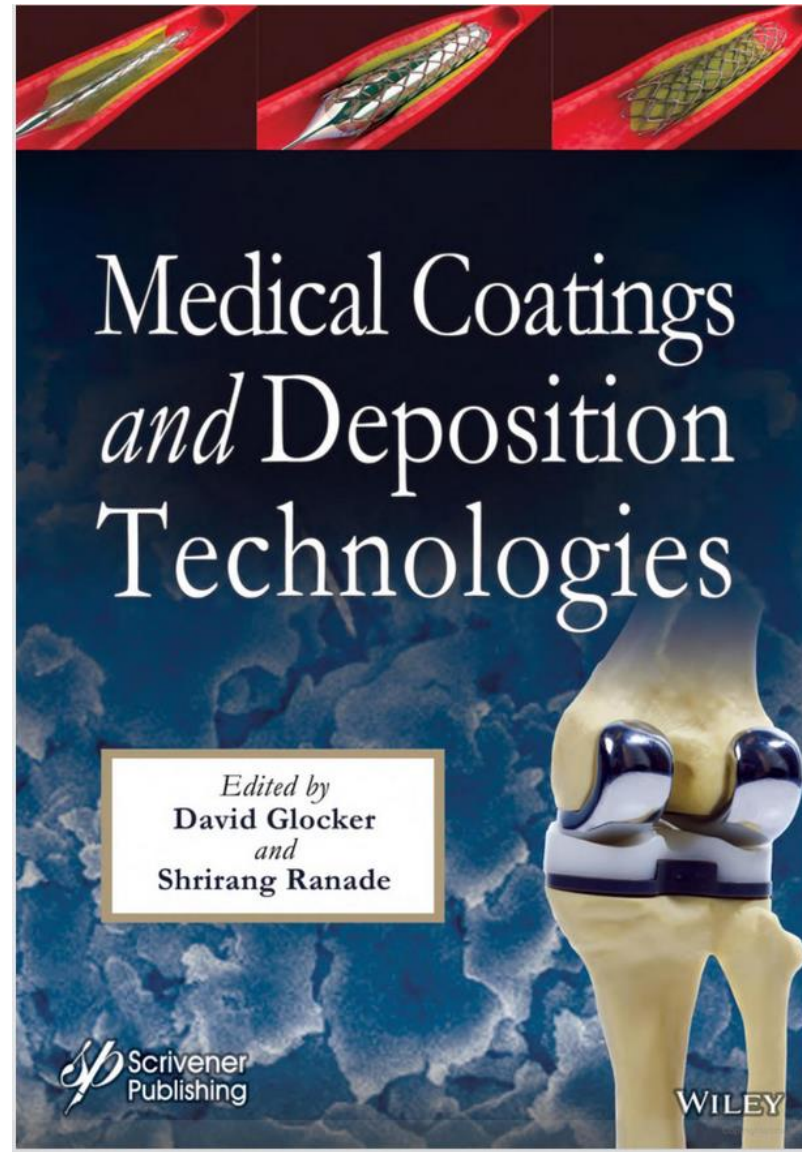


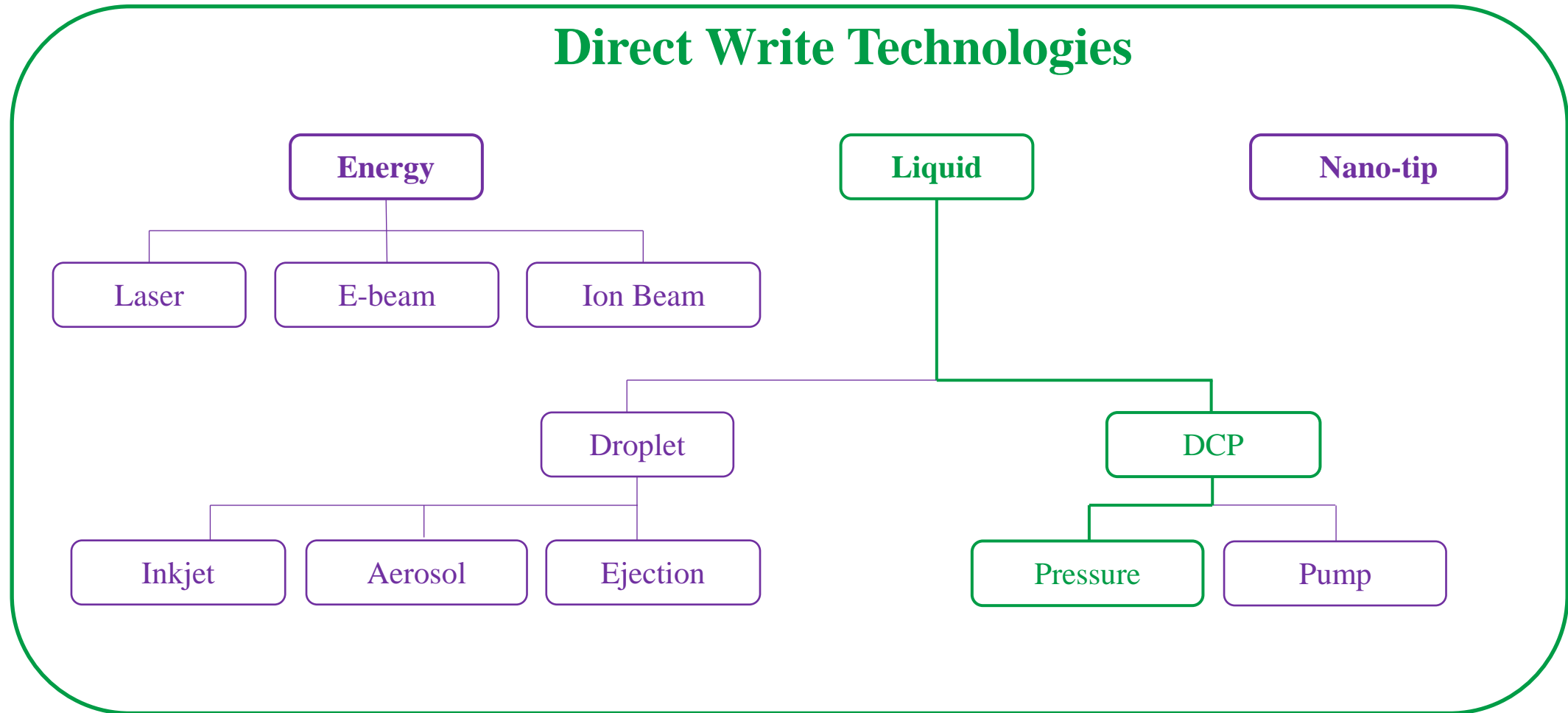
# DIRECT CAPILLARY PRINTING FOR COMMERCIAL DEVICE MANUFACTURE

Dr. William J. Grande  
CTO & VP & BDM

- Introduction to Direct Capillary Printing (DCP)
- Introduction to Exxelia Micropen
- Product Examples
  - Thick Film Resistors
  - Medical Devices
  - Instrumentation

