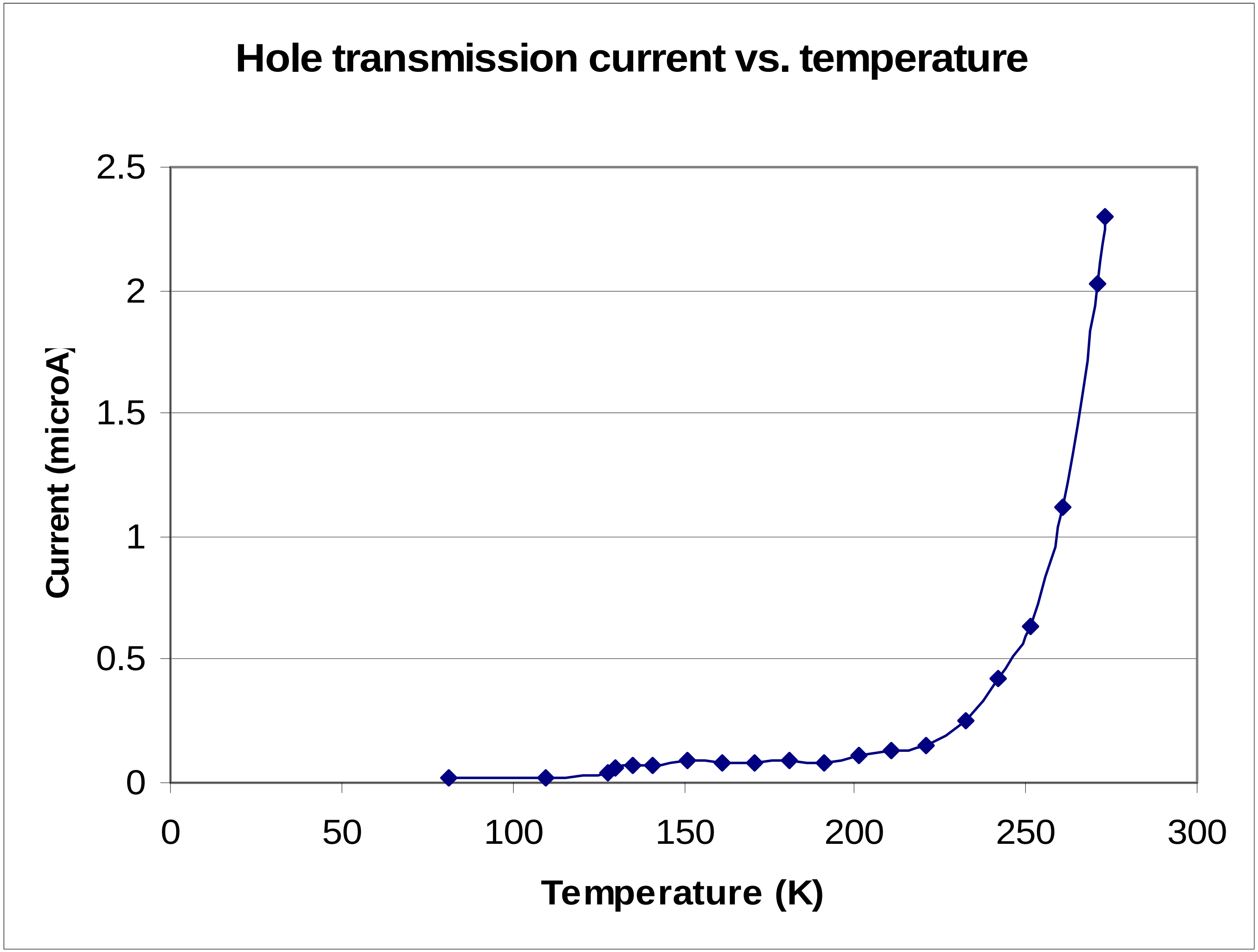
  No transmission is observed ($I_{Sec} < 1nA$)

  Presumably due to the poor diamond quality and very high concentration of charge carrier traps.
- “Single-crystal” diamond ($200\mu m \times \phi 6mm$).

  Primary current amplification from 2 to more than 200.

