

Submission ID #: 69595

Scriptwriter Name: Poornima G

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## **Title: Phase-Dependent Control of Trap Depth and Persistent Luminescence in Strontium Aluminate Phosphors**

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## **Author Questionnaire**

- 1. Microscopy:** Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**
  
- 2. Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **No**
  
- 3. Filming location:** Will the filming need to take place in multiple locations? **No**
  
- 4. Testimonials (optional):** Would you be open to filming two short testimonial statements **live during your JoVE shoot**? These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **No**

### **Current Protocol Length**

Number of Steps: 19

Number of Shots: 33

# Introduction

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*Videographer: Obtain headshots for all authors available at the filming location.*

**NOTE: The questions will not appear in the video**

## **INTRODUCTION:**

~~What is the scope of your research? What questions are you trying to answer?~~

- 1.1. **Guanyu Cai:** My research explores persistent luminescent materials such as strontium aluminates ZGO and how their trap structures enable bioimaging and advanced anti-counterfeiting.
  - 1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~What are the most recent developments in your field of research?~~

- 1.2. **Guanyu Cai:** Recent progress in the field shows color-tunable afterglow and time- and temperature-resolved luminescence from single persistent phosphor compositions.
  - 1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

## **CONCLUSION:**

~~What significant findings have you established in your field?~~

- 1.3. **Guanyu Cai:** I identified how the crystal phase controls trap depth, enabling blue or green persistent luminescence with distinct decay behaviors.
  - 1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~What research gap are you addressing with your protocol?~~

- 1.4. **Guanyu Cai:** This work addresses the lack of dynamic, time- and temperature-resolved strategies in persistent luminescence anti-counterfeiting.
  - 1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~What questions will future research focus on?~~

1.5. **Guanyu Cai:** My future research will focus on new dopants and structures for tunable lifetime, color, and biomedical compatibility.

1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

***Videographer: Obtain headshots for all authors available at the filming location.***

# Protocol

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## 2. Preparation and Mounting Strontium Aluminate (SAO) Material in the Chamber

**Demonstrator:** Guanyu Cai

- 2.1. To begin, press the pellets of SAO-B and SAO-G under a uniaxial pressure of 3.5 tons for 5 minutes [1-TXT]. Ensure each specimen has a uniform shape with a mass of approximately 120 milligrams, a diameter of 10 millimeters, and a thickness of 1 millimeter [2].
  - 2.1.1. **WIDE:** Talent placing powder into a pellet press and applying uniaxial pressure.  
**TXT:** SAO-B:  $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}, \text{Dy}^{3+}, \text{B}^{3+}$  (Blue-emitting@490 nm); SAO-G:  $\text{SrAl}_2\text{O}_4:\text{Eu}^{2+}, \text{Dy}^{3+}, \text{B}^{3+}$  (Green-emitting@520 nm)
  - 2.1.2. Close-up of the pressed pellet being removed and inspected for correct dimensions.
- 2.2. Heat the samples at 350 Kelvin for 10 minutes to remove shallow or surface traps [1]. Then, incubate the samples at 480 Kelvin for 10 minutes to eliminate deeper traps [2-TXT].
  - 2.2.1. Talent placing samples in a preheated oven set to 350 Kelvin.
  - 2.2.2. Talent adjusting the oven temperature to 480 Kelvin. **TXT: Choose the temperature depending on the material type**
- 2.3. Now, apply a thin, uniform layer of silver paste to the sample holder surface [1] and spread it evenly to ensure to ensure firm contact [2]. Wait for 10 to 15 minutes until the paste is completely dry [3].
  - 2.3.1. Talent using a spatula to apply a thin layer of silver paste onto the holder.
  - 2.3.2. Talent using a flat tool to spread the paste mixture evenly.
  - 2.3.3. Close-up of the sample dried holder
- 2.4. Then, mount the sample holder using the designated screws, ensuring each screw is in its correct matching position [1]. Tighten the screws in a crosswise pattern, repeating three times to apply even pressure [2].
  - 2.4.1. Talent placing screws into the corresponding holes on the sample holder.

2.4.2. Talent tightening the screws in a crosswise sequence across three full rounds.

2.5. Insert the inner chamber with open holes on all sides onto the mounted sample [1].

2.5.1. Talent aligning and gently placing the inner chamber over the mounted sample.

2.6. Next, place the external chamber over the inner chamber with the blocked window facing upward for ultraviolet-visible excitation [1] and ensure the valve remains closed throughout this process [2].

