PBS&T

Advanced Gas Delivery Approach for Focused Particle Beam System

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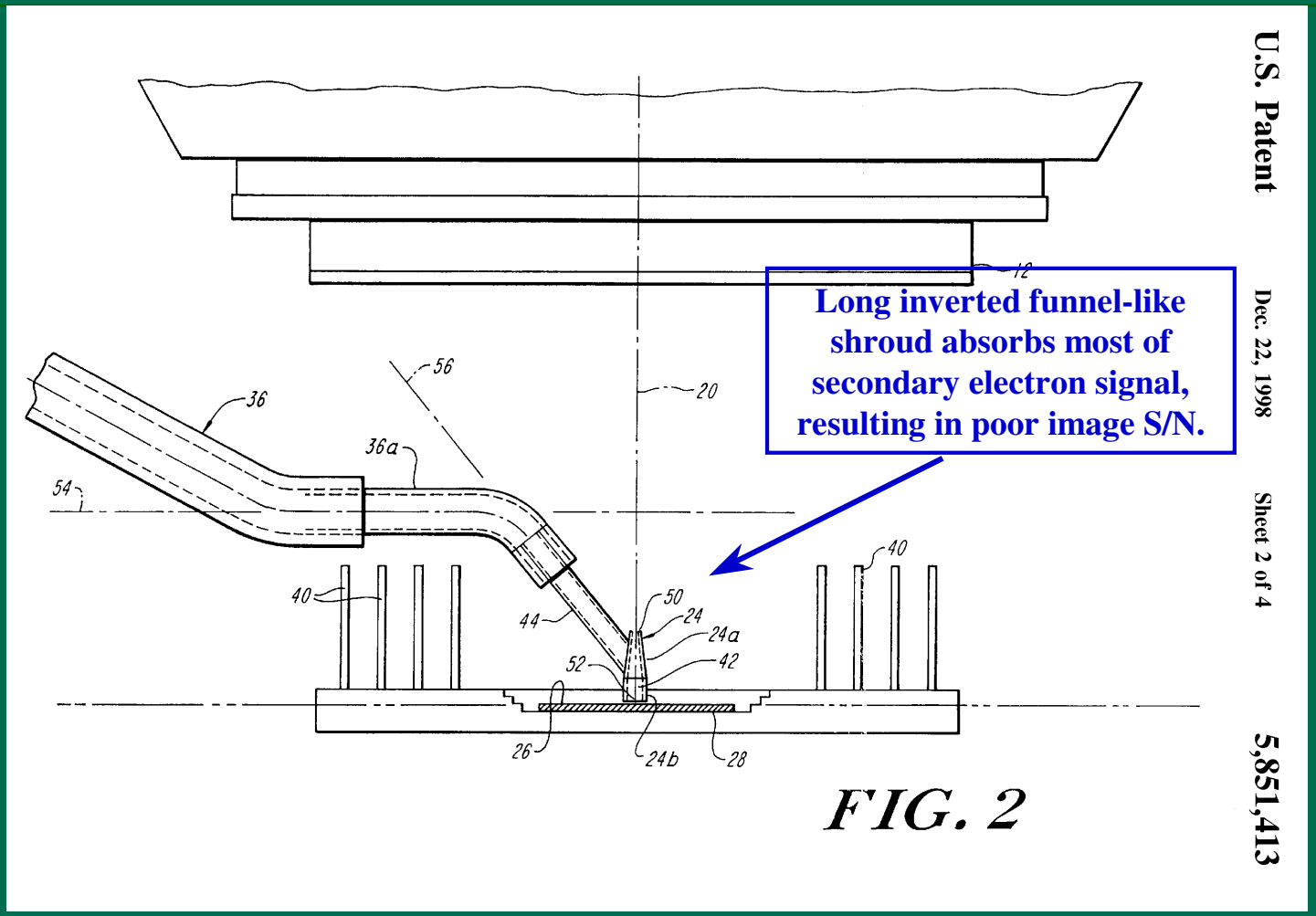
8th European FIB User Group Meeting