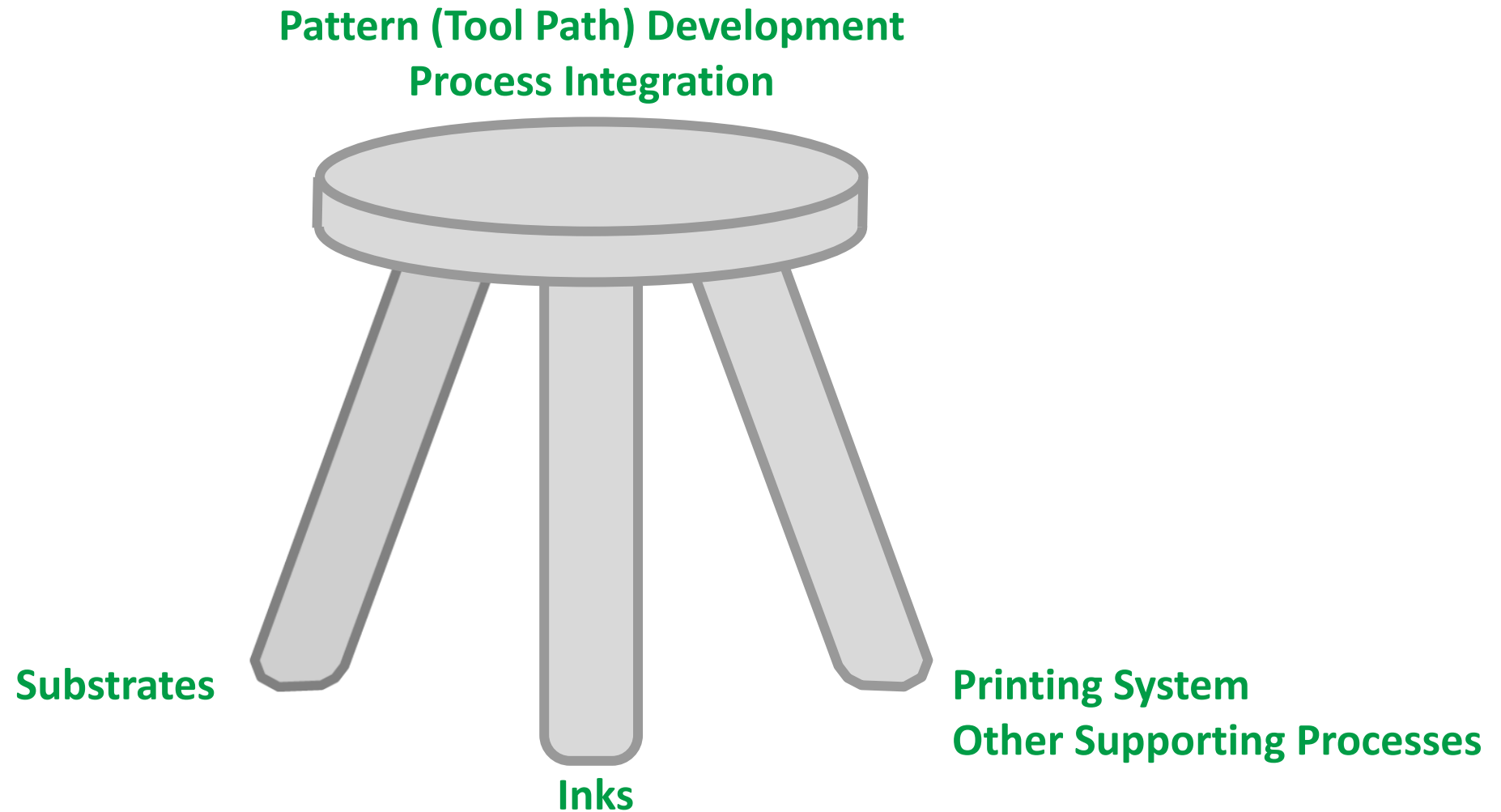


# Direct Capillary Printing

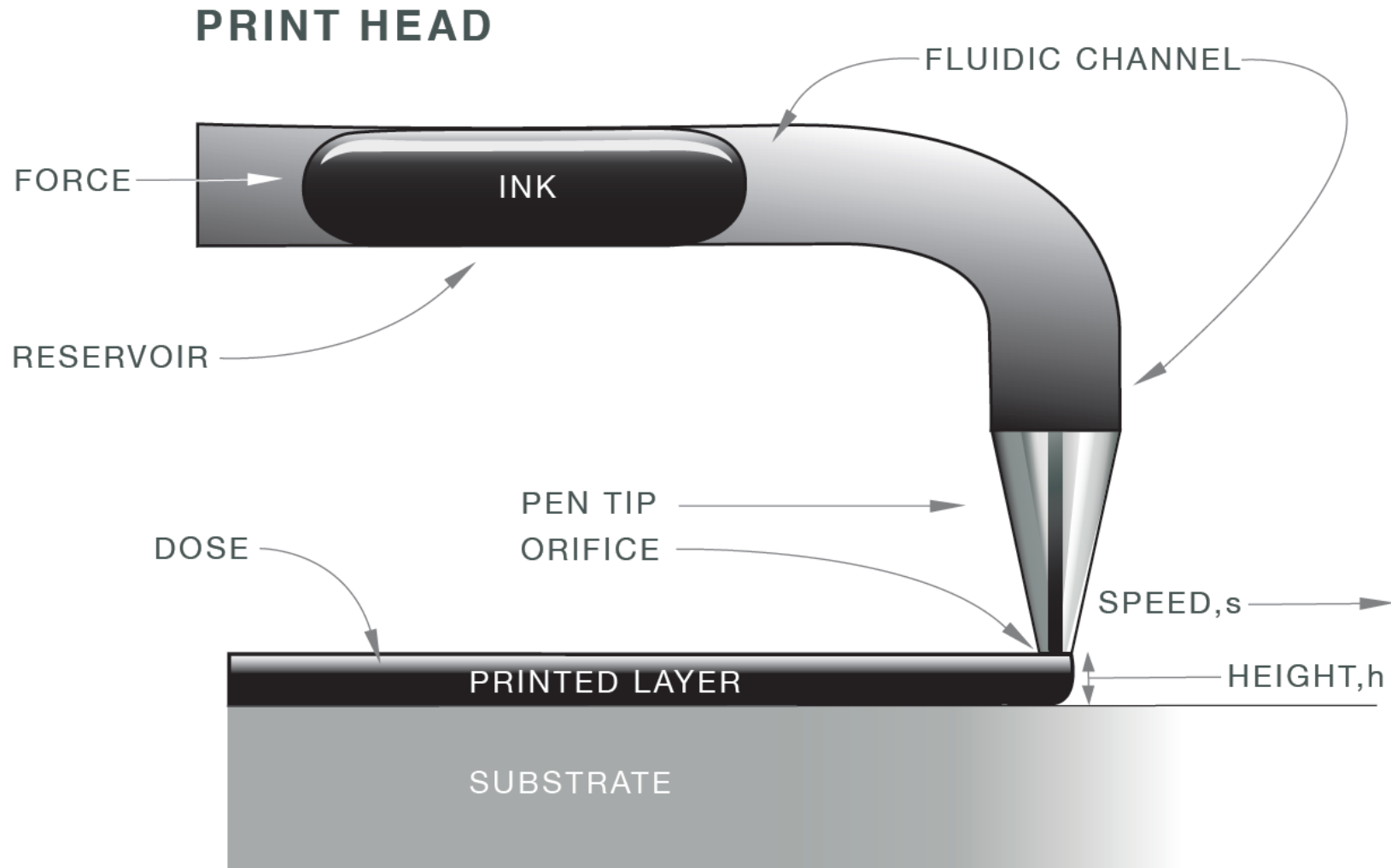


# Successful Products

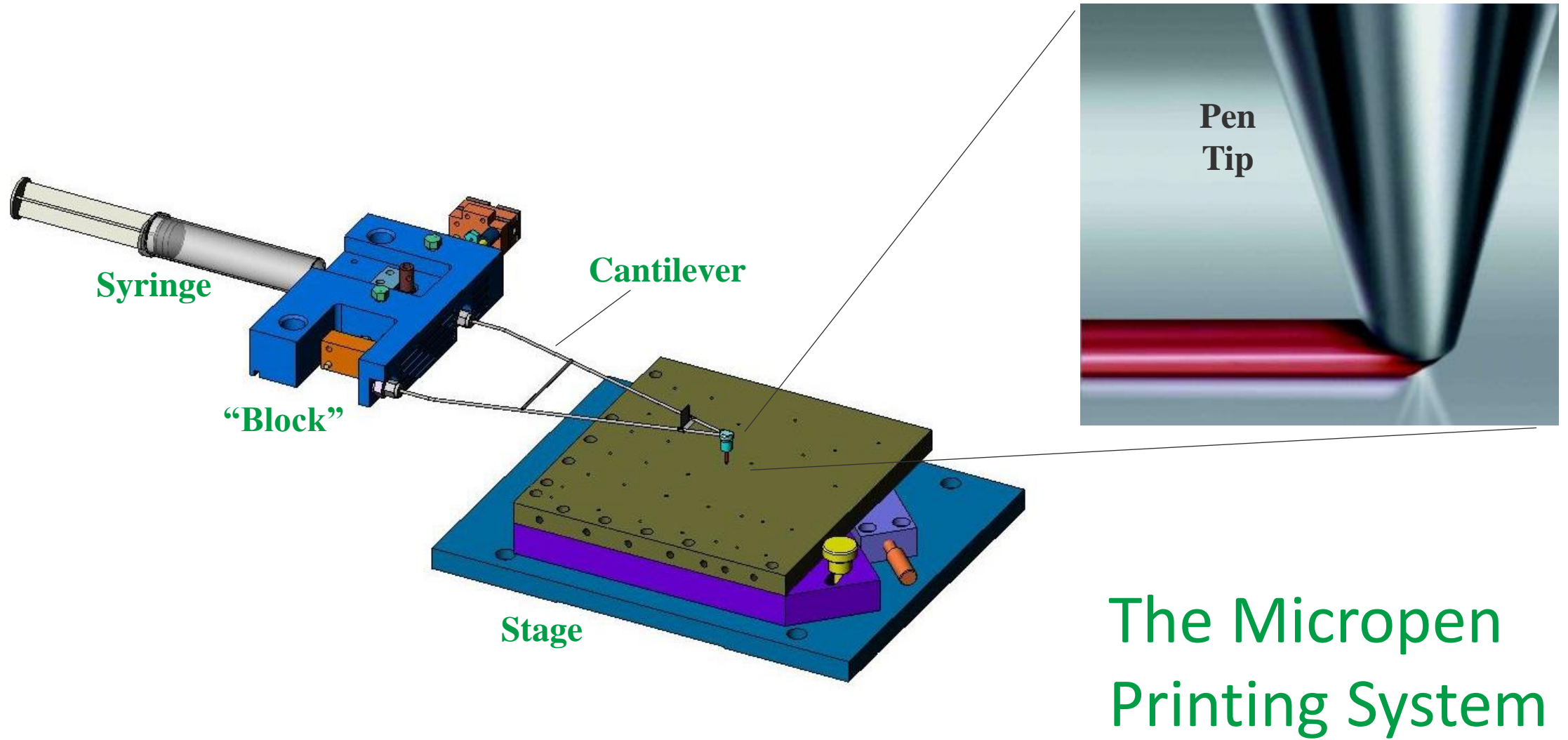
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# Direct Capillary Printing