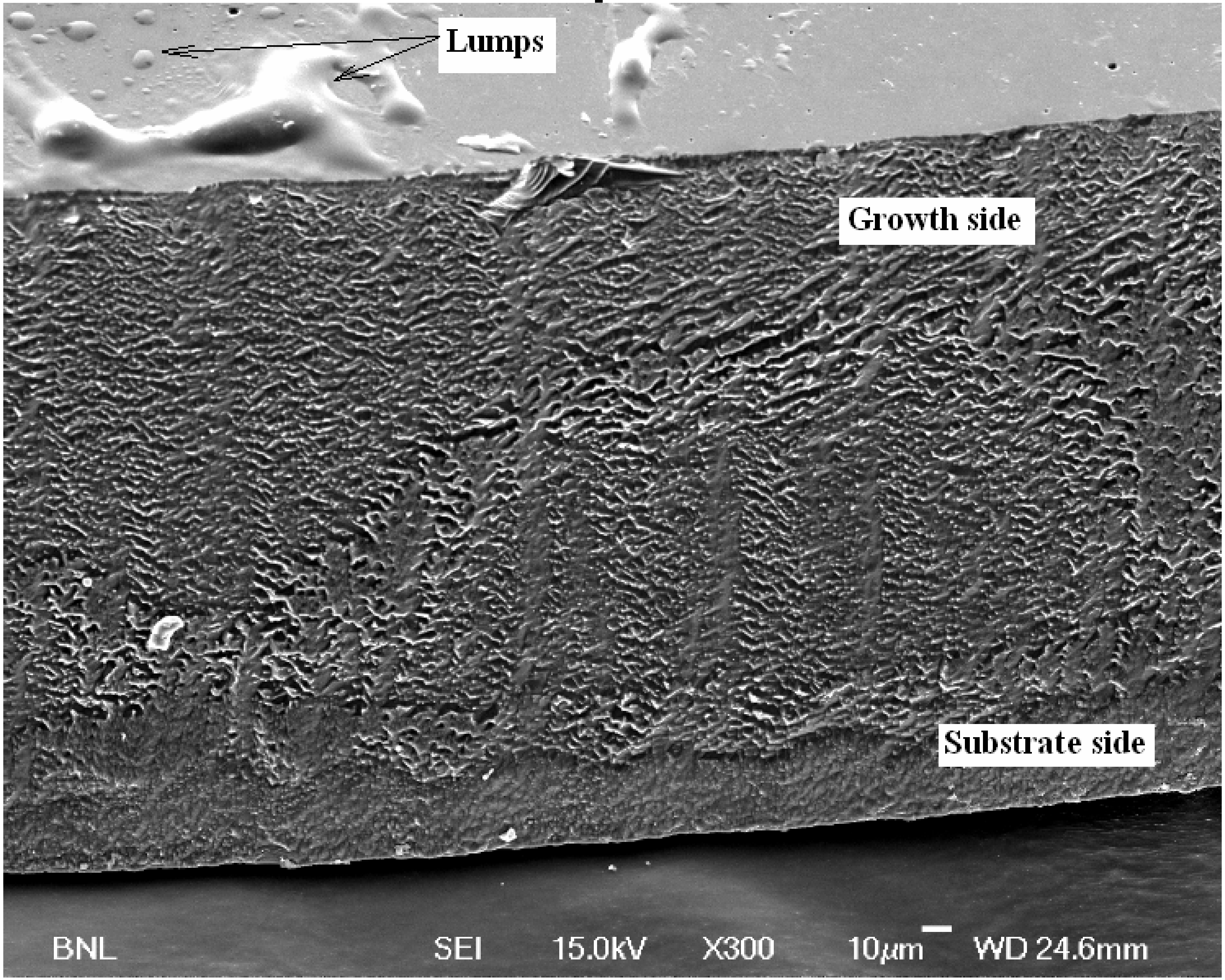


The current gain increased with time (of the order of minutes) presumably due to temperature rise in the diamond



At LN temperature (80K) the gain is 3 orders of magnitude lower than at room T (300K)

SEM picture


Lumps
Growth side
Substrate side
BNL
SEI
15.0kV
X300
10μm
WD 24.6mm

Electron transmission

Similar transmission gain was obtained for electrons and for holes under similar conditions (low primary energy and current, same electric field but at different polarities).

