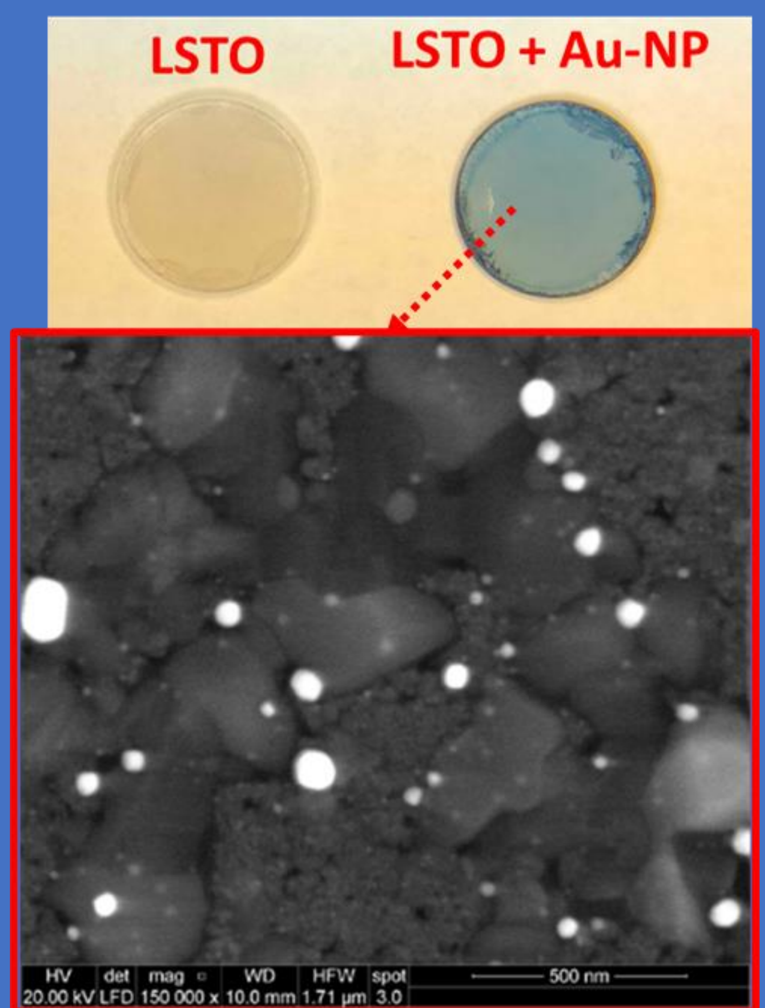
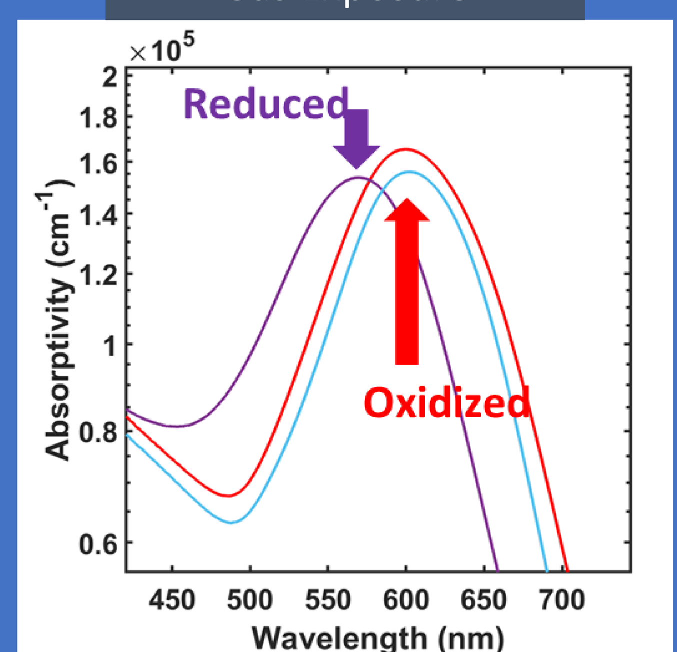

# Nanocomposite Films for Energy Infrastructure Sensing Applications on Optical Fiber

**Jeffrey Wuenschell[1,2], Ki-Joong Kim[1,2], Youngseok Jee[1,2], Michael Buric[1]**
[1]National Energy Technology Laboratory, Pittsburgh PA /Morgantown WV; [2]NETL Site Support Contractor, Pittsburgh PA / Morgantown WV