# Direct Capillary Printing



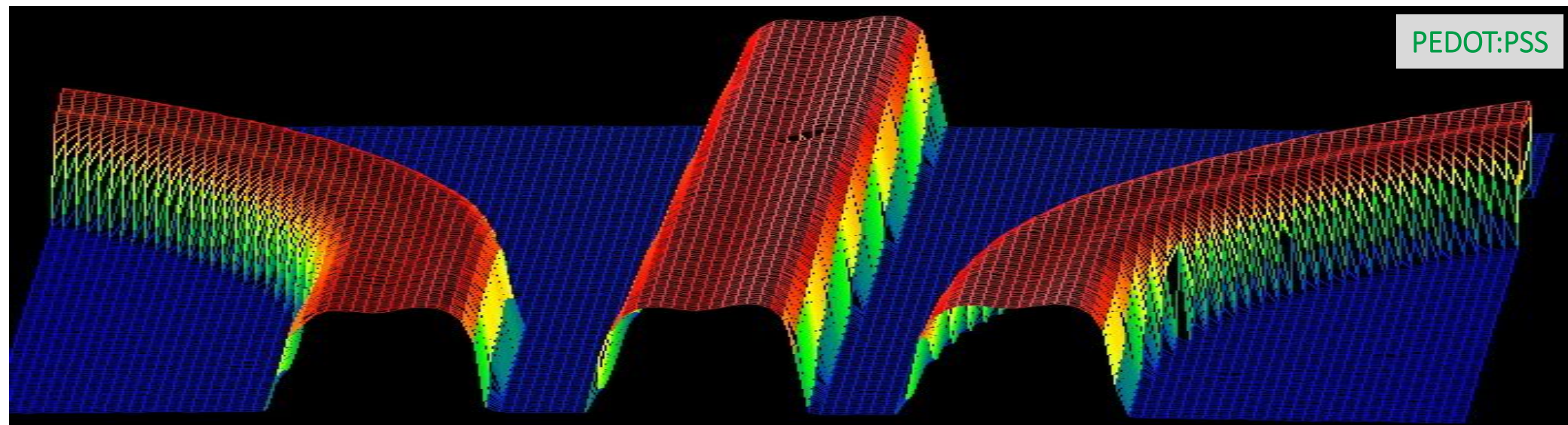
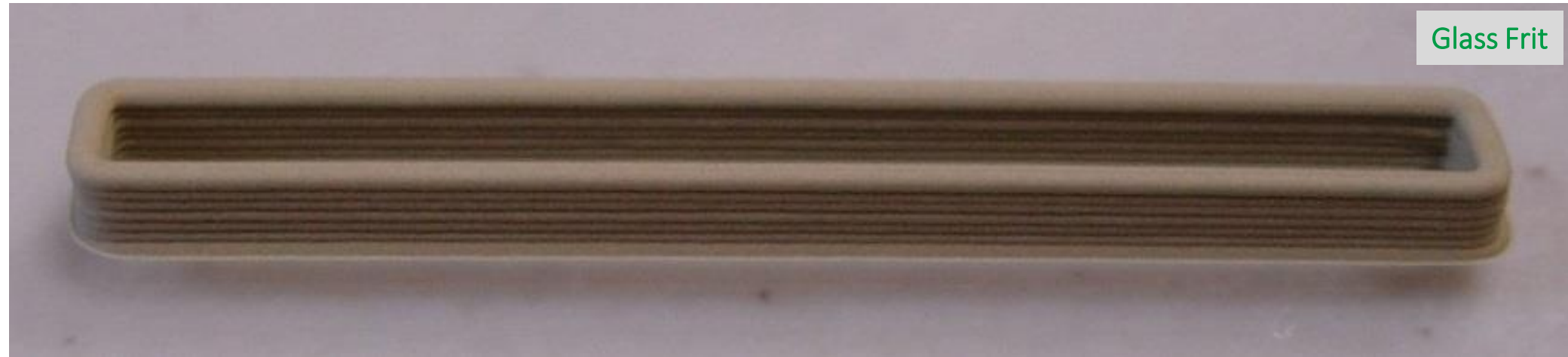
# Common Questions About Direct Capillary Printing

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- How thick?
- How narrow?
- How uniform?
- How expensive?

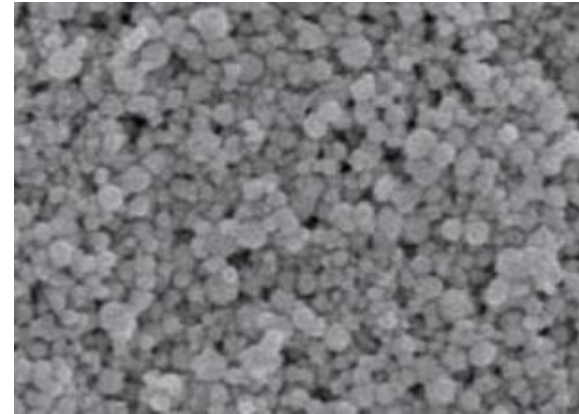


# Direct Capillary Printing – How Thick?

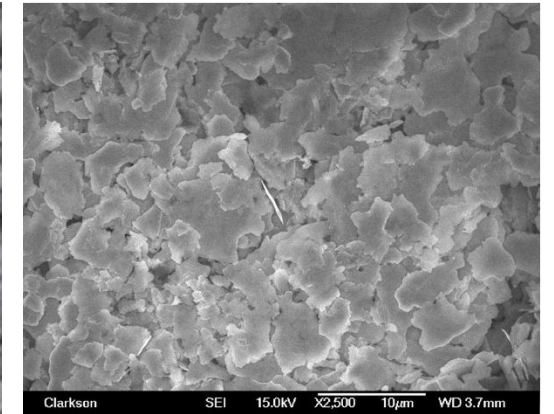


# Direct Capillary Printing – How Narrow?

- Depends on the particle size distribution of the ink



Refractory Ink  
Spherical Particles  
3 – 5  $\mu\text{m}$  diameters



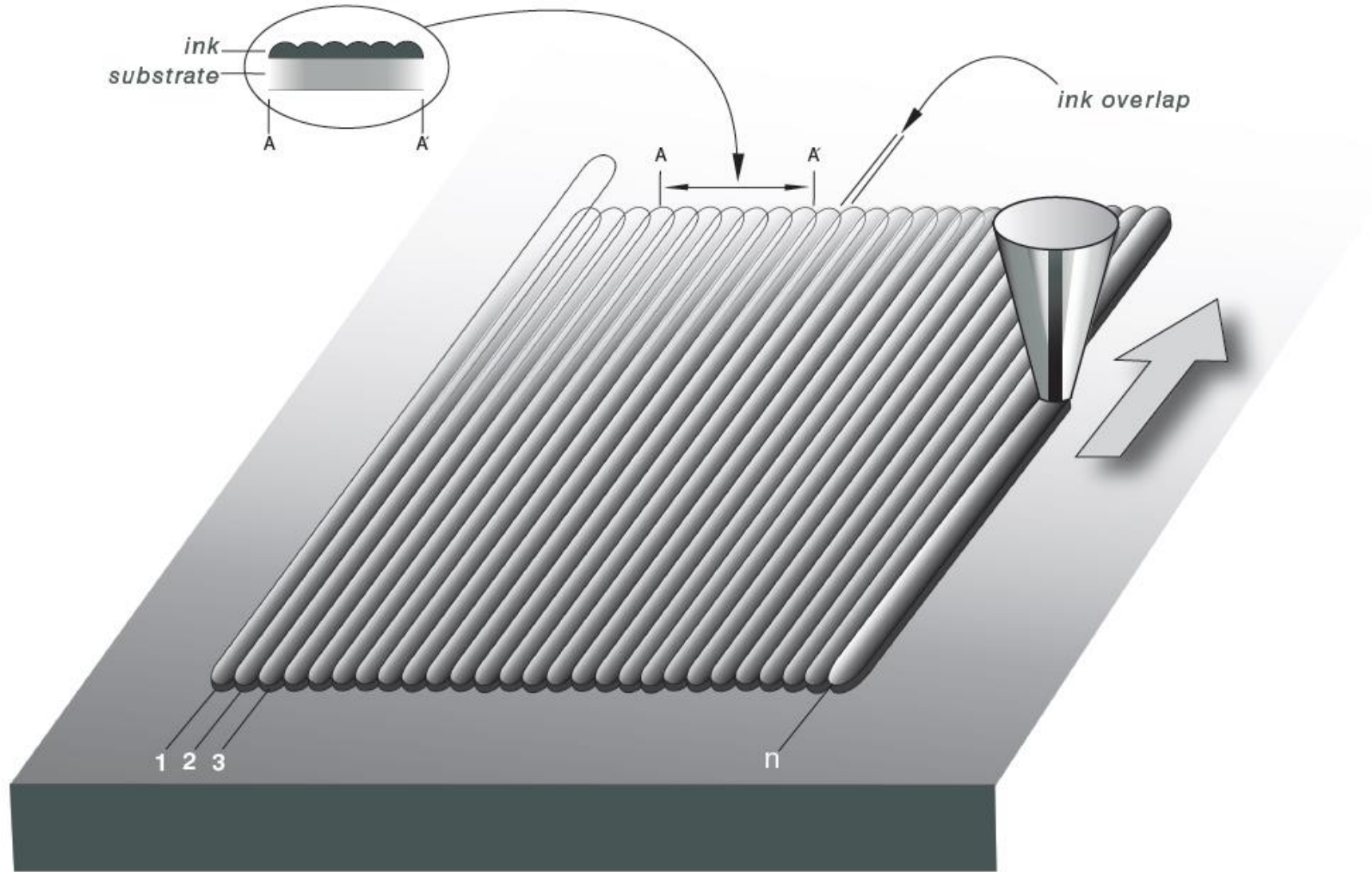
Low Temperature Polymeric Ink  
Flakes  
5 – 20  $\mu\text{m}$  major diameters

- Limited by the practical interactions between an ultra-fine pen tip and the substrate
- Our experience at Micropen

