

Transport-Mediated Transverse Momentum Filtering in Diamond

Photocathode Physics for Photoinjectors (P3) Workshop 2021

Louis Angeloni

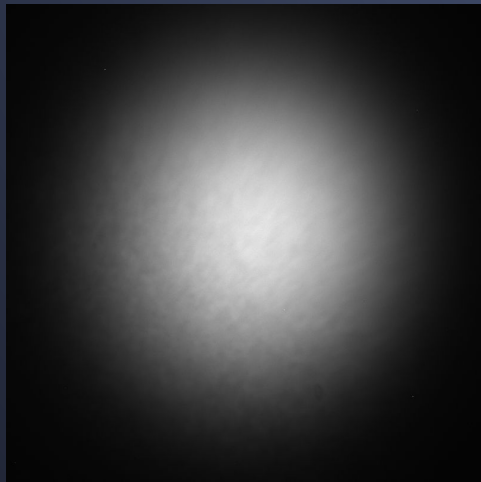
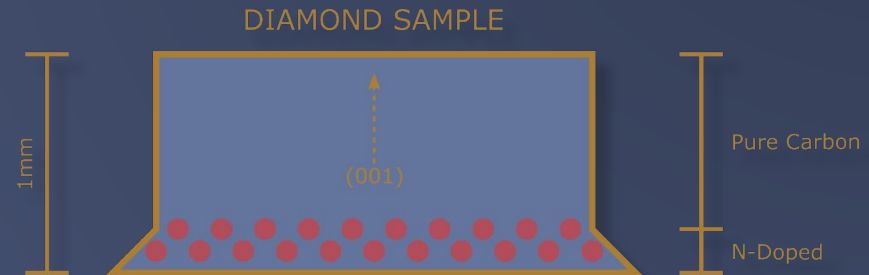
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Cathode Properties and Experiment

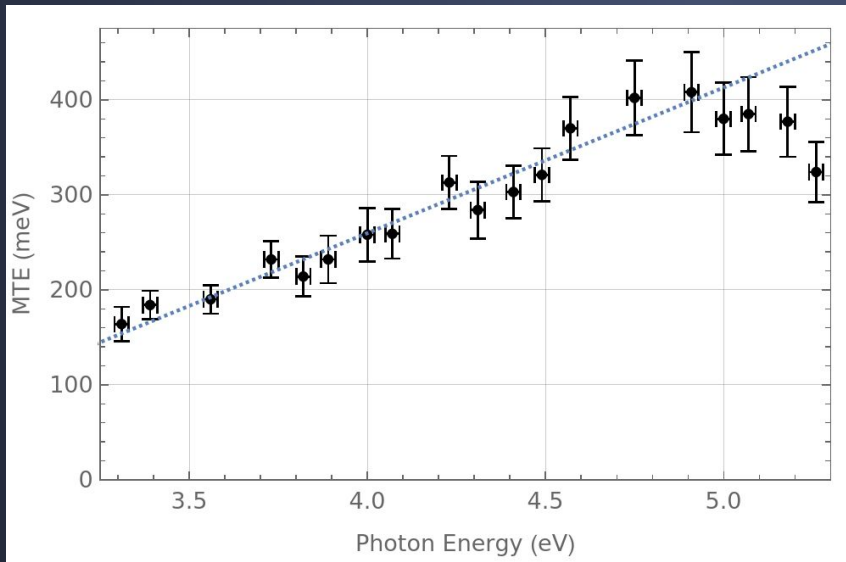
- Single Crystal Diamond (001) (1mm along (001))
- Thin nitrogen-doped CVD grown surface layer on one side
- Source: Fraunhofer USA



