The D4Scope: A Novel Low-Cost Fluorescence Detector for Point of Care Diagnosis

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Introduction

We have previously developed a new, highly sensitive point-of-care (POC) test —the D4 assay— that can detect analytes from a single drop of blood with femtomolar sensitivity. However, the commercial microarray imaging detector—the Axon Genepix— that we have used to date for D4 fluorescent readout is bulky, expensive, slow, and not suitable for use at the POC. **To address this limitation, we have developed a handheld, battery-powered, low-cost fluorescence detector that can image fluorescent microarrays with high sensitivity.**

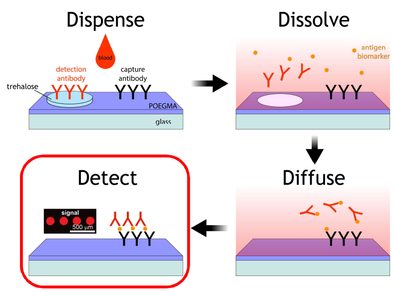


Figure 1: The four steps of the D4 immunoassay. All reagents are inkjet-printed onto a non-fouling polymer brush on glass. Each test requires 50 µL sample volume, 1 hour incubation time, and a wash step before readout.

Design Process and Fabrication

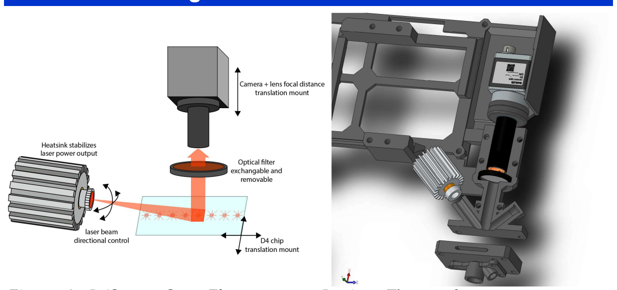


Figure 2: D4Scope Core Fluorescence Design. This configuration minimizes cost by forgoing a typical dichroic mirror, while maintaining high signal-to-noise, resolution, and field-of-view.

The detectors' fluorescence elements are set in an oblique angle laser excitation format. A 3-D printable housing was designed around these elements in a Solidworks assembly and 3-D printed on a Lulzbot Taz 6. The housing was designed for proper fit of all parts, portability, and durability.

SOLIDWORKS

Creality 3D

LULZBOT.

INNOVATION CO-LAB

Device Hardware

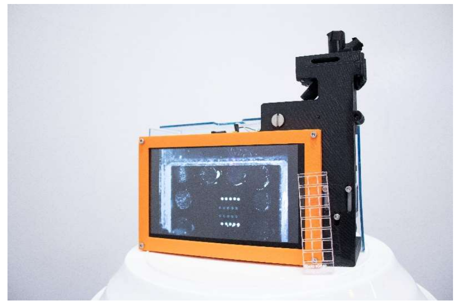


Figure 3: The Alpha D4Scope. The first fully standalone, handheld D4 detector made in-house. This detector was deployed for detection of Ebola virus at the Galveston National Laboratory's BSL4 lab in Texas on Ebola infected monkeys.

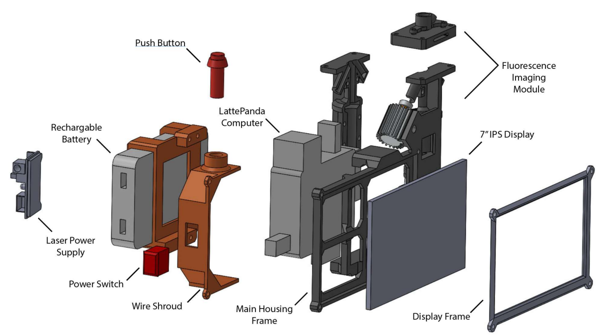


Figure 4: D4Scope Exploded View. All detector elements are designed and manipulated in Solidworks Assembly view. Total cost of parts ~1000 USD.

D4Scope Acquired Fluorescence Images

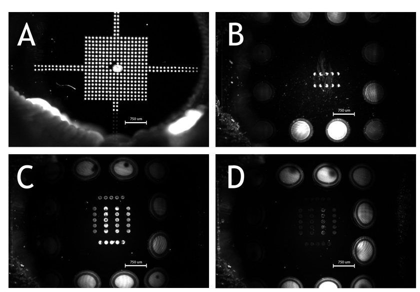
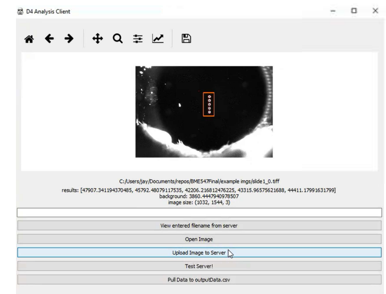


Figure 5: Images Captured on the D4 Scope. (A) Fluorescent calibration target for laser beam shaping and focus. **(B)** Ebola-D4 positive sample. **(C)** HCC-D4 6-biomarker multiplex positive sample. **(D)** HCC-D4 negative sample.

Automated Microarray Analysis Software



Flask

mongoDB

Figure 6: D4Scope Microarray Analysis Software. We wrote a Python QTPY user interface front-end for user friendliness, and a Flask server back-end with a MongoDB database to store all microarray images and analysis data. The server runs on a Duke Virtual Machine with RESTful API endpoints.

Device Performance

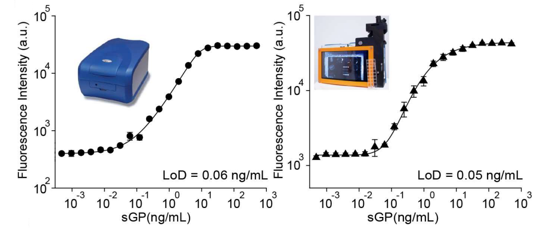


Figure 7: D4Scope POCT performance against Axon Genepix. (above) Zaire Ebolavirus dose response curves generated from scanning by Genepix and D4Scope show broad dynamic range (>4 logs) and equivalent limits of detection (~0.05 ng/mL).

Conclusions

Together with the D4 POCT, this customized, low-cost, hand-held detector promises to democratize sandwich immunoassays in a microarray format for clinical and research use.

QR Code link to Project Website for more details

Scan this QR code to access the project website for more information:

- Project abstract
- 3D CAD model files (STL)
- Github code repository
- Video of software operation
- Video of the device operation

Acknowledgements

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