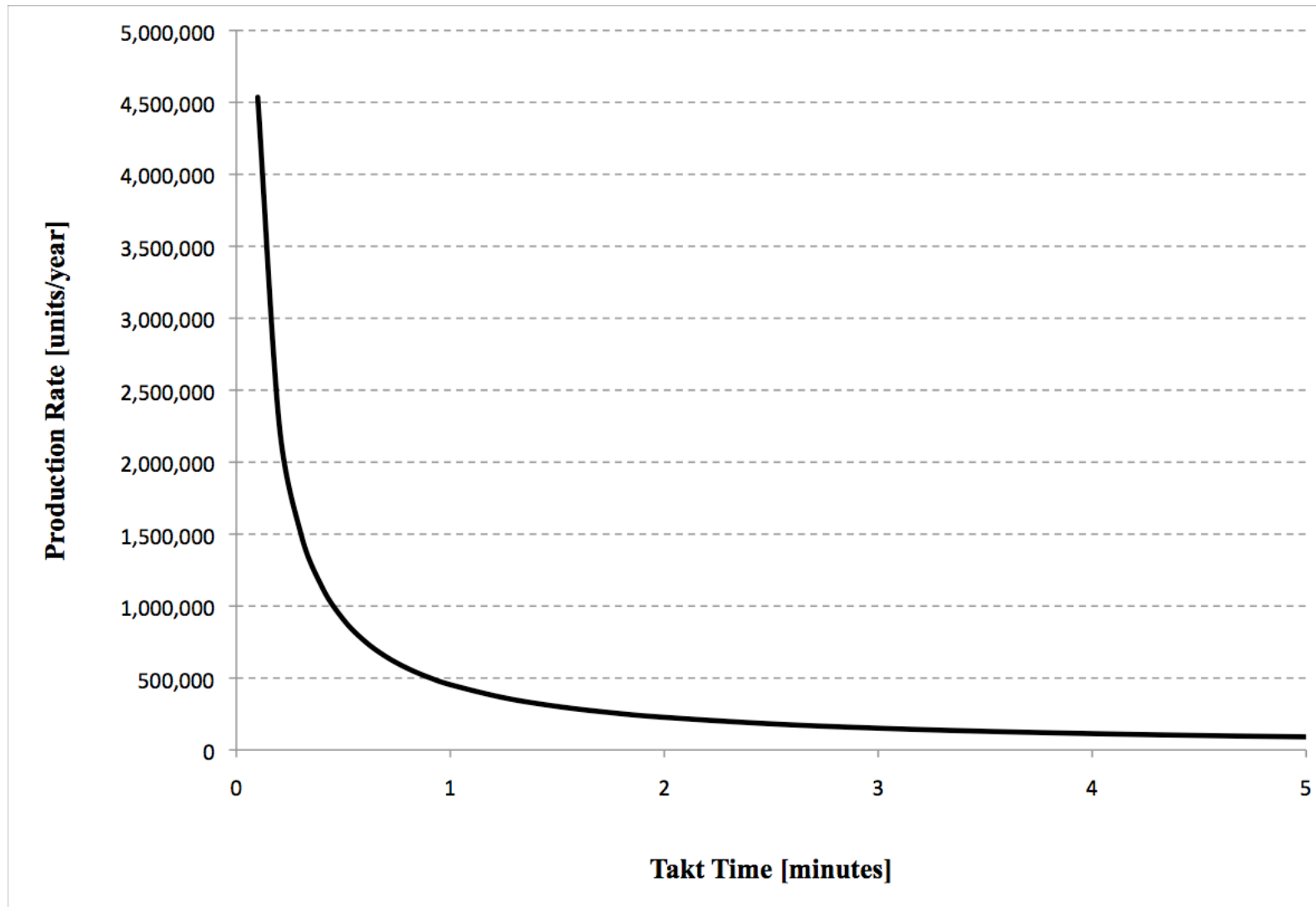
Hero Experiment: approximately 20  $\mu\text{m}$  with nanoparticle Ag ink

Practical Manufacturing: approximately 50 – 75  $\mu\text{m}$  linewidth and 25  $\mu\text{m}$  spaces with refractory inks

# Direct Capillary Printing – How Uniform?



# Direct Capillary Printing – How Expensive?





# Introduction to Exxelia Micropen

- Micropen Inc. founded in 1982
- Acquired by Exxelia Group in 2019
- 80 employees
- 2 Business Units
- Exxelia Ohmcraft Division – Custom Thick Film Resistors
  - End-seller (Inside Sales, Reps, Distributors) and Private Label Manufacturer
  - Markets: Medical, Space/Military, Instrumentation, Power Supply
- Exxelia Micropen Division – High Value Components and Sub-Systems
  - Contract R&D, Product Development, and Manufacturer
  - Markets: Medical Devices, Test & Measurement, Instrumentation
- 40K ft<sup>2</sup> facility on 11 acres – owned, single location
  - 7K ft<sup>2</sup> clean manufacturing space
  - Selective humidity-controlled manufacturing space
  - 10K ft<sup>2</sup> light manufacturing space



# Introduction to Exxelia Micropen



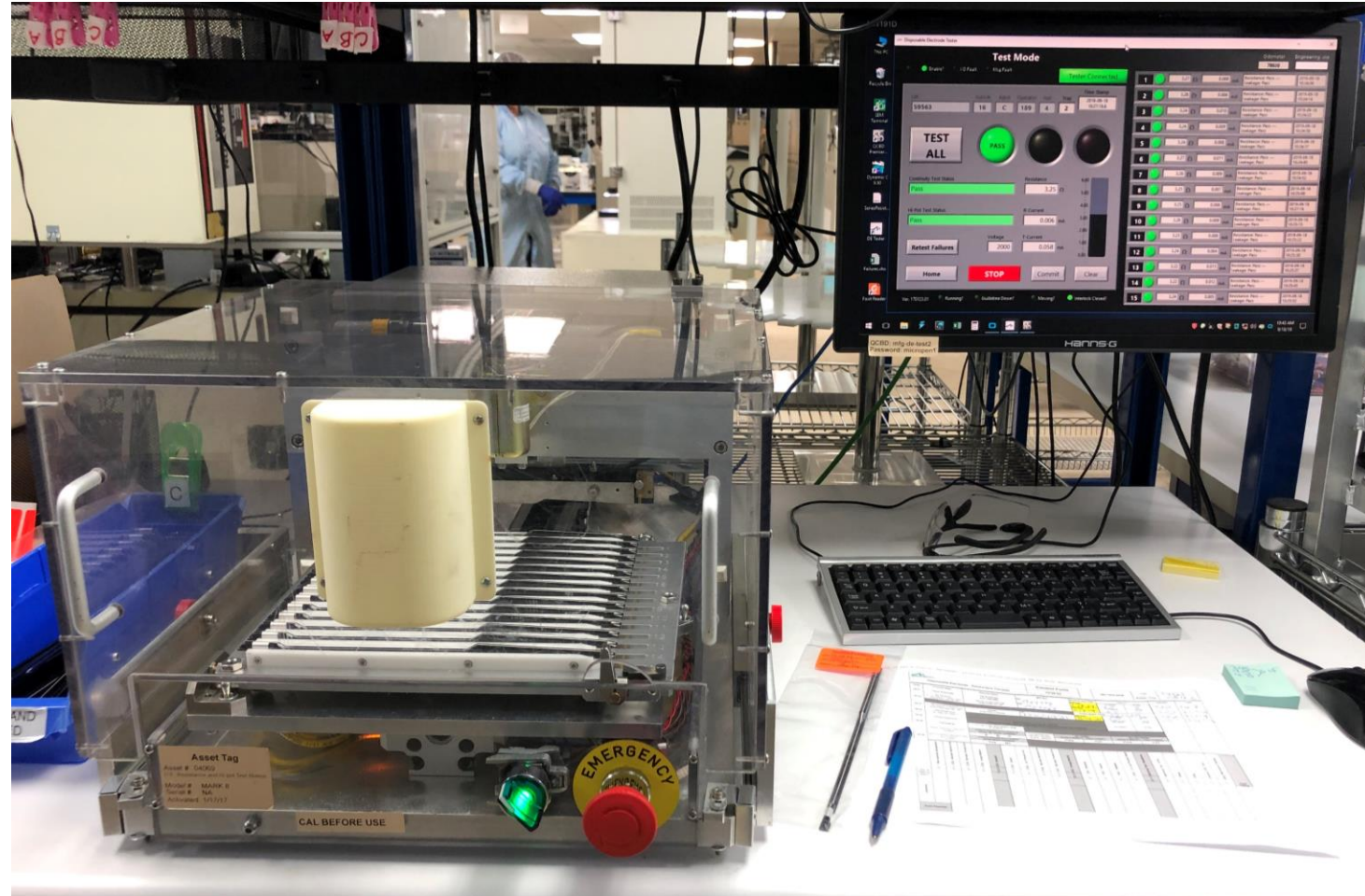
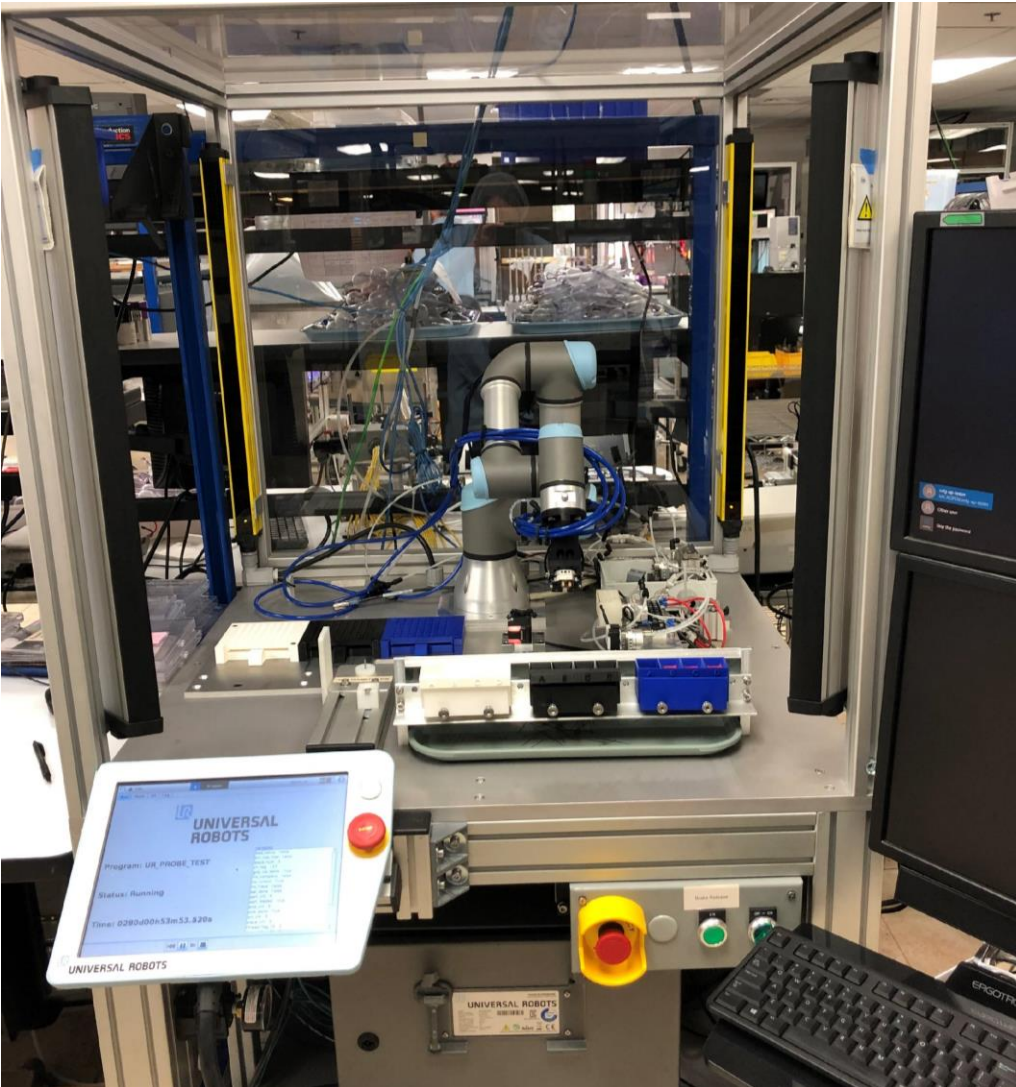


