DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

GROUP 04

Abdullah Alhadlaq
Abdulrahman Aljedaibi
Mohammed Kassab
Mohammed Nasser

Alentic microscience

*Department of Electrical & Computer Engineering*

# Development of an Electrostatic Nanoprinter

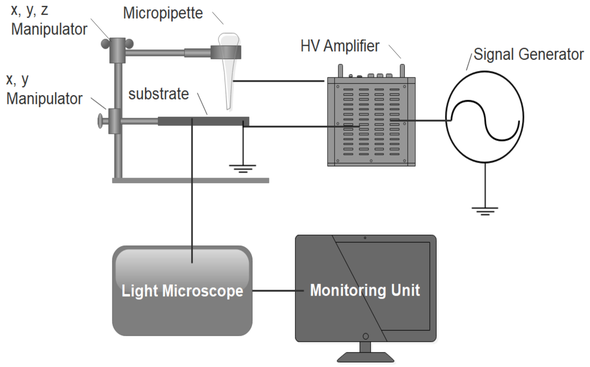
## Abstract

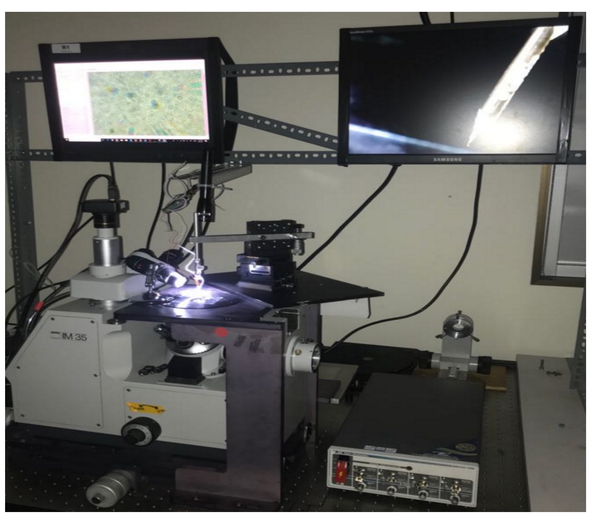
Nanotechnology's potential is restricted by its difficult and expensive fabrication methods. The electrostatic nanoprinter assembled by the team creates useful nanostructures using less expensive techniques without significant performance compromise.

## Project Description

The main objective is to develop a printer capable of producing nanostructures on conductive surfaces. The client supplied a detailed article that features methods to assemble a nanoprinter with promising results. Other promising usage of this technology is to print on non-conductive substrates such as live tissues. This project is a step towards the client's goal of printing structures using organic material. This technology can advance fields such as medicine, electronics, and biophysics.

## Setup



## Theory

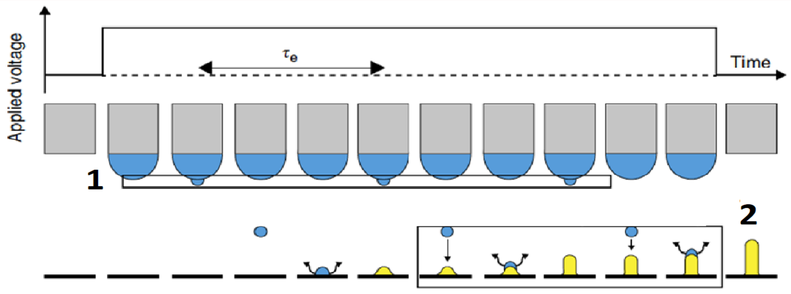



Figure: Adapted from Galliker et al., 2012

Driving principles:

1) ElectroHydroDynamic Ink Ejection: utilizes the electric field force to release charge carrying ink droplets from a tiny pipette nozzle (~1µm tip diameter).

2) Electrostatic Nanodroplet Autofocusing: focuses droplets on top of each other since the already printed structure is grounded with respect to the incoming charged droplet.

