Silver nanowire thin-film heaters in bioplastic microfluidic devices for molecular diagnostics

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Introduction
- Microfluidic nucleic acid detection assays rely on bulky, expensive laboratory equipment, limiting their application in point-of-care settings
- Aim to develop a low-cost, minimal-equipment heating method using transparent, conductive silver nanowires on microfluidic devices
- Great potential for more sustainable and accessible health monitoring

Method
- Custom fabrication technique developed to integrate silver nanowires (AgNW) and bioplastic polyactic acid (PLA) for thin-film, transparent heater
- Heating ability characterized with Arduino-powered thermocouples & Seek infrared thermal camera
- Demonstration of molecular diagnostic assay on a microfluidic chip: isothermal amplification with AgNW-PLA heater via RT-LAMP for detection of SARS-CoV-2 in saliva

Results
Heating characterization

![Image](https://example.com/image1.png)

Figure 4. Images of AgNW-PLA heater. (A) Standard camera image demonstrates transparency of AgNW-PLA. (B) Infrared thermal images of AgNW-PLA heater across different temperatures (left to right: 45°C, 65°C, 85°C).

Figure 5. (A) Heating stability of AgNW-PLA heater. Plot shows average temperature across replicates. Each replicate (n=2) required slightly different voltage to reach target temperatures (45°C, 65°C, 85°C); voltage range shown in legend. (B) Relationship between applied voltage across copper electrodes and temperature of AgNW-PLA heater demonstrates linear pattern. (C) Efficiency (kJ/min) of AgNW-PLA heaters at different temperatures (n=4).

Conclusion
- AgNW-PLA heater demonstrates fast response and stable heating
- AgNW-PLA heater exhibits high conductivity and great Joule heating efficiency
- AgNW-PLA heater allows for successful detection of SARS-CoV-2 on a microfluidic chip via RT-LAMP molecular diagnostic assay.
- The biodegradability of PLA simplifies disposal processes and promotes sustainability.
- Combining the compact design with the high sensitivity and accuracy molecular diagnostics can offer, these diagnostic tools signify great potential for application in point-of-care and resource-constrained environments.

Future Work
- Optimize heating distribution by implementing different coating methods
- Enhance contact between copper plates and silver nanowire to improve conductivity and uniform distribution
- Explore alternative conducting nanomaterials such as iron, zinc, or magnesium for improved biosafety during biodegradability

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