# Introduction to Exxelia Micropen





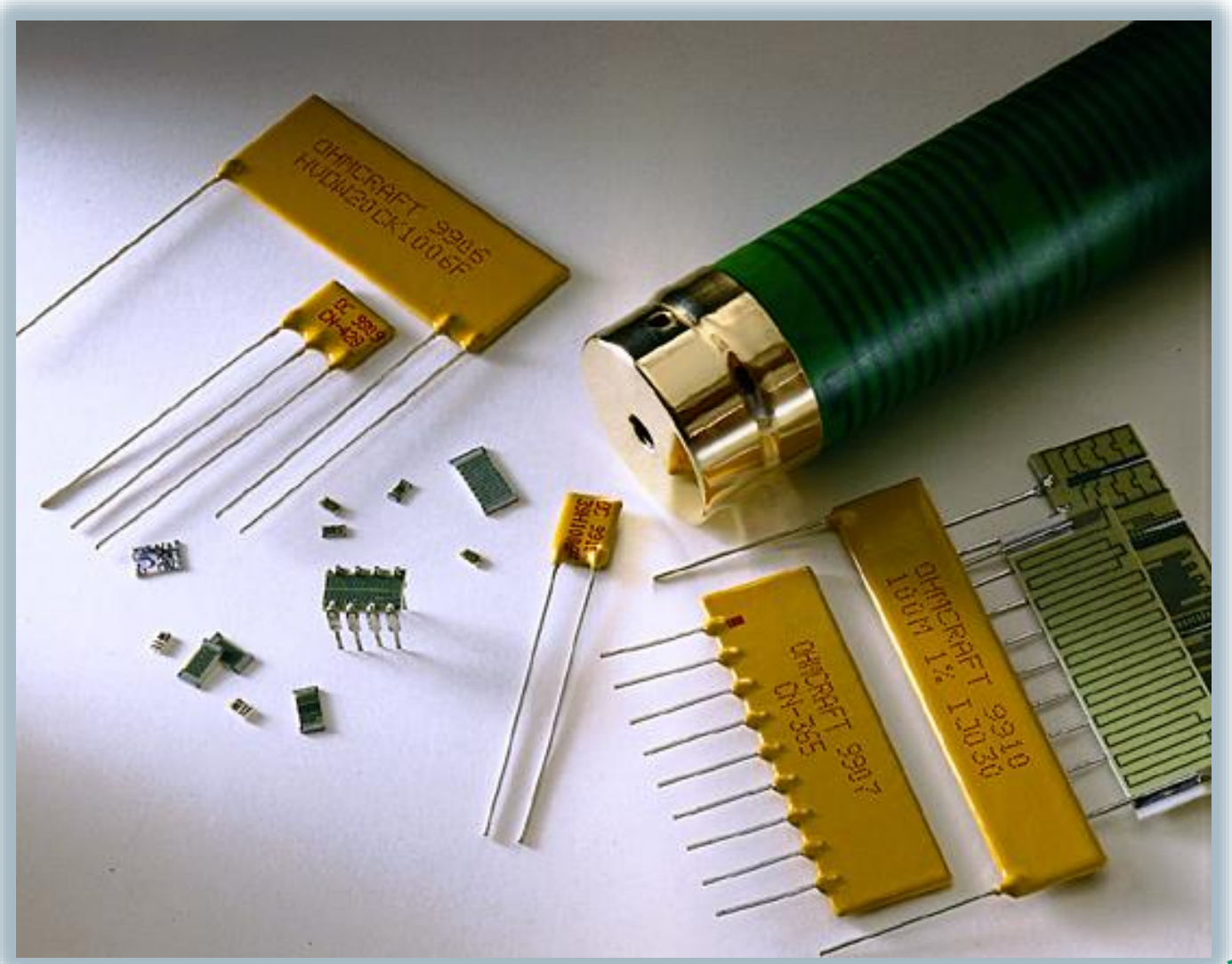
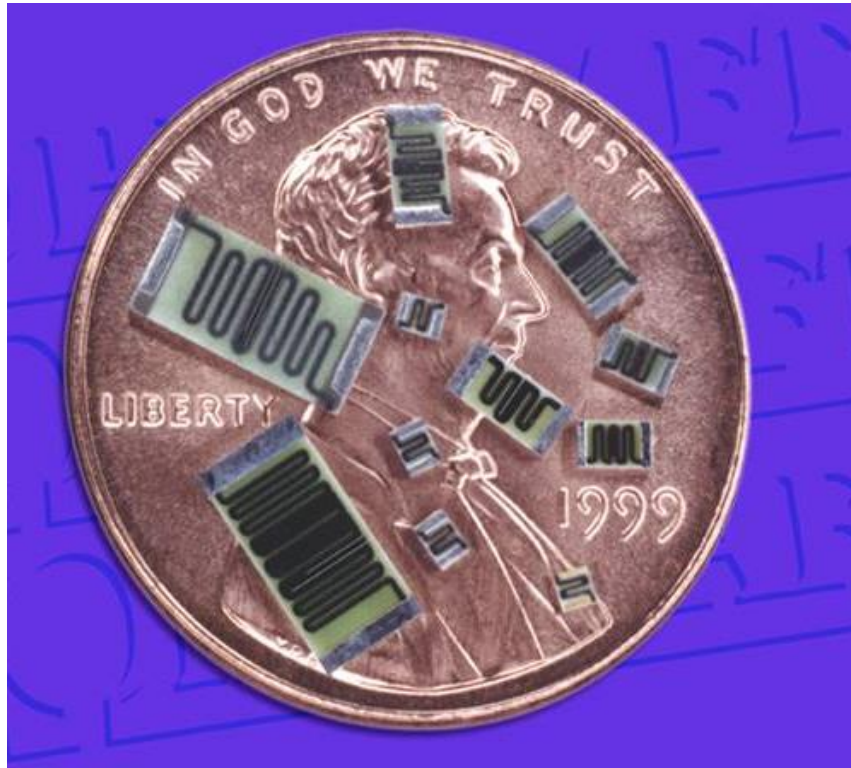
# Introduction to Exxelia Micropen





## Printed Thick Film Resistors

# Exxelia Ohmcraft Resistors



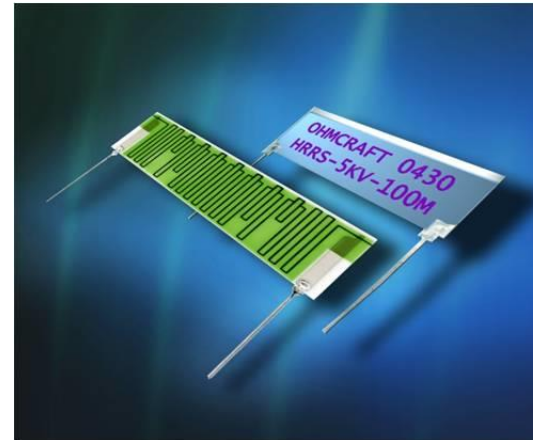
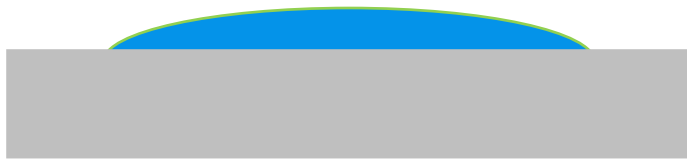
# Exxelia Ohmcraft Resistors

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- *High Voltage*
- *High Ohmic Value*
- *High Precision*
- *Low Noise*
- *High Energy Pulse Dissipation*
- *Fast Lead Times*
- *Customized Properties*
  - *Physical Dimensions*
  - *R, TCR, VCR, Operating Voltage*
  - *Termination Style*
  - *Packaging*

# Advantages of DCP for Resistors

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- *High heat transfer to the substrate*
- *Use of low resistivity inks and long path lengths*
- *Passivated surface states/favorable grain structure (?)*

