Reporting on wavelength shifters sublimation under high vacuum

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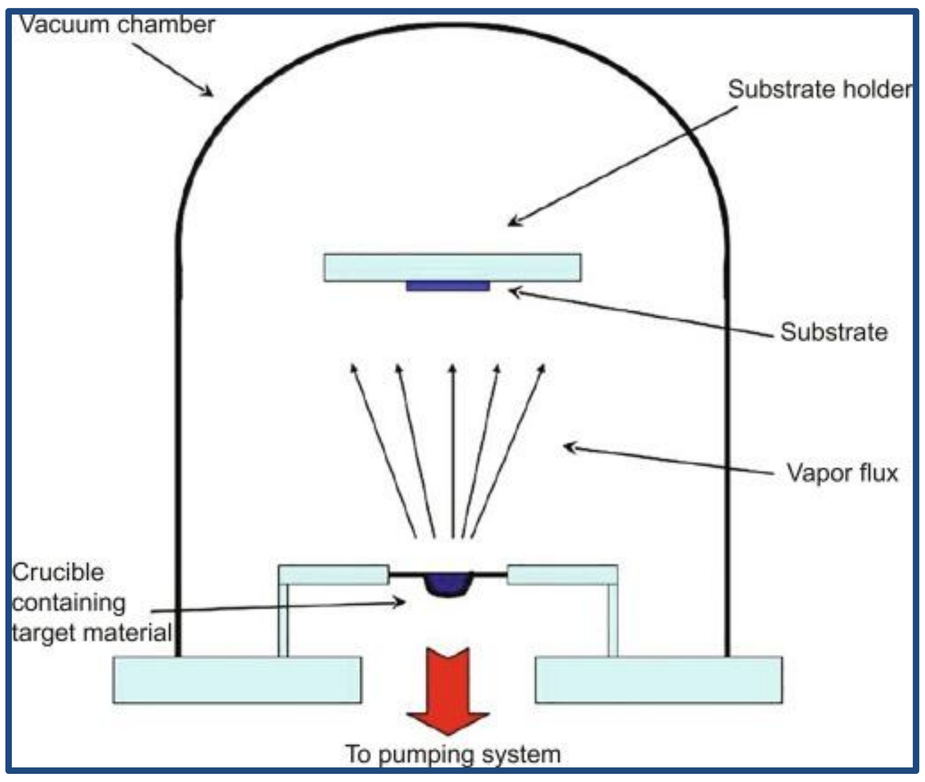
Our investigation reveals an intriguing phenomenon on a commonly used wavelength shifter (pTP). We observed a possible spontaneous sublimation when exposing pTP to high vacuum. This work presents our findings on the sublimation behavior of pTP under such extreme conditions. We have quantified the sublimation rate of these substances on different pressure conditions and sample thickness. We also assessed this phenomenon's influence on the surface of these materials.

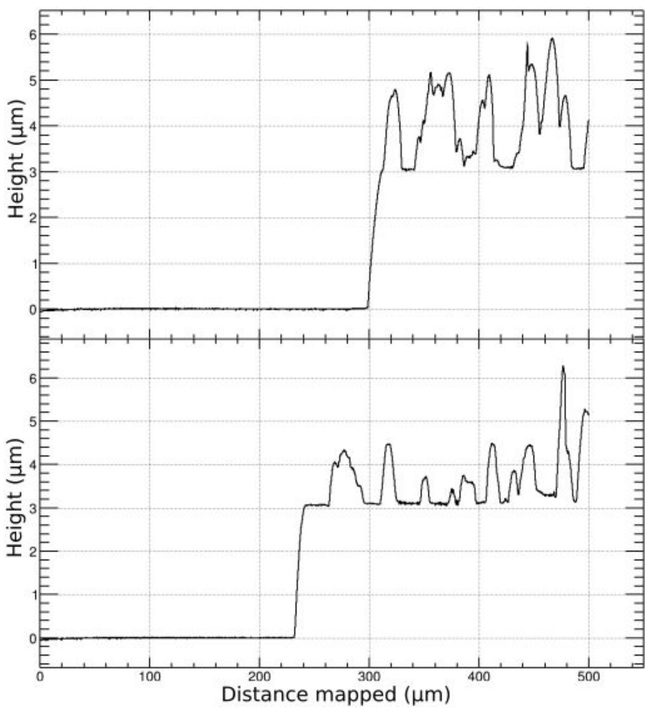
Based on our results, we suggest special attention and care when exposing pTP to vacuum conditions. These insights could improve the reliability and efficiency of these materials in advanced photodetection systems by optimizing the application of this, and possibly others, wavelength shifter in the design of experiments.