EFUG 2004, Dübendorf, Switzerland

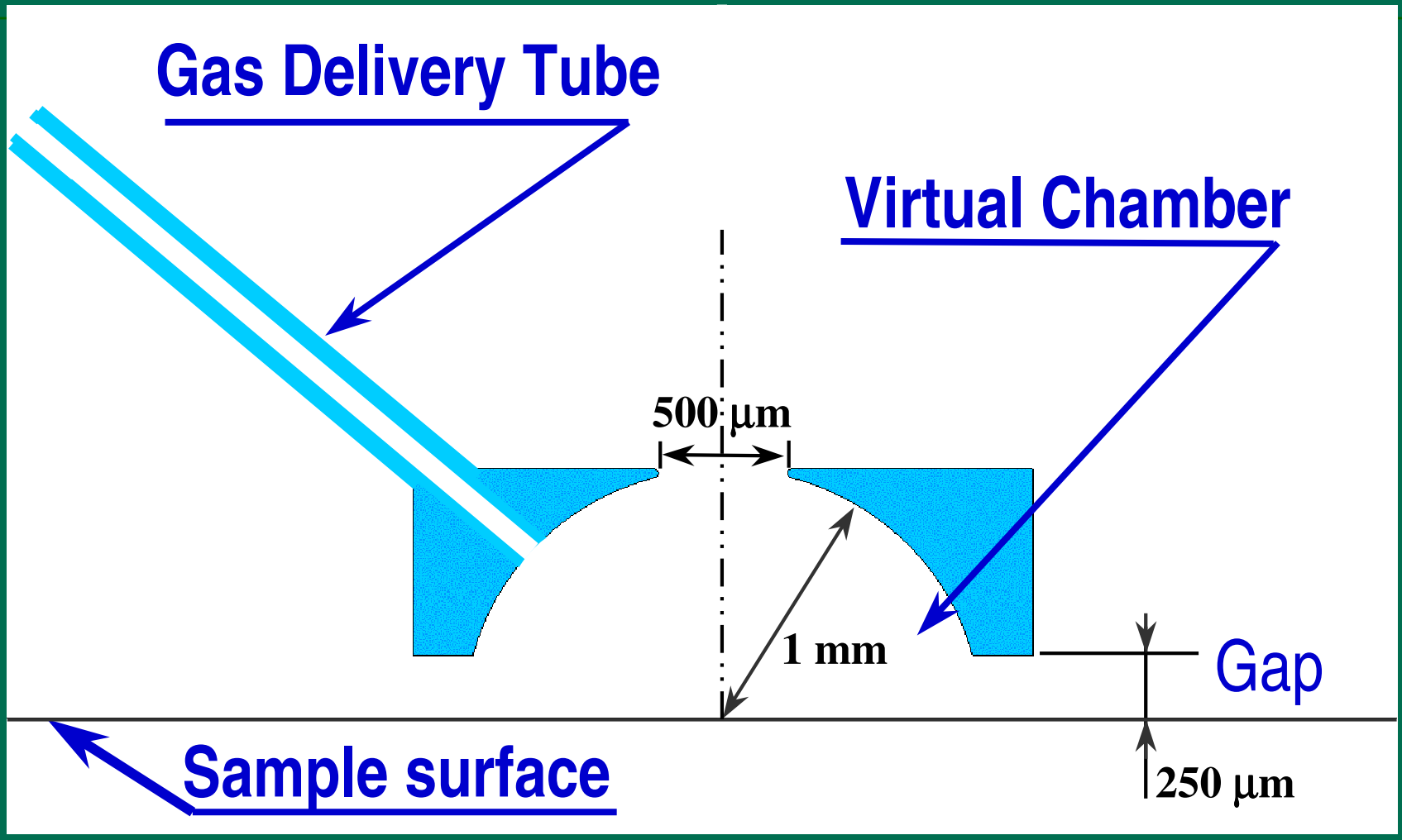
Historical Methods of Gas Delivery in Focused Particle Beam Systems

- **Hypodermic needles** (J. Orloff, "Charged Particle Optics", CRC Press, 1997, pp. 441 - 453, and elsewhere)
- **Separately pumped gas-filled sample chamber** (Y. Ochiai et al, "Pressure and Irradiation Angle Dependence of Maskless Ion Beam Assisted Etching of GaAs and Si" J. Vac. Sci. Technol. B 3(1) 1985)
- **EBD cell with vapor source** (A. Filch et al, "High-vacuum versus "environmental" electron beam deposition" J. Vac. Sci. Technol. B 14(4) 1996)
- **"*Shroud*" or "*Beehive*" gas concentrator** (Casella et al, 1998, US Patent 5,851,413 and Libbi et al, 2002, US Patent 6,497,194)