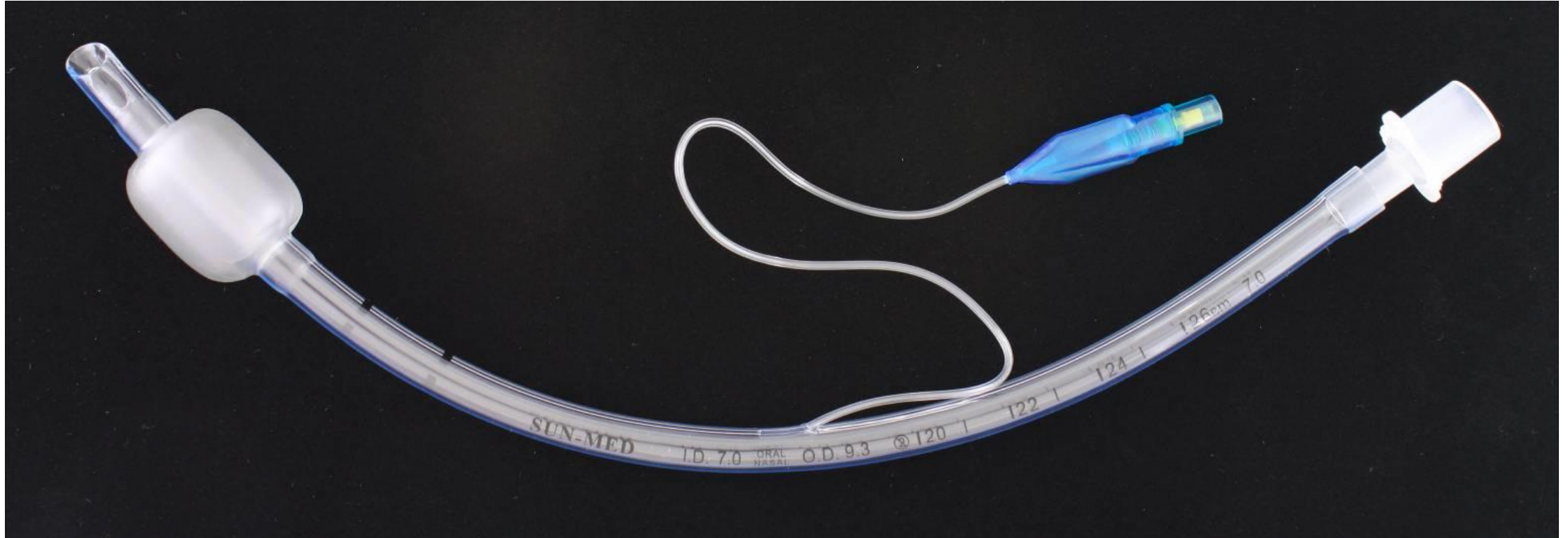
# Product Examples

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## Medical Devices

# Endotracheal Tubes

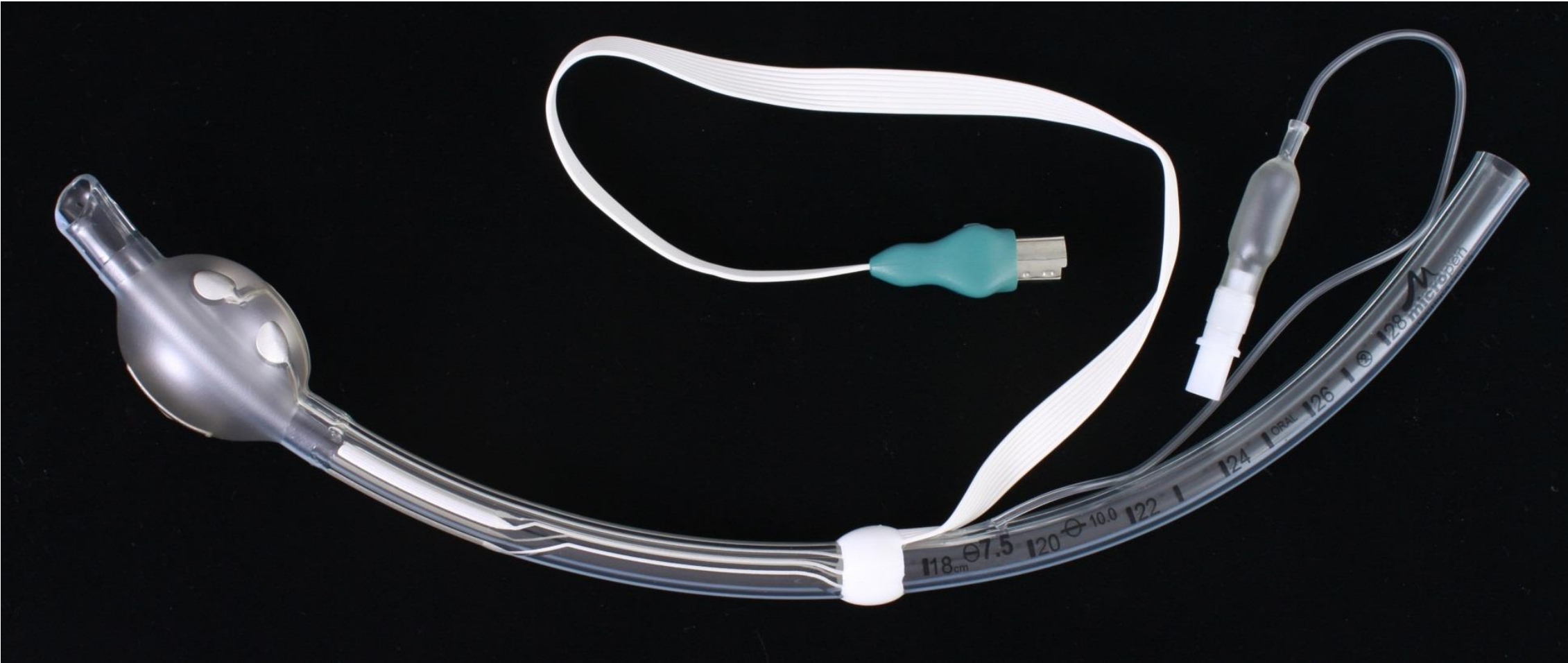
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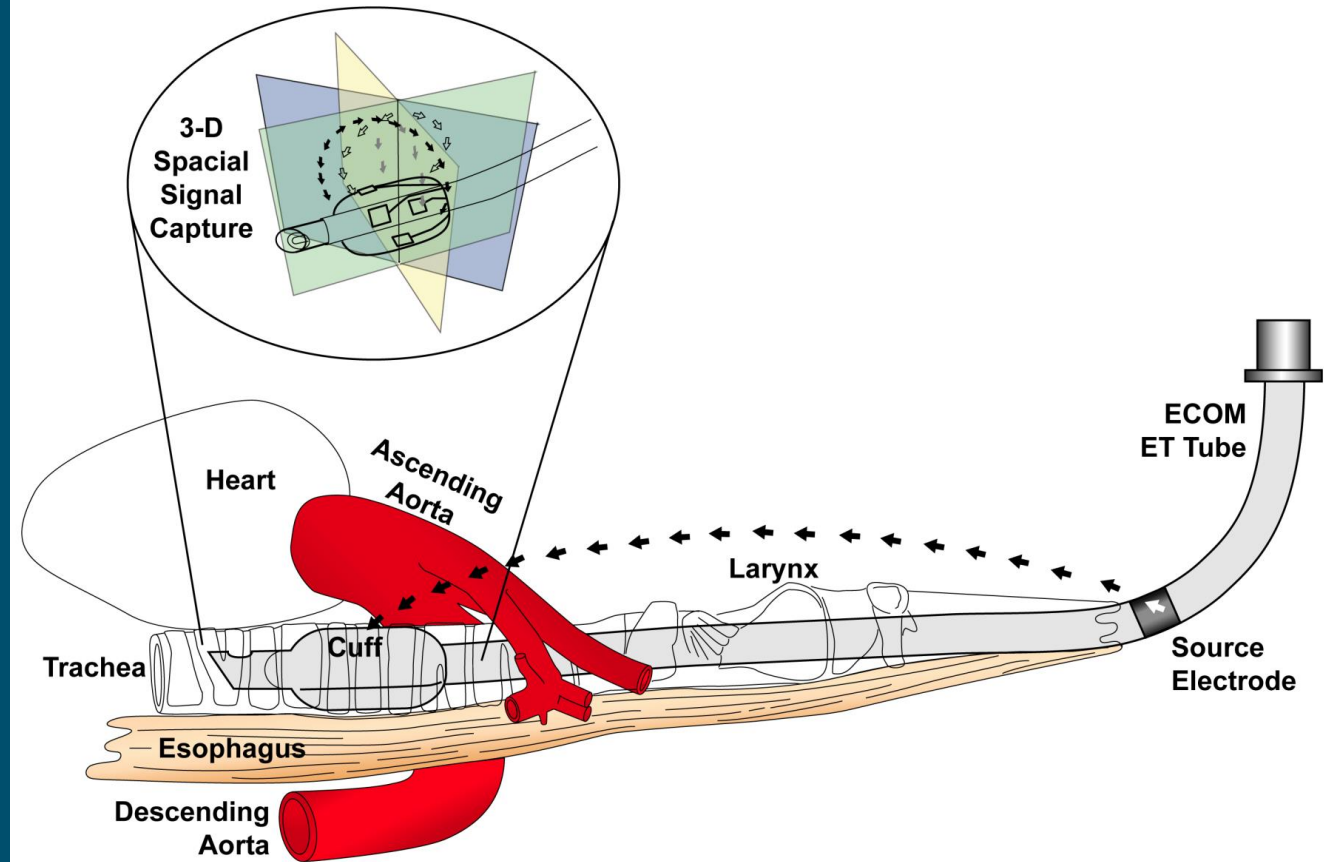
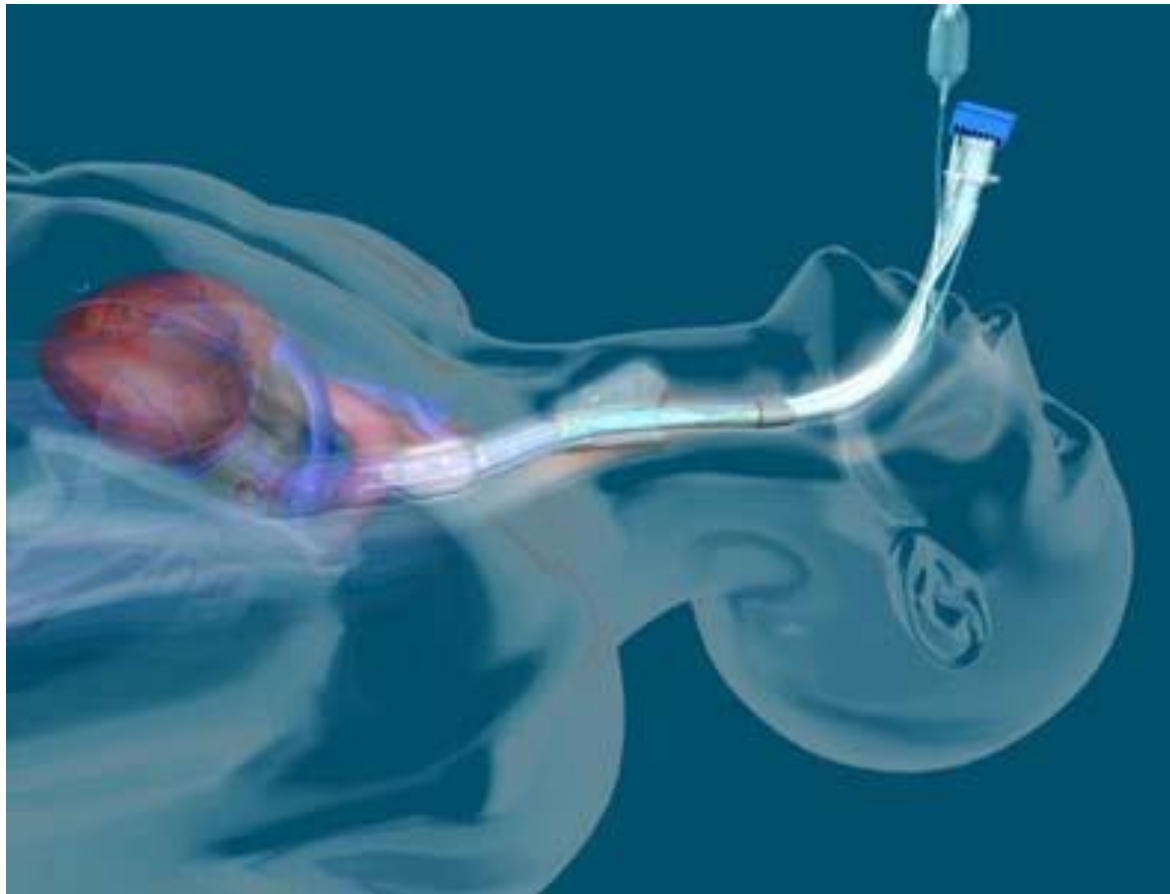


