1. Quantifying:
  - emission area
  - current density
  - beam brightness

of field emission cathodes made of carbon nanotubes (CNTs) fiber or ultrananocrystalline diamond (UNCD).

2. Comparing the results with theory.

Experiment Setup

- Anode: Mo coated C-doped yttrium aluminum garnet screen (YAG; Ce)
- Cathode: sample under test
- Micrographs are created by capturing the emission pattern on the anode screen by camera.
- Fully automated setup: voltage sweeps, feedback voltage and current is recorded, and photo is taken automatically with regular intervals.

Motivation

1. Fitting Gaussian curves to each peak position to filter out false positives
2. Comparing the results with theory.

Fast Image Processing

Steps:
1. Each spot appears as Gaussian peaks (Fig.A).
2. Find position of peaks by computing each pixel’s distance to nearest brighter pixel and choosing large distance and bright pixels as the peak points (Fig B).
3. Fitting Gaussian curves to each peak position to filter out false positives and to decide emission area corresponding to the peak.

Results and Comparison with theory

- Emission area increases as applied field increases while current density shows saturation in order of magnitude.
- Increase in current is a result of increase in emission area, not a result of increase in current density.
- The trend in current density is different than theoretical prediction of Fowler-Nordheim and Murphy-Good theory.
- Saturation effect cannot be explained with space-charge effect as the current density is much lower than $10^7$ A/cm$^2$.
- Discrepancy between theory and experiments can be solved by considering limited charge carriers in non-metal emitters.

References

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- Michigan State University
- Argonne National Laboratory
- Arizona State University

Field Emission Microscopy of Diamond and Nanotube Materials
Taha Y. Posos1, Mitchell Schneider1, Emily Jeverjian1, Jiahang Shao2, Oksana Chubenko3 and Sergey V. Baryshev1

- 1Michigan State University
- 2Argonne National Laboratory
- 3Arizona State University

First row shows typical original micrographs from three sample. Second row shows detected emission area (shown with blue) by the algorithm.