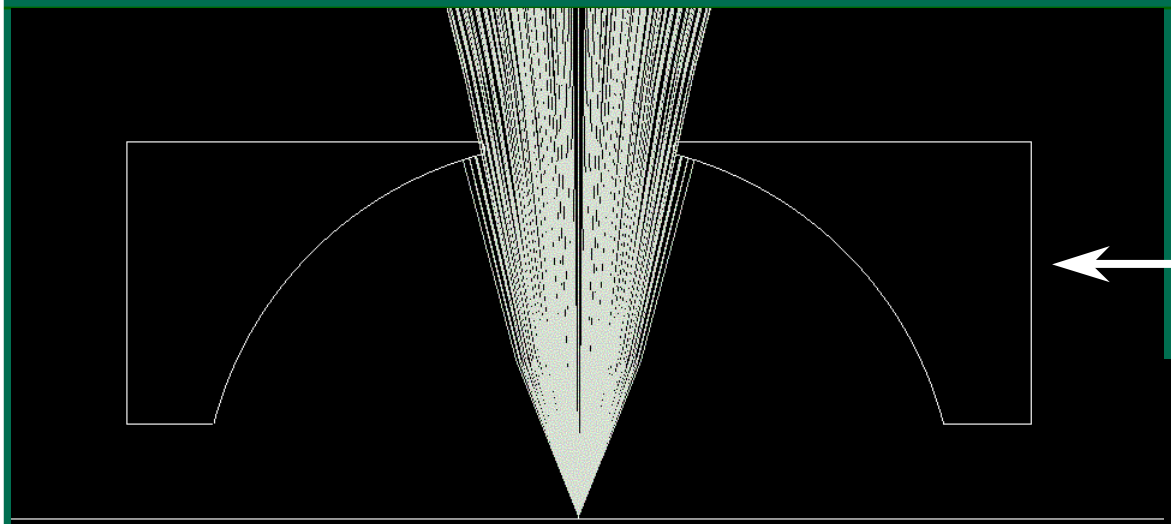
Limitations of *Shroud* ("*Beehive*") Concentrator