*Standard Endotracheal Tube*



# Directly Printed ET Tube





**Endotracheal Cardiac Output Monitoring (ECOM) Tube**

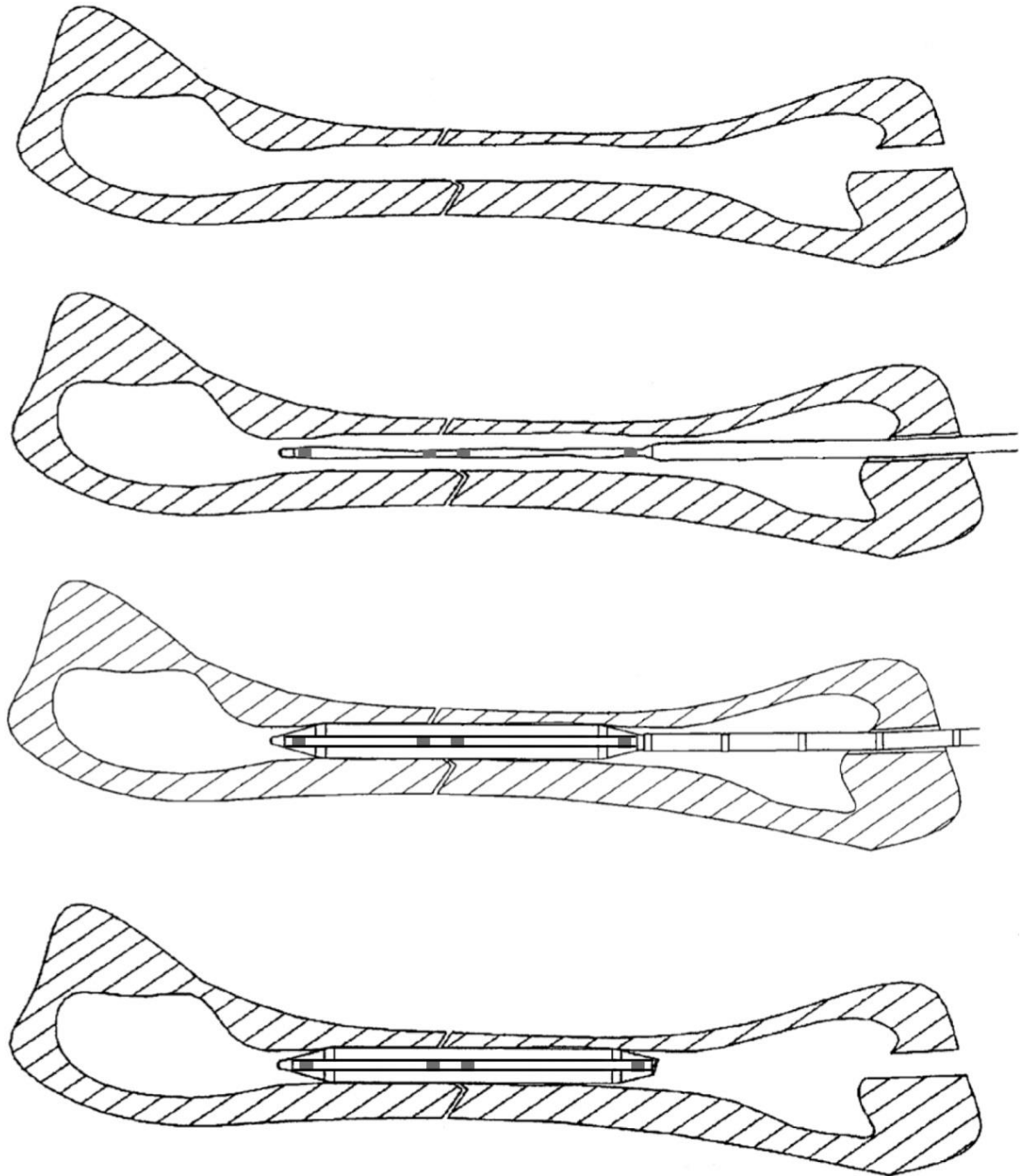
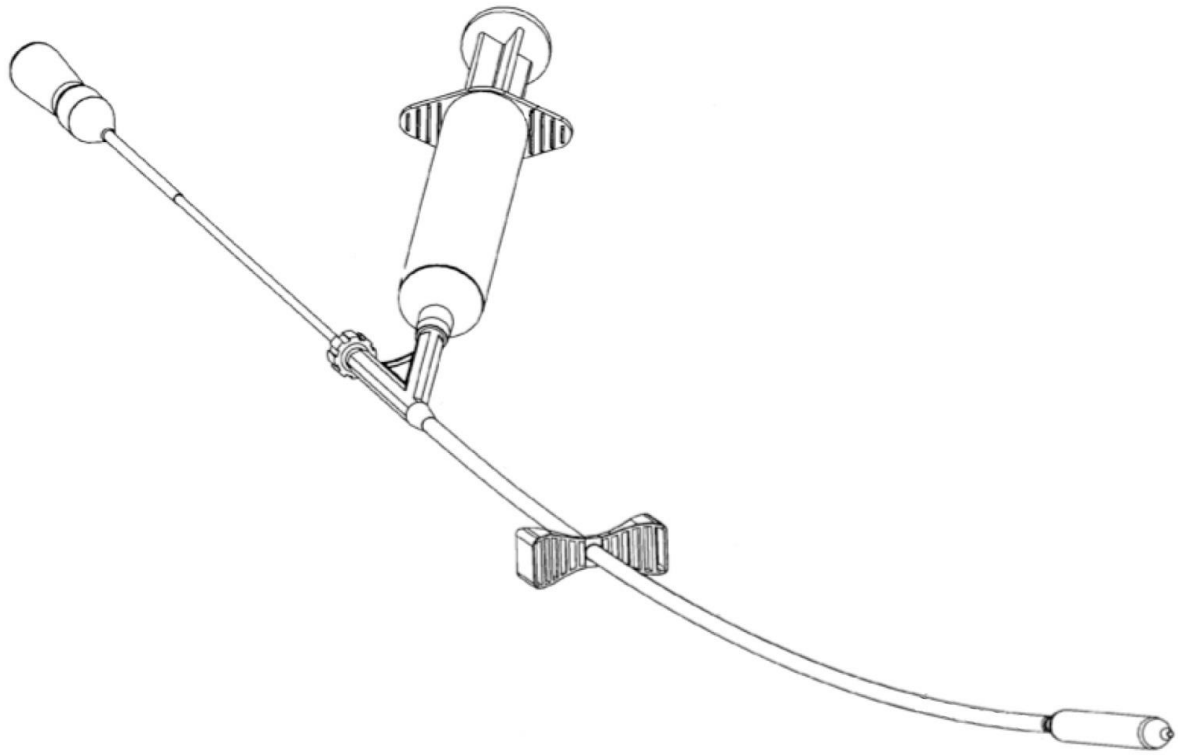


