Inkjet Printing of Functional Polymer Composites for Chemiresistive Gas Sensors

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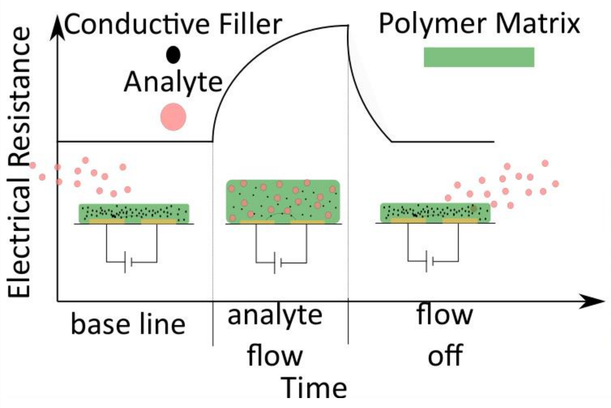
Abstract

Drop-on-Demand Inkjet printing can be used as an effective technique to deposit the sensing layer in chemiresistive gas sensors[1]. In this type of gas sensors, a composite containing an insulating polymer mixed with a conductive filler is used for sensing analytes[2]. However, formulation of inks containing functional materials remains challenging due to rheological constraints imposed by the inkjet printer. Here, we show the process of ink formulation for functional inks containing polyvinylpyrrolidone (PVP), a polar polymer, and carbon black (CB). We formulated composite inks containing PVP with different molecular weights (40 and 360 kDa) and studied their inkjet-abilities based on their shear viscosity and particle size distribution. Composite inks were successfully printed onto the sensor platforms and their electrical properties were characterized.

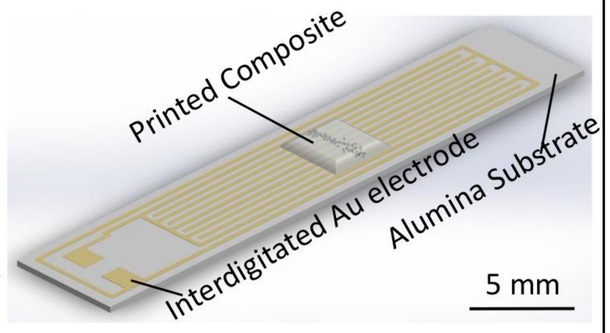
Working principle of chemiresistive gas sensors

❑ Polymer/Analyte interaction → Resistance increases[3]