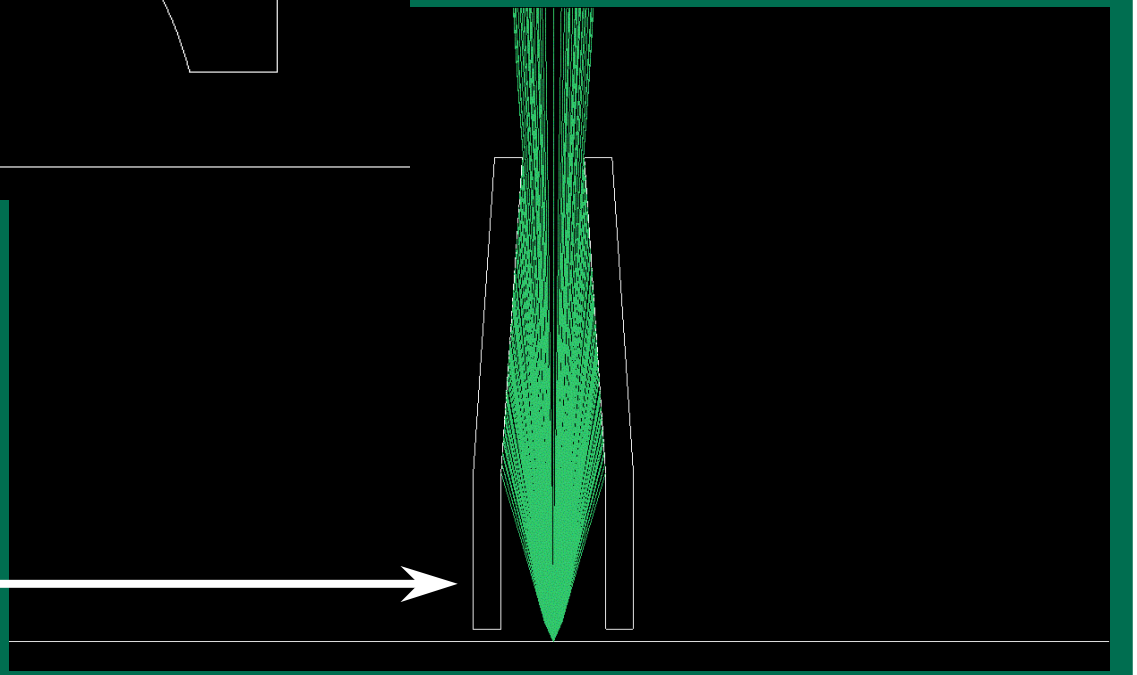
Proposed "*Cupola*" Nozzle



Electron-Optics Simulations of "*Cupola*" and "*Beehive*" Nozzles



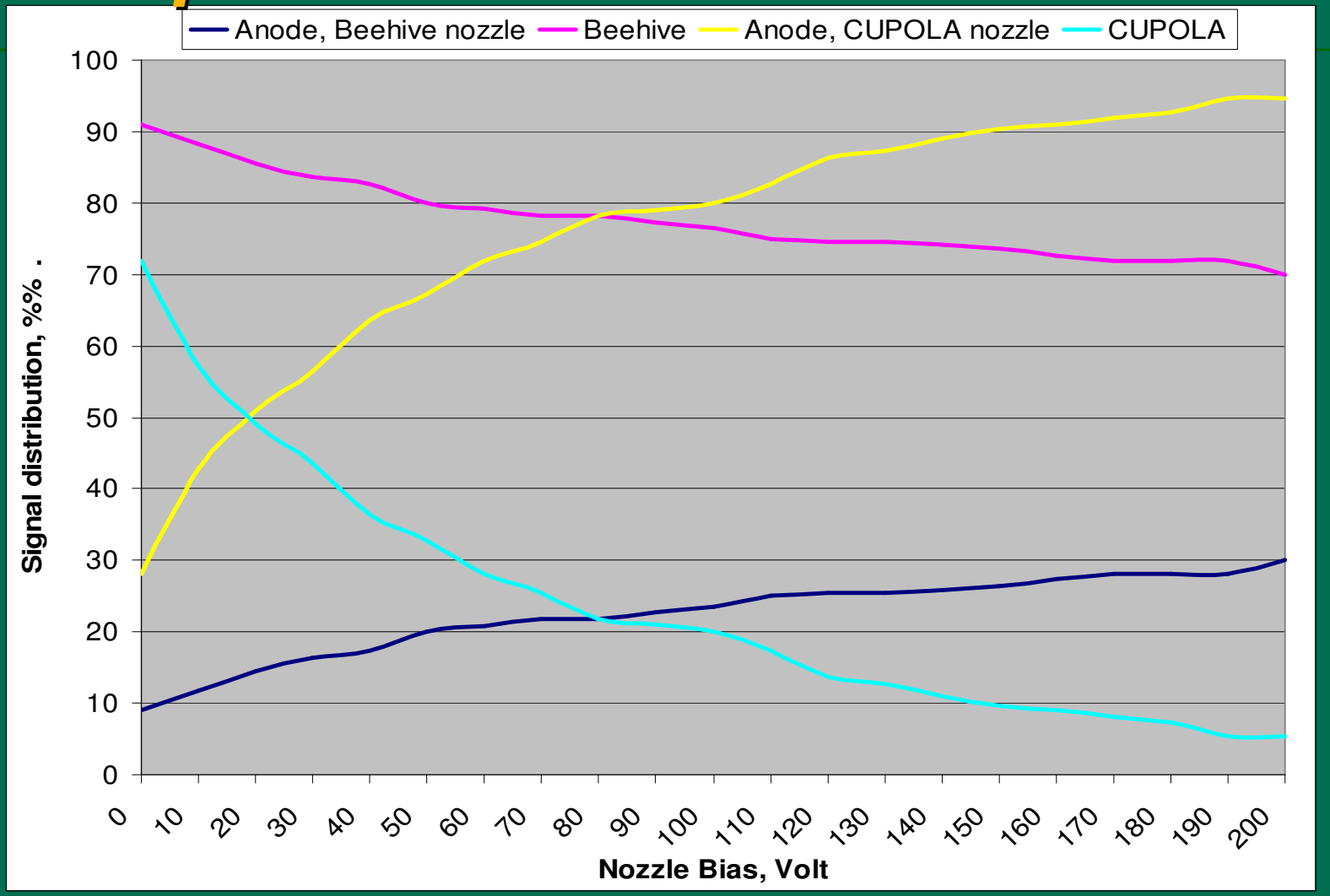
"Cupola" nozzle biased +200V transmits 94.5% of secondary electrons.



Same 2 mm width of bottom opening is simulated for both nozzles.

"Beehive" nozzle biased +200V transmits 30% of secondary electrons.

Electron-Optics Simulations of "*Cupola*" and " *Beehive*" Nozzles



Conclusions

1. Proposed virtual processing chamber concept and "*CUPOLA*" nozzle geometry provide viable advancement of gas delivery techniques for charged particle beam processing apparatus. The concept is equally applicable to Focused Ion Beam (FIB) and Focused Electron Beam (FEB) systems.

2. Secondary electron trajectory simulations of "*CUPOLA*" geometry suggest that ~80% of the signal could be extracted through the "*CUPOLA*" under 100V positive bias conditions, a X4 improvement comparatively to the existing "*Beehive*" nozzles.

3. Secondary electron trajectory simulations suggest that a significant fraction of the secondary electrons are absorbed by the gas delivery nozzles and sets a basis for experimental investigation of possibility to monitor the nozzle current for the purposes of detecting material-dependent transitions in a secondary electron emission.