## A Brief History ...

- |                                |                |              |
|--------------------------------|----------------|--------------|
| • Splint                       | Unknown        | 1500 BCE (?) |
| • Metal Nail for Hip Fractures | Smith-Peterson | 1925         |
| • Intramedullary Nail          | Küntscher      | 1939         |
| • Intramedullary Balloon       | IlluminOss     | 2015         |

# Medical Devices

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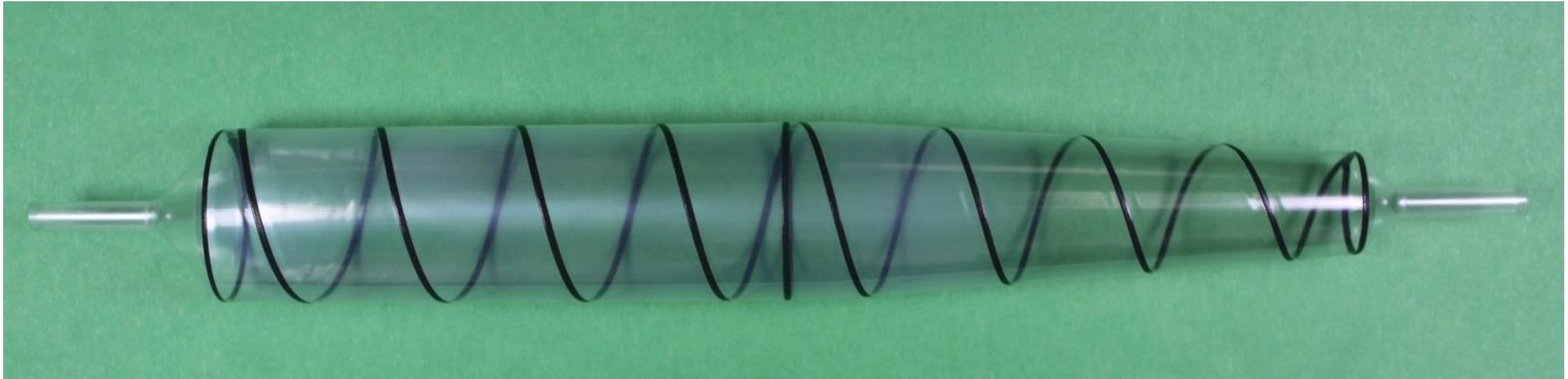


# Medical Devices



# Medical Devices

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# Medical Devices

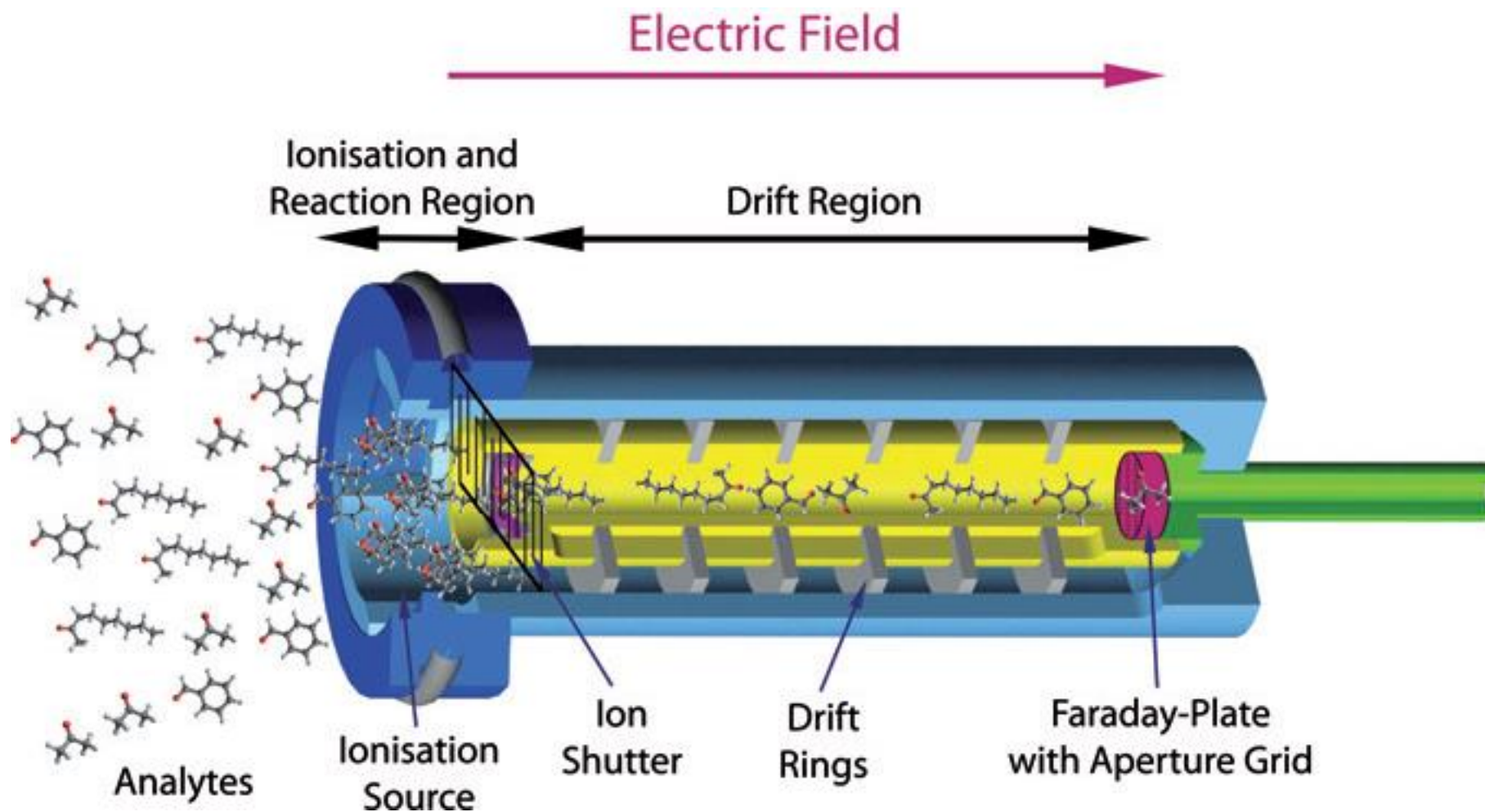
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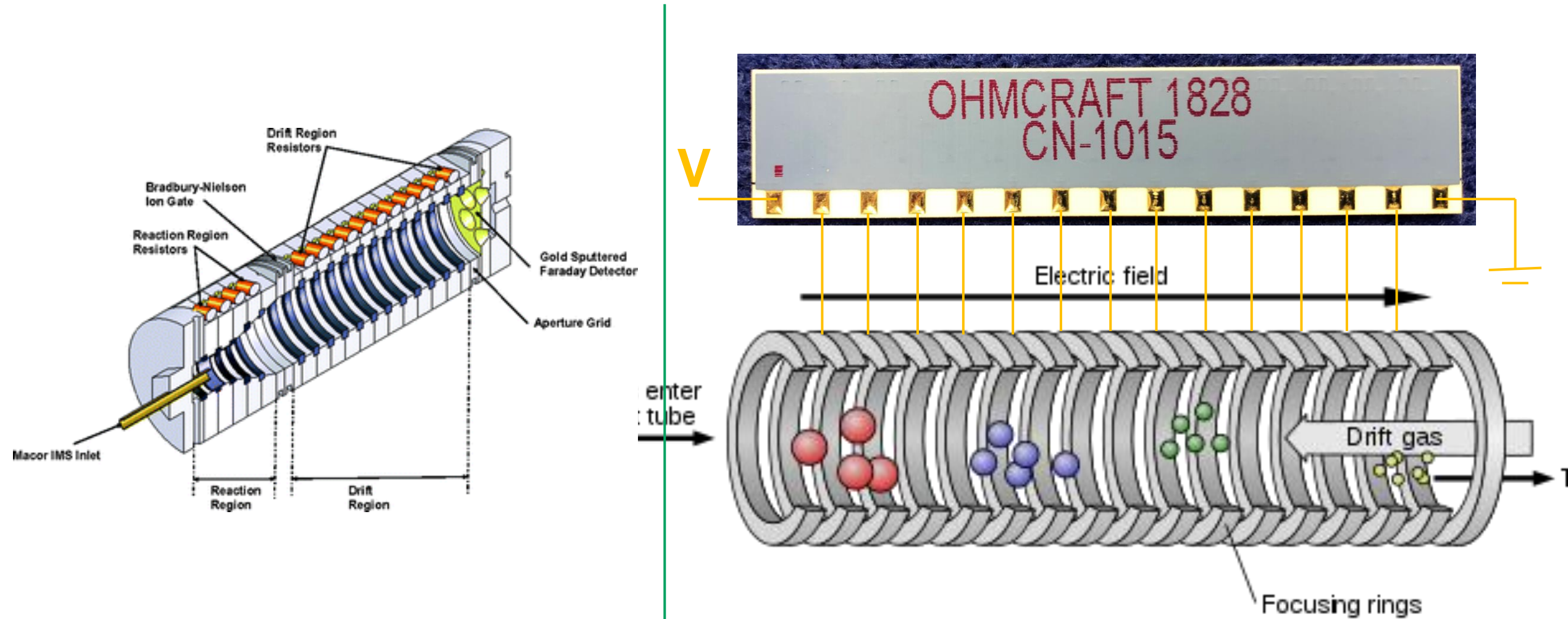
## Instrumentation



# Ion Mobility Spectroscopy



# Ion Mobility Spectroscopy





# IMS Drift Tube

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# Summary

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- DCP is conceptually simple but challenged by many practical considerations
- Finding suitable applications for DCP is not simple and often rests upon a geometric or functional requirement that precludes the use of more traditional manufacturing techniques
- DCP is just one of many processes and skills required to create a sustainable, successful business



Contact Information

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