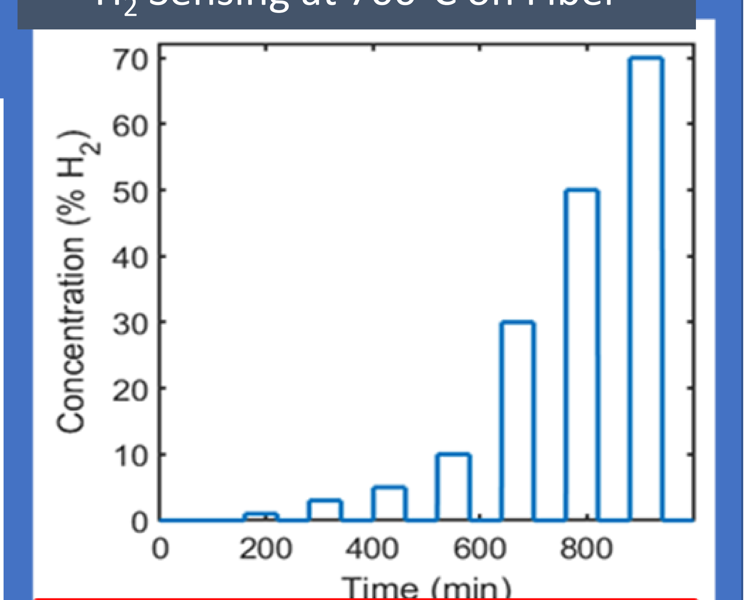
## High Temperature Plasmonics for Gas Sensing [1,2]