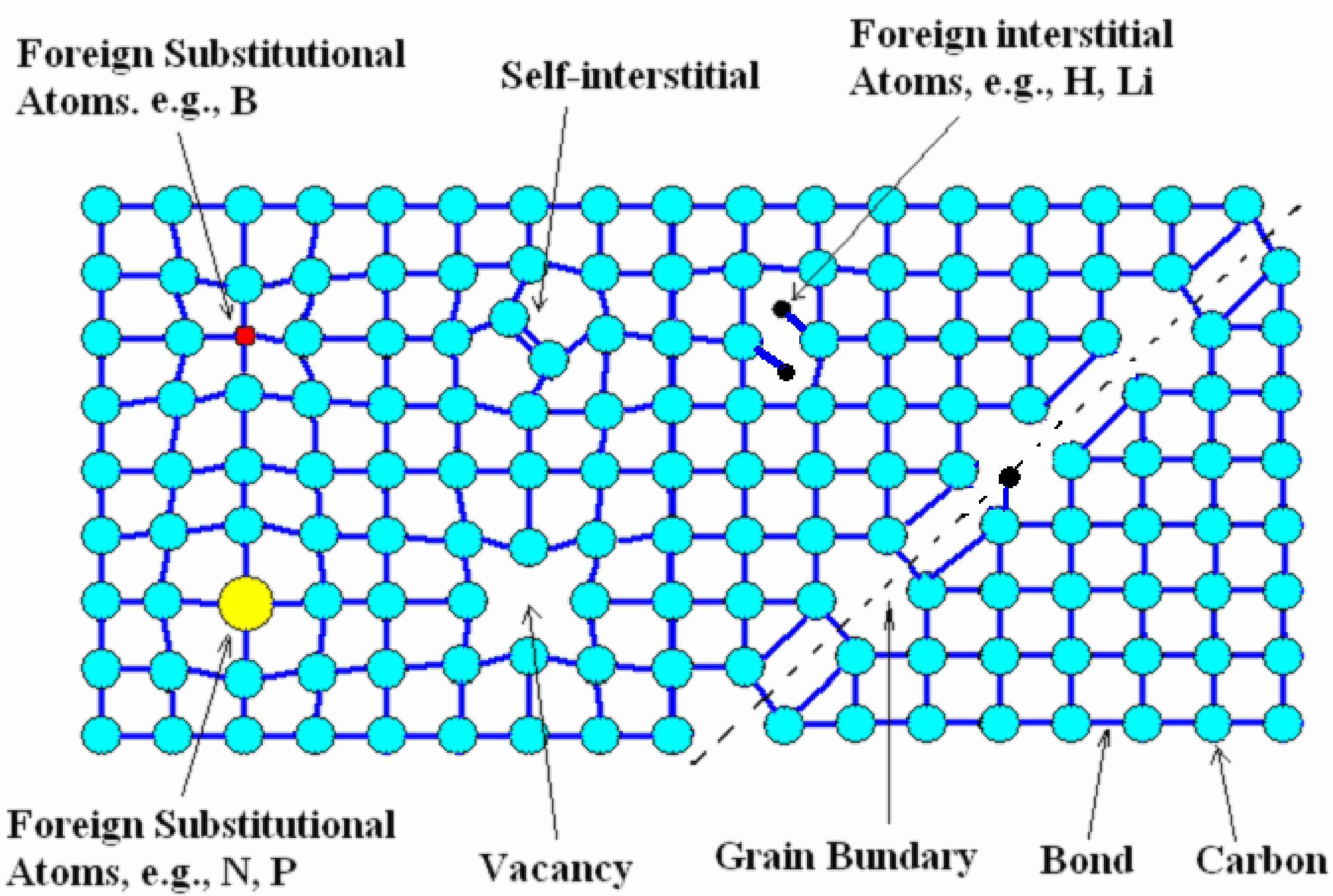
Summary

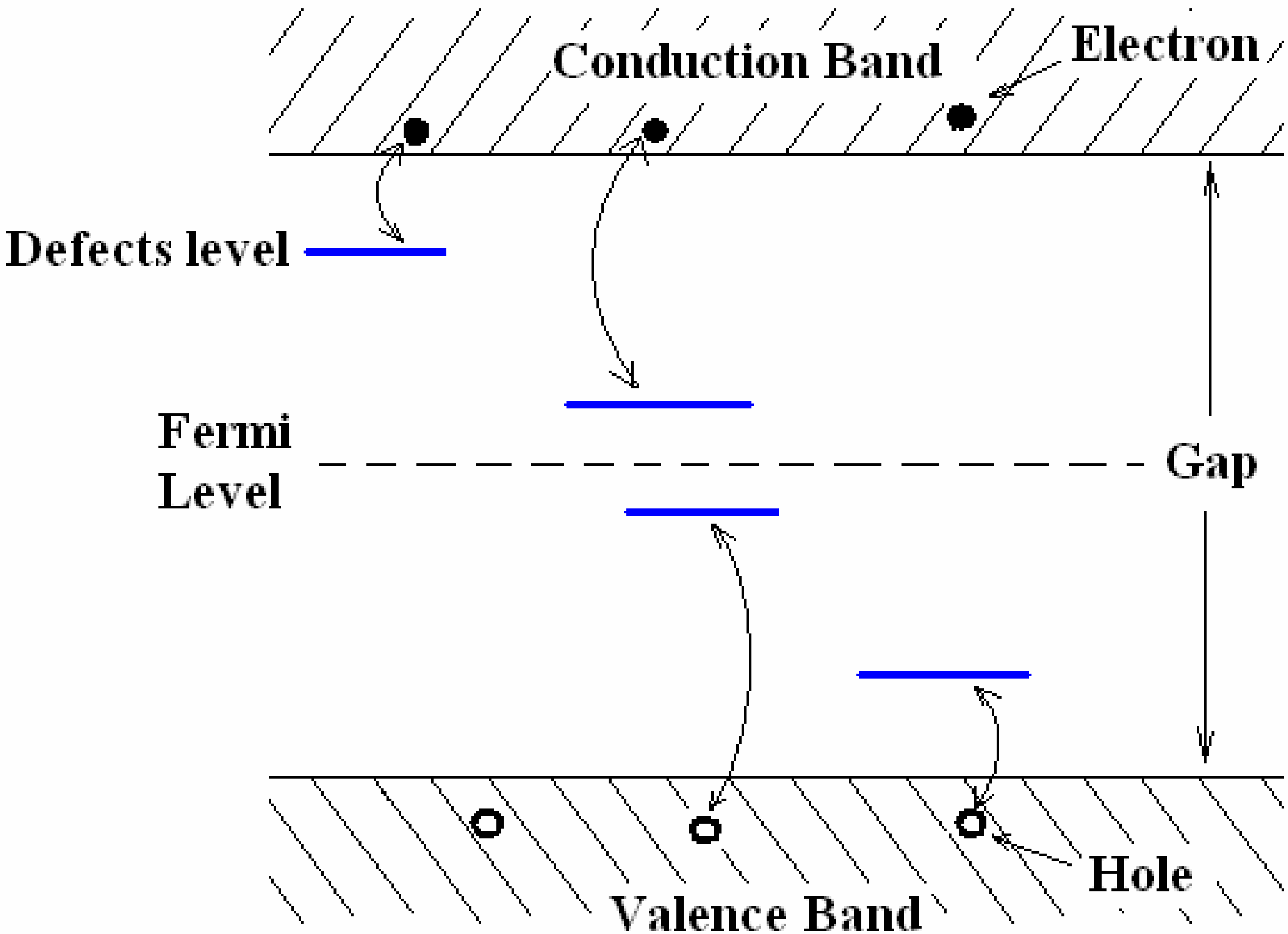
- Simulations show the feasibility of the Secondary Emission Enhanced Photoinjector.
- We measured transmission current through 200μm “single-crystal” diamond. The amplification of primary current is in excess of 200.
- Transmission is strongly dependent on diamond temperature. Poor diamond (too many traps and small grain size) was used. Better diamond quality is required.