## Methods

### Preparation of Components

| Pulling Pipette | Coating Pipette | Mixing Ink | Wiring |
|---|---|---|---|
| Glass capillaries are heated and pulled to form nozzle diameter of 1µm.  | Coated with 10 nm of Ti followed by 100 nm of gold.  | Nano-ink mixed with a hydrocarbon solvent to create a ~ 0.1% volume concentration ink. | Thin wires are glued to substrate and pipette using epoxy conductive glue. |

### Nanoprinter Component Assembly

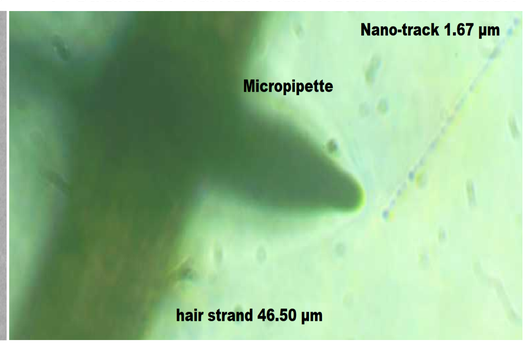
- Align coated pipette vertically on printing surface.
- Connect the pipette and printing surface to the amplifier via pre-connected wires.
- Calibrate the distance between the pipette and surface to achieve 1-5 µm separation.
- Apply voltage up to 400V to eject ink and move pipette to shape the nanostructures.

## Results

Printed structures of different sizes by varying parameters such as voltage and distance.

The word "DAL" printed using gold particles

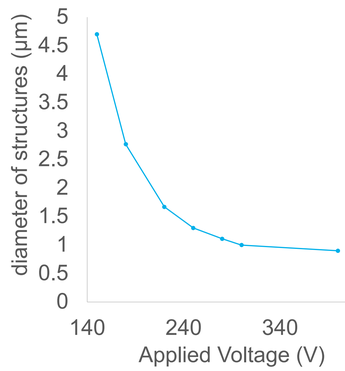
A strand of human hair next a nano-track

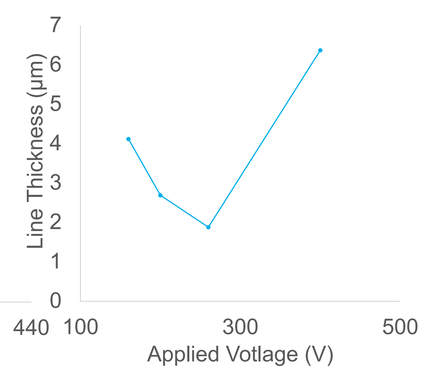



## Discussion

Relationship of parameters responsible for shape construction:

- Voltage:
  ↑ voltage ↓ structure size
- Nozzle diameter:
  ↑ diameter ↑ structure size
- Vertical distance:
  ↑ distance ↑ scattering
- Ink concentration:
  ↑ concentration ↑ density ↑ clogging




These data points are obtained using 4.7 µm diameter pipette

## Conclusion

The team found solutions that the supporting article did not address such as calibrating the vertical distance. The finalized product is capable of printing down to the nano scale by producing <1 µm droplets satisfying the objective of this project. The printer can be used to create nano circuit lines or further enhanced to print organic compounds on different substrates.

## Acknowledgments

The team would like to thank the client, Dr. Fine, for providing the necessary components and for his support. Also, we would like to thank Mr. Goroshkov for his thoughtful conversations and supervision. We would like to thank Dr. Ma for her help and support. We would also like to thank Dr. Elsankary and Dr. Gonzalez for managing this project.

## References

Galliker, P. *et al*. Direct printing of nanostructures by electrostatic autofocusing of ink nanodroplets. *Nat. Commun.* 3:890 doi: 10.1038/ncomms1891 (2012)

Tse, L. (2018). Physics-Based Printhead Designs for Enhanced Electro hydro dynamic Jet Printing.