2.6.1. Talent positioning the outer chamber with the blocked window facing upward.

2.6.2. Talent pointing to the valve in the closed position.

### **3. System Setup for Thermoluminescence Measurement**

3.1. Switch on the vacuum pump while keeping the valve in the closed position [1].

3.1.1. Talent powering on the vacuum pump with the valve visibly closed.

3.2. Monitor the pump indicator and, once it changes from yellow blinking to solid green, open the valve [1].

3.2.1. Show the pump interface as the indicator light changes from yellow blinking to solid green, then show the valve being opened.

3.3. Observe the manometer during pumping: a red blinking light indicates gas pressure on the black scale, while a green blinking light indicates pressure on the red scale [1]. Ensure the pressure drops below  $1 \times 10^{-3}$  millibar before opening the valve to the chamber [2].

3.3.1. Show a close-up of the manometer display with blinking red and green lights corresponding to different pressure scales.

3.3.2. Shot of the valve being opened to the chamber.

3.4. Now, connect the fiber optic cable and adjust it to optimally collect the emitted light [1]. Cover the entire setup with a black blanket to block stray light and background

excitation [2].

3.4.1. Talent connecting and positioning the fiber optic cable in place for emission collection.

3.4.2. Talent carefully covering the entire apparatus with a black blanket.

3.5. Next, open the water supply before activating the cryostat and compressor for cooling [1].

3.5.1. Talent turning on the water supply line and preparing the cryostat.

3.6. Switch on the temperature controller and set the heater range to 50 milliwatts and the target temperature to 10 Kelvin [1]. Use the displayed menu and confirm the settings twice [2].

3.6.1. Talent powering on the temperature controller and entering 50 milliwatts and 10 Kelvin.

3.6.2. Show the final settings.

3.7. Now, allow the system to cool until it reaches the target temperature [1].

3.7.1. Show the system interface displaying the decreasing temperature approaching 10 Kelvin.

3.8. Continue pumping to maintain vacuum around the sample holder [1-TXT].

3.8.1. Talent monitoring the system while the pump continues running to sustain the vacuum. **TXT: Record emission spectra during and after excitation**

3.9. For thermoluminescence, excite the sample with ultraviolet or visible light [1]. After excitation, ramp the sample temperature at a controlled rate of 10 Kelvin per minute up to the desired target temperature, such as 470 Kelvin [2-TXT].

3.9.1. Show the sample under ultraviolet excitation.

3.9.2. Talent programming the temperature ramp settings on the controller and starting the temperature increase. **TXT: Continuously record the luminescence spectra**

3.10. Finally, disassemble the chamber [1] and remove the sample holder once the system

has reached room temperature [2].

3.10.1. Talent opening the chamber and carefully detaching the sample holder.

3.10.2. Talent removing the sample.

## Results

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### 4. Results

- 4.1. Upon ultraviolet excitation at 275 nanometers, SAO-B exhibited a persistent luminescence peak at 490 nanometers [1], while SAO-G showed a peak at 520 nanometers, confirming their blue and green emissions, respectively [2].
  - 4.1.1. LAB MEDIA: Figure 3A. *Video editor: Highlight the blue curve with a peak at 490 on the horizontal axis.*
  - 4.1.2. LAB MEDIA: Figure 3A. *Video editor: Highlight the green curve with a peak at 520 on the horizontal axis.*
- 4.2. SAO-B demonstrated a longer decay time [1] than SAO-G following the same ultraviolet pre-excitation [2].
  - 4.2.1. LAB MEDIA: Figure 3B. *Video editor: Highlight the blue curve for SAO-B*
  - 4.2.2. LAB MEDIA: Figure 3B. *Video editor: Highlight the green curve for SAO-G.*
- 4.3. SAO-B exhibited a thermoluminescence peak centered at 350 Kelvin [1], while SAO-G presented two distinct peaks at 290 Kelvin and 320 Kelvin, indicating a broader trap depth distribution [2].
  - 4.3.1. LAB MEDIA: Figure 4. *Video editor: Highlight the blue curve's peak centered at 350 on the horizontal axis.*
  - 4.3.2. LAB MEDIA: Figure 4. *Video editor: Highlight the green curve's peak*
- 4.4. A dual-color anti-counterfeiting pattern displaying PSL made from SAO-B and SAO-G ceramics emitted blue and green colors, respectively, for over 1 hour after ultraviolet pre-excitation [1].
  - 4.4.1. LAB MEDIA: Figure 5.
- 4.5. In the temperature-resolved anti-counterfeiting application, the luminescence of the green-labeled CHIMIE (*shee-mee*) decreased significantly at approximately 370 Kelvin [1], while the blue-labeled PARIS (*paris*) remained visible [2].
  - 4.5.1. LAB MEDIA: Figure 6. *Video editor: Highlight the fading green word "CHIMIE" at the middle temperature level labeled ~100 °C.*

4.5.2. LAB MEDIA: Figure 6. *Video editor: Highlight the still-visible blue word “PARIS” at the same middle temperature level labeled ~100 °C.*

4.6. At approximately 420 Kelvin, the emission from the green-labeled CHIMIE became indistinguishable [1], and only the blue-labeled PARIS remained emitting [2].