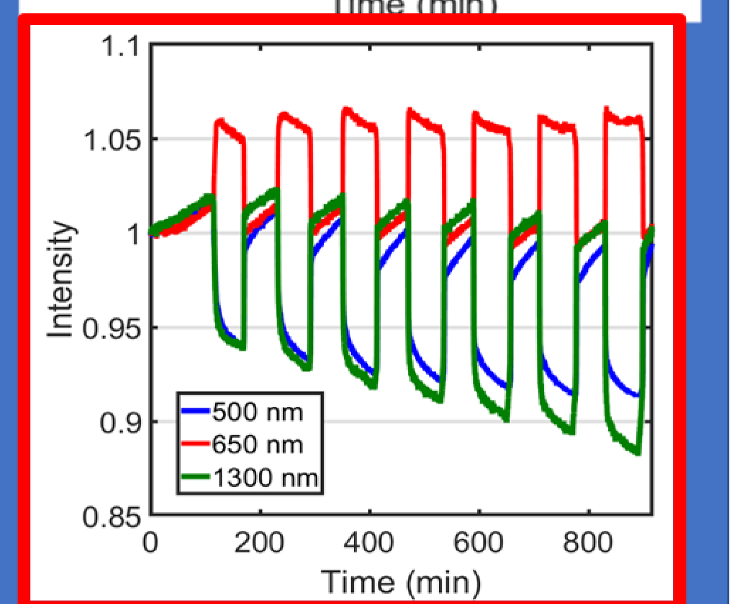



Plasmonic Shift under Gas Exposure




$H_2$ Sensing at 700°C on Fiber

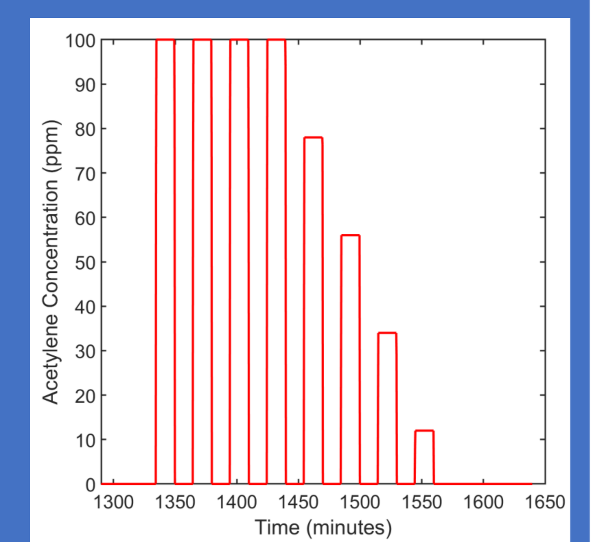


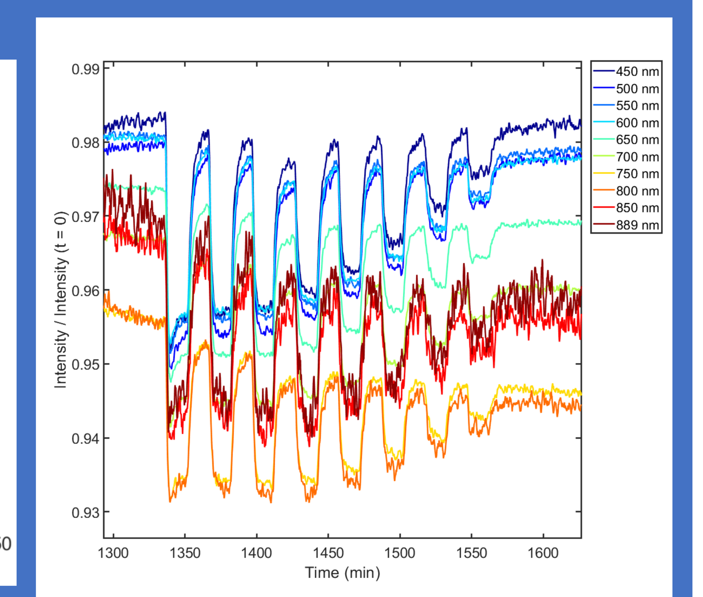



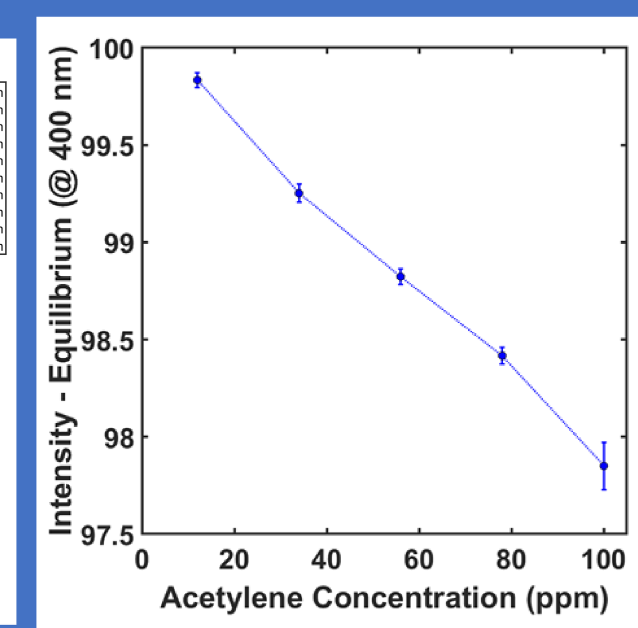

- Combined conducting oxide / plasmonic films interact with oxidizing reducing gas streams at high temperature.
- Optical signatures in visible and near-infrared can be used for oxygen or fuel gas sensing at high temperature (>500°C).
- Applications: solid oxide fuel cell monitoring (anode, cathode); monitoring of $H_2$, $CH_4$; and post-combustion oxygen monitoring.
- Areas of current interest: implementation with scalable single crystal fiber for extreme temperature environments (>1000°C), distributed sensing with silica or single crystal fiber (i.e., with optical time domain reflectometry, OTDR).

## Ni/Silica Nanocomposite Sensing Layers for Transformer Monitoring [3]

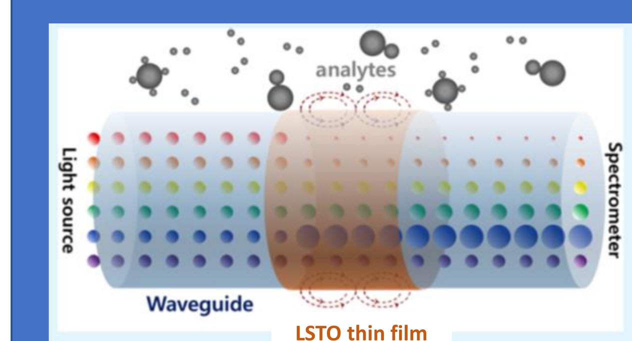
- Presence of acetylene dissolved in oil-filled transformers is indicative of discharge faults.
- Dissolved gas analysis (DGA) of collected oil samples is the gold standard for discharge fault detection.
- Optical fiber-based sensors desired to operate in-situ and provide real-time feedback.
- Areas of current interest – distributed sensor development. Multi-variate sensor of relevant combustible gas species ("photonic nose").