Future Plans

- Improve sample quality
- Use thinner sample
- Measure electron transmission and emission
- High charge measurement
- Temperature dependence
- RF test
- Capsule design and test

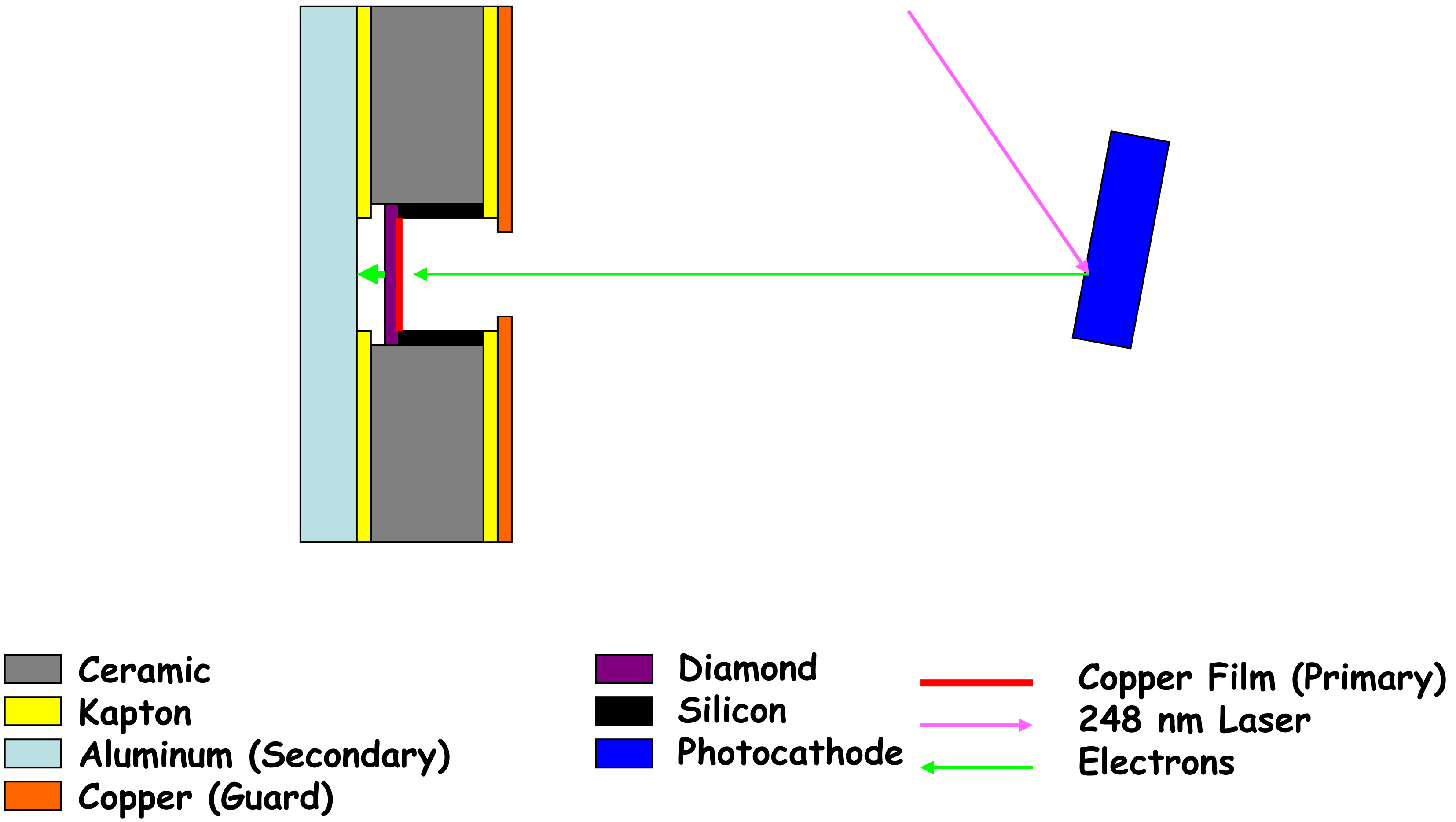
Trapping


Foreign Substitutional
Atoms. e.g., B
Self-interstitial
Foreign interstitial
Atoms, e.g., H, Li
Foreign Substitutional
Atoms, e.g., N, P
Vacancy
Grain Bundary
Bond
Carbon



Conduction Band
Electron
Defects level
Fermi
Level
Gap
Hole
Valence Band

Pulsed primary electron beam, Hydrogenated surface



Measurements

Sample:

Polycrystalline,

30 μm thick, 1 cm diameter on Si ring

Optically transparent

Undoped, 50 MΩ across

Cu on incident face

Primary electron:

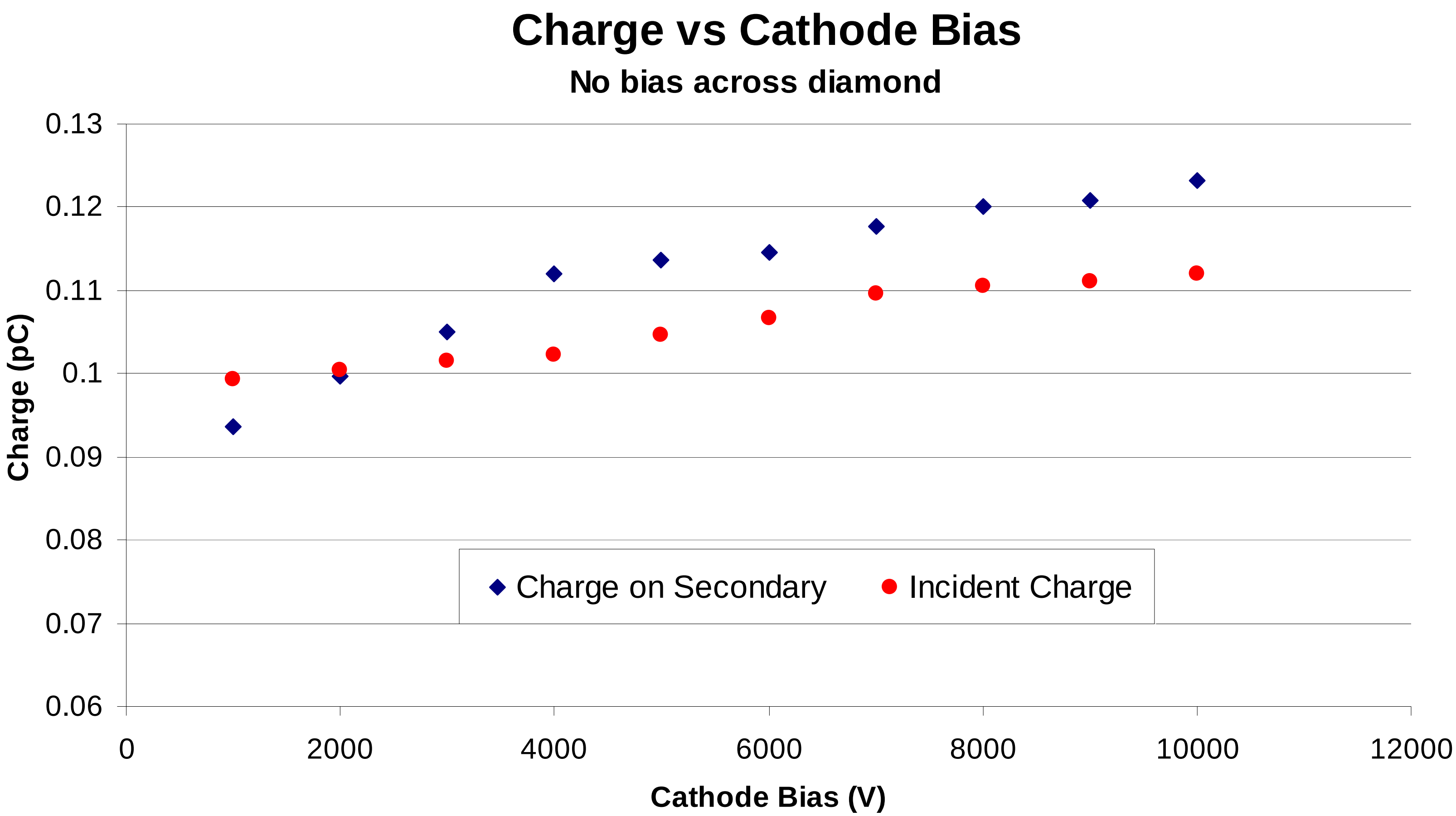
Pb photocathode biasable

12 ns, 248 nm laser

Measurement:

Charge sensitive preamp.

Integration time of 1 μs



Electron emission through hydrogenated surface

Electron gain modulated by induced charge