4.6.1. LAB MEDIA: Figure 6. *Video editor: Highlight the empty left side of the bottom panel at ~150 °C.*

4.6.2. LAB MEDIA: Figure 6. *Video editor: Highlight the bottom “PARIS” text, which remains slightly visible at ~150 °C.*

1. Uniaxial

Pronunciation link: <https://www.merriam-webster.com/dictionary/uniaxial>

IPA: /ˌjuːniˈæk.si.əl/

Phonetic Spelling: yoo·nee·ak·see·uhl

2. Specimen

Pronunciation link: <https://www.merriam-webster.com/dictionary/specimen>

IPA: /ˈspes.ə.mən/

Phonetic Spelling: spes·uh·muhn

3. Thermoluminescence

Pronunciation link: <https://www.merriam-webster.com/dictionary/thermoluminescence>

IPA: /ˌθɜː.məʊ.luː.məˈnes.əns/

Phonetic Spelling: thur·moh·loo·muh·nes·uhns

4. Ultraviolet

Pronunciation link: <https://www.merriam-webster.com/dictionary/ultraviolet>

IPA: /ˌʌl.trəˈvaɪ.ə.lət/

Phonetic Spelling: uhl·truh·vai·uh·luht

5. Excitation

Pronunciation link: <https://www.merriam-webster.com/dictionary/excitation>

IPA: /ˌek.saiˈteɪ.ʃən/

Phonetic Spelling: ek·sai·tay·shuhn

6. Incubate

Pronunciation link: <https://www.merriam-webster.com/dictionary/incubate>

IPA: /ˈɪn.kjəˌbeɪt/

Phonetic Spelling: in·kyuh·bayt

7. Kelvin

Pronunciation link: <https://www.merriam-webster.com/dictionary/kelvin>

IPA: /ˈkel.vɪn/

Phonetic Spelling: kel·vin

8. Manometer  
Pronunciation link: <https://www.merriam-webster.com/dictionary/manometer>  
IPA: /məˈnɑː.mə.tər/  
Phonetic Spelling: muh·naa·muh·ter
9. Cryostat  
Pronunciation link: <https://www.merriam-webster.com/dictionary/cryostat>  
IPA: /ˈkraɪ.ə.stæt/  
Phonetic Spelling: kry·uh·stat
10. Compressor  
Pronunciation link: <https://www.merriam-webster.com/dictionary/compressor>  
IPA: /kəmˈpres.ə/  
Phonetic Spelling: kuhm·pres·er
11. Fiber optic  
Pronunciation link: <https://www.merriam-webster.com/dictionary/fiber-optic>  
IPA: /ˌfaɪ.bəˈɑːp.tɪk/  
Phonetic Spelling: fy·ber·op·tik
12. Luminescence  
Pronunciation link: <https://www.merriam-webster.com/dictionary/luminescence>  
IPA: /ˌluː.məˈnes.əns/  
Phonetic Spelling: loo·muh·nes·uhns
13. Spectra  
Pronunciation link: <https://www.merriam-webster.com/dictionary/spectra>  
IPA: /ˈspek.trə/  
Phonetic Spelling: spek·truh
14. Vacuum  
Pronunciation link: <https://www.merriam-webster.com/dictionary/vacuum>  
IPA: /ˈvæk.ju:m/  
Phonetic Spelling: vak·yoom
15. Ultraviolet-visible  
Pronunciation link: No confirmed link found  
IPA: /ˌʌl.trəˈvaɪ.ə.lət ˈvɪʒ.ə.bəl/  
Phonetic Spelling: uhl·truh·vai·uh·luht vizh·uh·buhl
16. Anti-counterfeiting  
Pronunciation link: <https://www.merriam-webster.com/dictionary/anticounterfeiting>  
IPA: /ˌæn.tiˈkaʊn.t̬əˈfiː.tɪŋ/  
Phonetic Spelling: an·tee·koun·ter·fee·ting
17. Indistinguishable  
Pronunciation link: <https://www.merriam-webster.com/dictionary/indistinguishable>  
IPA: /ˌɪn.dɪˈstɪŋ.gwɪˌʃə.bəl/  
Phonetic Spelling: in·di·sting·gwish·uh·buhl
18. Milliwatts  
Pronunciation link: <https://www.merriam-webster.com/dictionary/milliwatt>

IPA: /'mɪl.i.wɑ:t/

Phonetic Spelling: mil·ee·waat