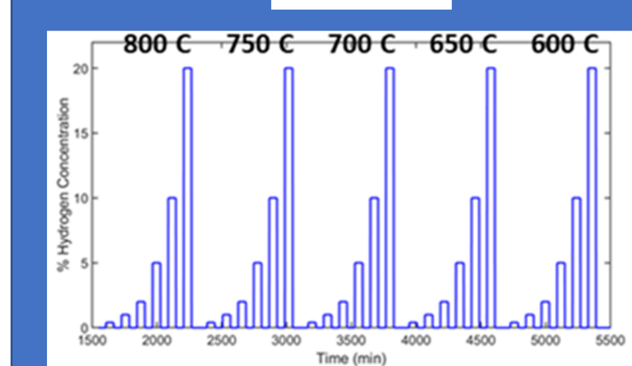


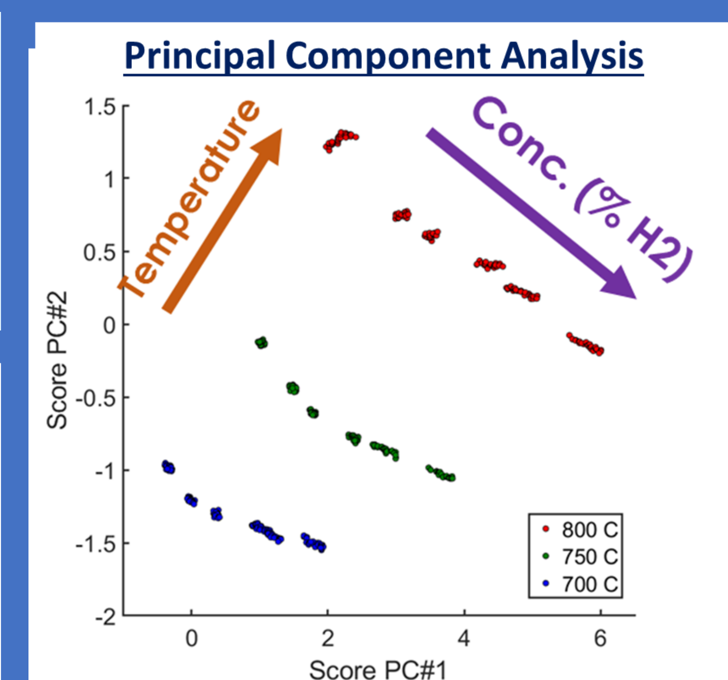



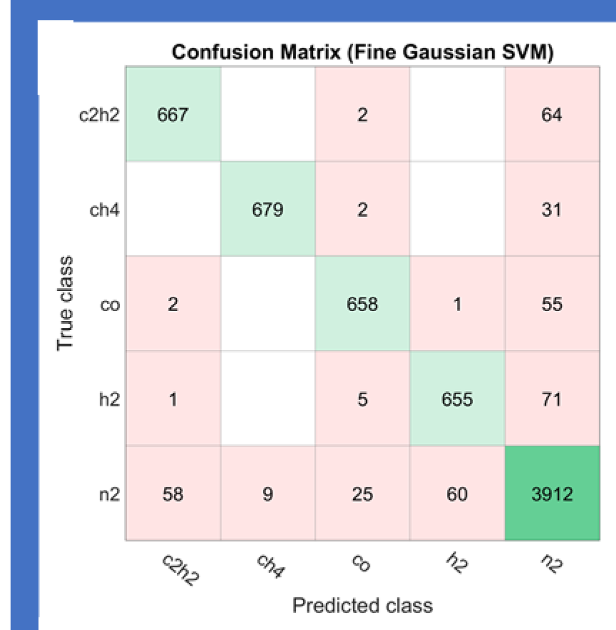

## Multi-Variate Discrimination with Machine Learning [1,3]

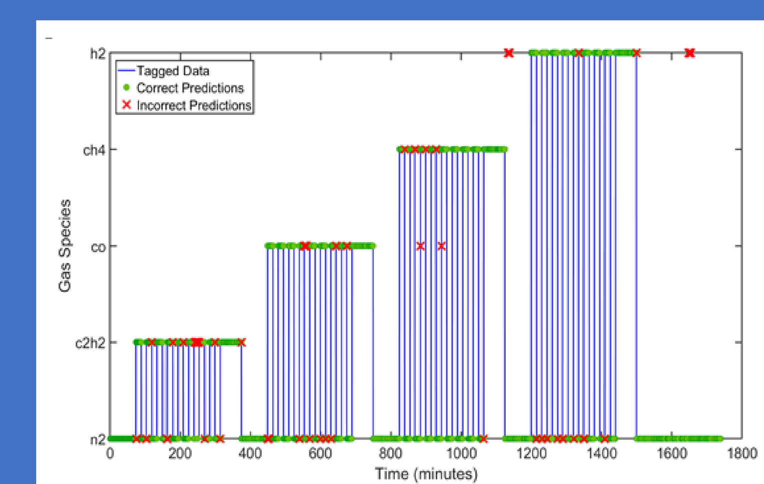



Support Vector Machine (SVM) Training with Spectral Data




- Nanocomposite films can be tuned to include multiple sensing mechanisms for multiple gas species, temperature, and pressure.
- Broadband or multi-wavelength interrogation is easy to implement on optical fiber.
- AI/ML techniques can extract multi-variate information from feature-rich spectral data.

## References

[1] Wuenschell, et al. *Nanoscale* 12.27 (2020): 14524-14537.
[2] Wuenschell, et al. *MRS Communications* (2022): 1-7.
[3] Wuenschell, et al. *Fiber Optic Sensors and Applications XVIII*. Vol. 12105. SPIE, 2022.

## Disclaimer



## Acknowledgements

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