Example of data image

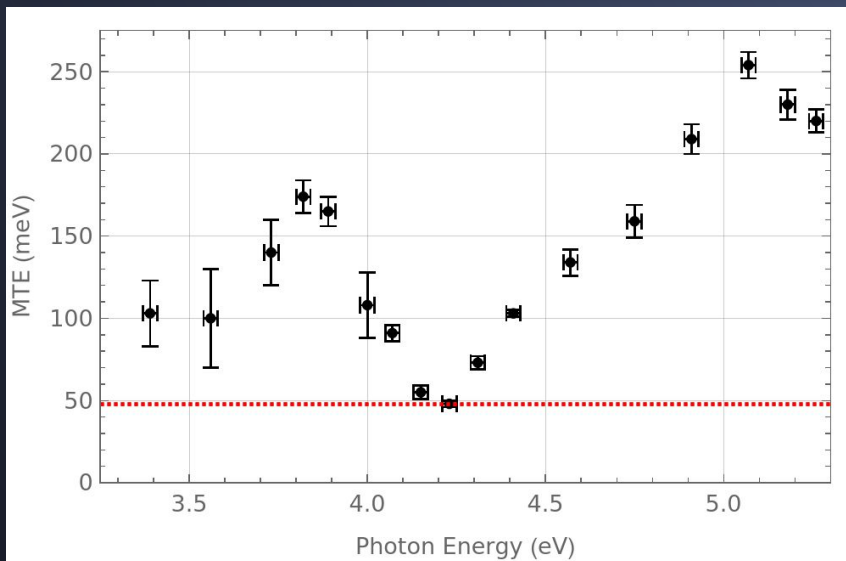
- Tunable-UV LASER system for MTE and Q.E. measurements vs. photon energy
- Simple DC electron gun and drift region, terminating at MCP signal amplifiers
- Data from detector screen

Results of Experiment



“Front Face” Illumination

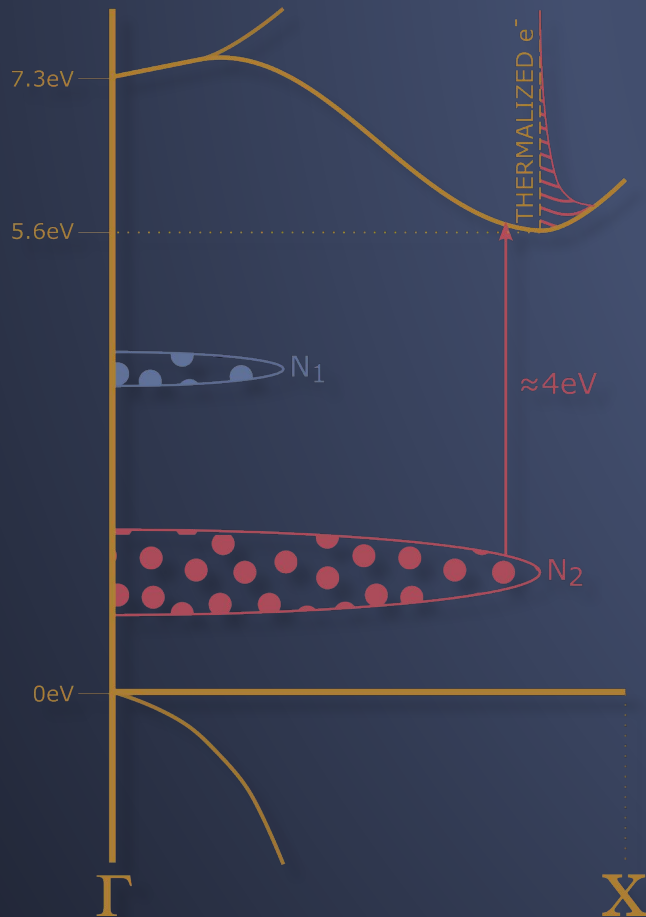
- Nitrogen doped layer at emitting surface
- “Typical” emission behavior: MTE is linear
- Diamond is transparent to our photon energy range; this data characterizes emission requiring N-dopant states alone



“Back Face” Illumination

- Not “typical” - Nitrogen layer “flipped” to back of sample; electrons from nitrogen states forced to travel through length of diamond to get out (justified, see Smedley, et al.¹)
- Unorthodox nonlinear shape to MTE
- Minimum of about 45meV at 4.23eV

Proposed Mechanism and Closing



- At this doping level, two possible states from Nitrogen
- First MTE turnover for “back face” illumination likely when second state becomes accessible, minimum when it dominates fully
- Thermalized emission from $\Gamma \rightarrow X$ valley
- E-field heating; LO-phonon cooling
- Lower bound for electron MTE can be found: no further states for electrons below $k_B T_e = \hbar\omega_{LO}$

$$MTE \geq \left| \frac{m^*}{m_0} \right| k_B T_e \approx \left| \frac{m^*}{m_0} \right| \hbar\omega_{LO} \approx (0.3)(150 \text{ meV}) = 45 \text{ meV}$$

- Transport through the diamond can act as a momentum filter
- Future work: e.g. metallized back face, different filtering materials
- Further examples of band effects in photoemission in Prof. Schroeder’s talk (Theory Session)