Sensor Response

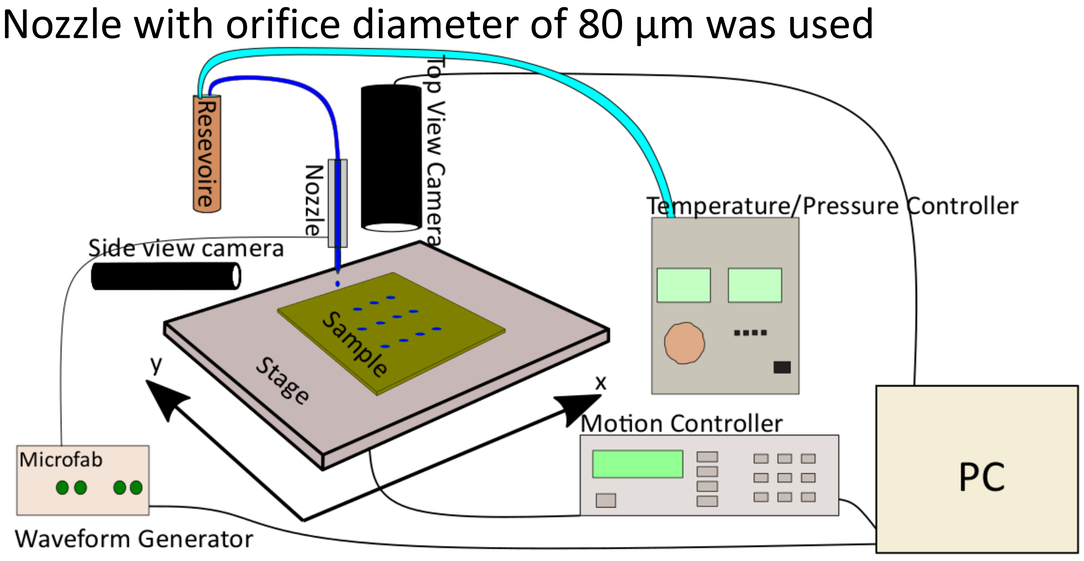


Schematic of the Sensor



Inkjet setup

❑ Nozzle with orifice diameter of 80 µm was used



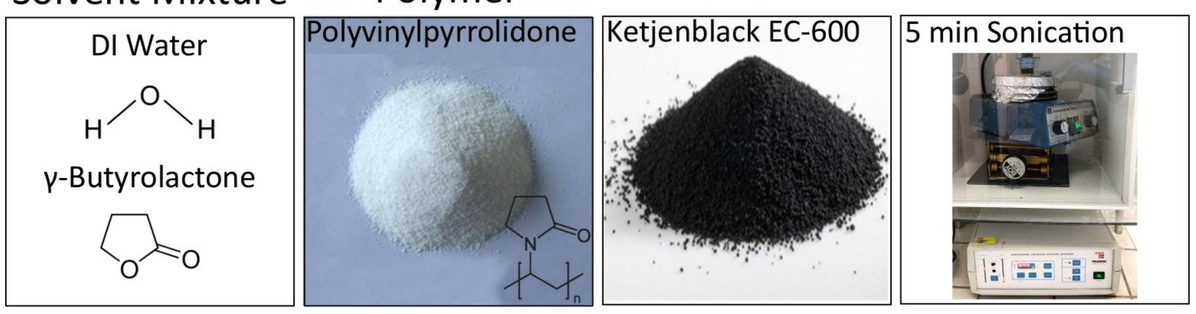
Ink formulation

Solvent Mixture: DI Water; γ-Butyrolactone

Polymer: Polyvinylpyrrolidone

Filler: Ketjenblack EC-600

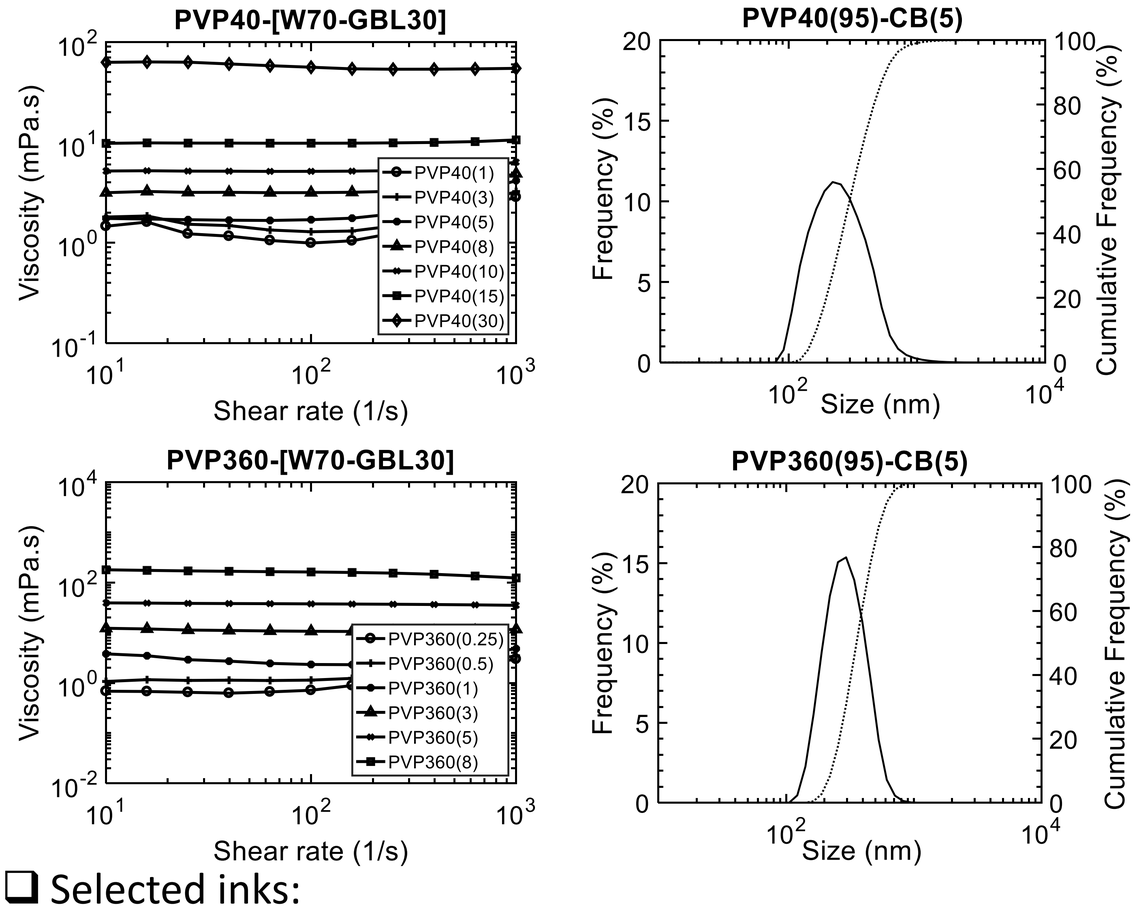
5 min Sonication



Ink characterization

❑ Viscosity measured as a function of polymer concentration

❑ Particle size distribution with DLS after 5 min sonication



❑ Selected inks:

PVP40 + CB (wt%)		PVP360 + CB (wt%)	
PVP40/Solvent	PVP40/CB	PVP360/Solvent	PVP360/CB
10/90	95/5	99.75/0.25	95/5

