NASA SPACE TECHNOLOGY RESEARCH FELLOWSHIP

Grant 80NSSC17K0190

SAND2018-8446R

GOAL / EXPECTED OUTCOMES

- Literature review of thermographic phosphors that will be appropriate for use within the environment of a burning solid propellant when performing temperature measurements.
- Investigate the fluorescence seen from AP/HTPB solid propellant samples when excited by a 355 nm laser and determine how this could affect phosphor thermometry experiments (the sample is not burned).
- Begin testing samples containing phosphors at room temperature.
- Begin performing calibration experiments with thermographic phosphors.

TECHNICAL APPROACH

- The induced emission of thermographic phosphors is temperature dependent and can therefore be exploited by thermometry.
- Focus will be placed on the intensity ratio approach toward phosphor thermometry during this project.
- Two different optical filter used to find an intensity ratio of the induced emission from the phosphors.
- A spectrometer was used to characterize the emission when exploring some of the goals above.
- Figure 1 shows the lifetime and intensity ratio of several thermographic phosphors and how they depend on temperature.

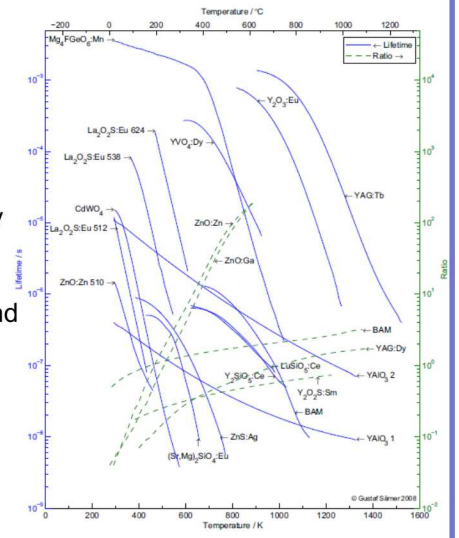

Figure 1. The lifetime and intensity ratio of several thermographic phosphors as a function of temperature [1].

RELEVANCE TO NASA

- Phosphor thermometry shows promise to provide temperature measurements within transient combustion environments with high spatial and temporal resolution.
- Can be used to validate existing models and help create new models of these types of environments, aiding with the development of SRMs.

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration | NTESS

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Sandia National Laboratories

TITLE	High-frequency surface and near-surface temperature measurements of burning composite propellants
SPACE TECHNOLOGY FELLOW	Eric Westphal
FACULTY ADVISOR / PRINCIPAL INVESTIGATOR	Steven Son
UNIVERSITY	Purdue University
DEGREE PROGRAM	Aeronautical and Astronautical Engineering
NSTRF YEAR (e.g., 1 of 4)	1 of 4
NASA RESEARCH COLLABORATOR (include NASA Center or Affiliation)	Pat Lampton, NASA Marshall Space Flight Center

MAJOR ACCOMPLISHMENTS (TO-DATE)

- Spectroscopic results show that emission from ZnO:Ga phosphors embedded within an AP/HTPB propellant is clearly distinguishable from any other induced fluorescence from the constituents of the propellant (figure 2).
  - Background fluorescence from the propellant should be low enough to not interfere with fluorescence from the phosphors.
  - Chemiluminescence will need to be considered when taking temperature measurements of a burning propellant.
- VTE performed at Sandia National Laboratories. X-rays and LEDs were explored as excitation sources for phosphor thermometry.
  - 365 nm LED successfully excited YAG:Dy phosphors (figure 3).
  - Both X-ray phosphors and thermographic phosphors are being explored for their temperature sensitivity when excited by X-rays

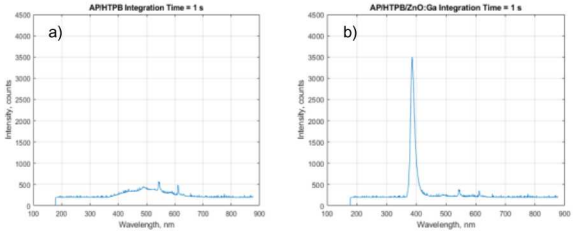

Figure 2. Plots comparing the spectra of the induced emission from an AP/HTPB solid propellant a) without and b) with ZnO:Ga phosphors added as inclusions. A peak near 390 nm is expected for this phosphor at room temperature.

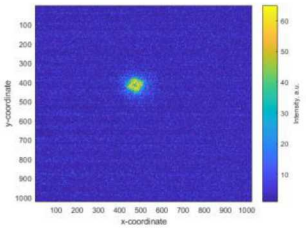

Figure 3. Emission from a YAG:Dy sample excited by a 365 nm LED and imaged using an intensified camera.

[1] M. Aldén, A. Omrane, M. Richter, G. Särner, Thermographic Phosphors for Thermometry: A Survey of Combustion Applications, Prog. Energy Combust. Sci. 37 (2011) 422–461.