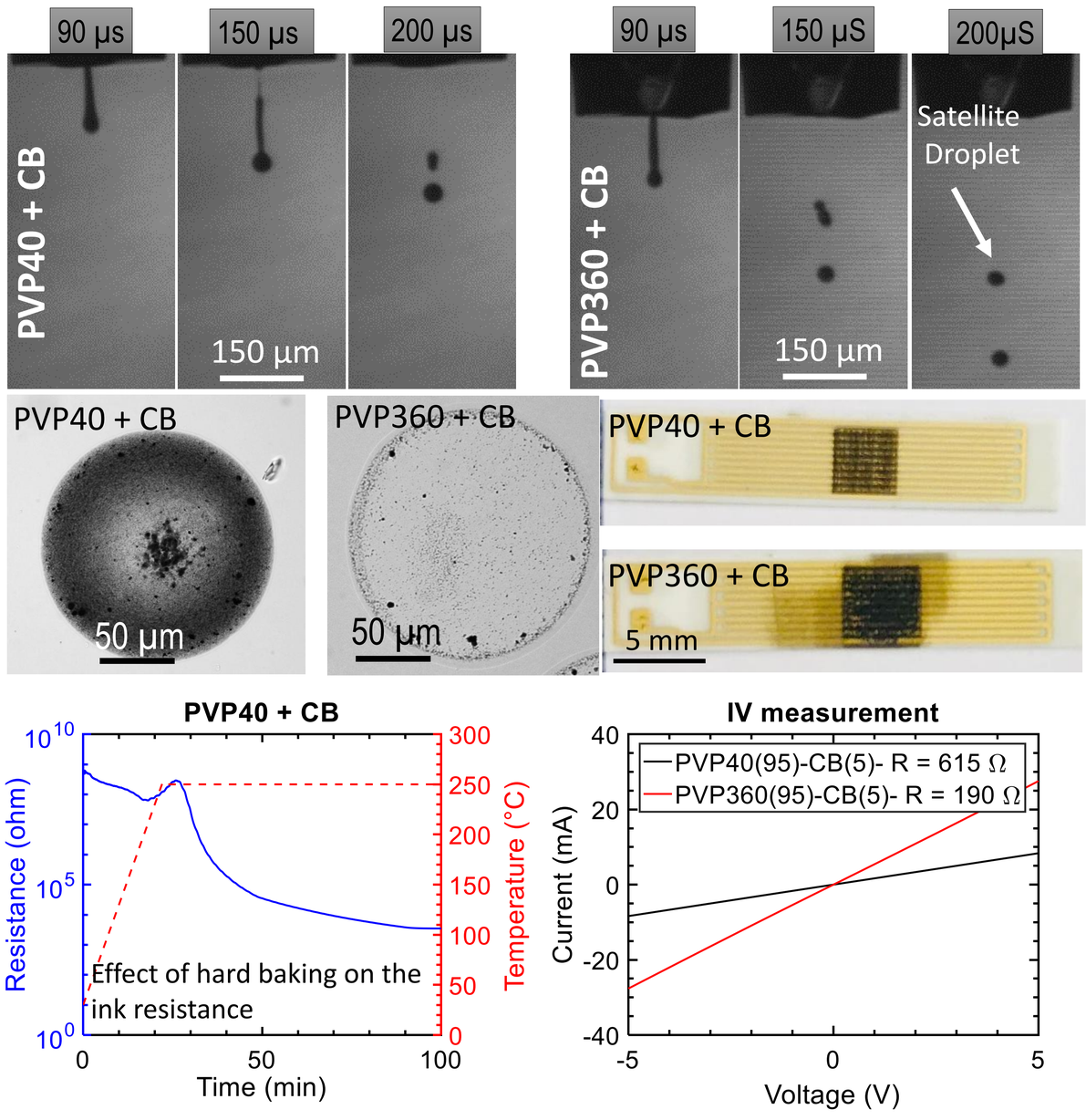
Printing the composite ink

❑ Inkjet printing of composite inks is demonstrated

❑ No strong coffee stain effect was observed

❑ 40×40 array of droplets printed on the sensor platform

❑ Resistance of the inks were measured after a hard baking step



Outlook

- Comprehensive characterization of the sensing behavior of the printed sensors
- Development of inkjet printed sensor array

Reference

[1] N. Komuro, S. Takaki, K. Suzuki, and D. Citterio, "Inkjet printed (bio)chemical sensing devices," *Anal Bioanal Chem*, 2013.
[2] X. Liu, S. Cheng, H. Liu, S. Hu, D. Zhang, and H. Ning, "A Survey on Gas Sensing Technology," *Sensors*, 2012.
[3] Beth C. Muñoz, Gregory Steinthal & Steven Sunshine. Conductive polymer-carbon black composites-based sensor arrays for use in an electronic nose. *Sens. Rev.* **19,** 300–305 (1999).

Acknowledgments

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