Thermal thin film deposition



Thermal evaporation is a widely employed method for fabricating thin films. In this process, the material intended for deposition is heated in a crucible within a vacuum chamber, causing it to sublimate and generate a molecular flux. The low pressure environment (10^{-6} Torr) ensures a high mean free path for the molecules, allowing them to travel directly to the substrate without collisions. Upon reaching the cooler substrate surface, the molecules condense and form a well-adhered thin film.

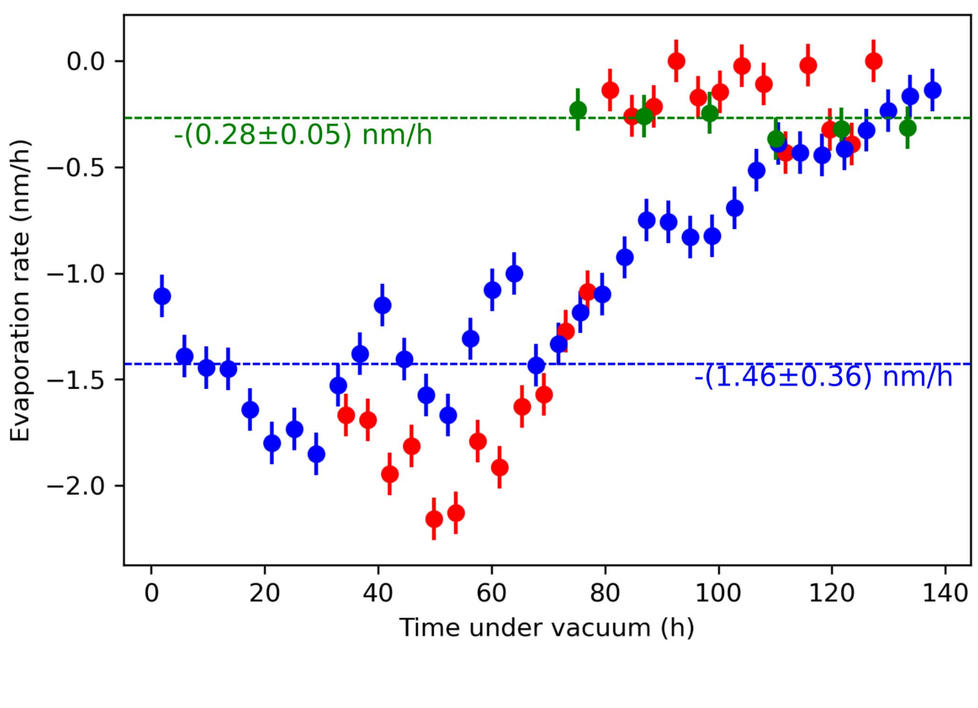
Effects on the surface roughness



Spontaneous sublimation is a process that can be influenced by surface area, potentially impacting high-surface-area crystal growths on thick pTP films. To explore how sublimation affects surface roughness, we performed surface profilometry on multiple samples before and after exposure to vacuum. A consistent reduction in surface roughness was observed across all tested samples.

Sublimation might pose challenges in detector design and operation, it can be leveraged advantageously to produce smoother films. By initially growing the device to a thickness several hundred nanometers greater than desired and allowing it to undergo sublimation under HV pressures for a week, smoother samples can be achieved. This technique could prove invaluable in our efforts to develop MagLiTe.

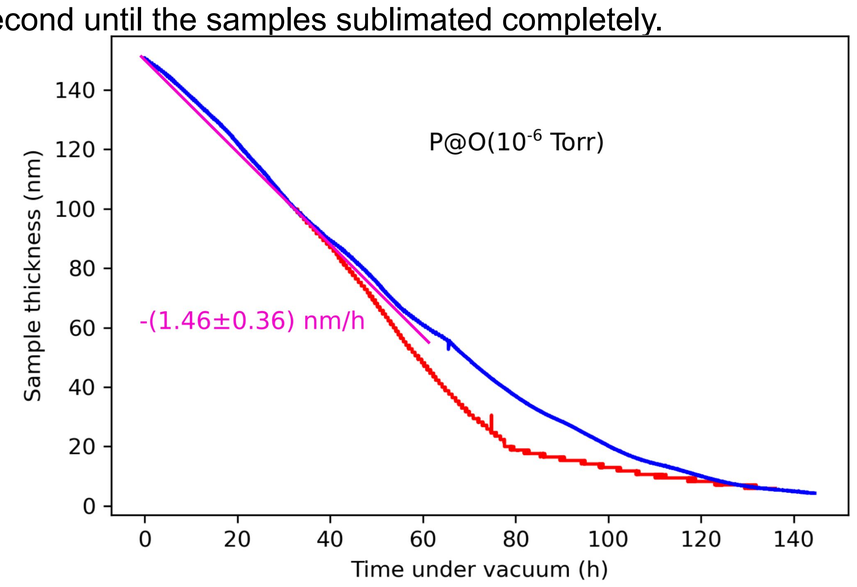
Spontaneous sublimation rate



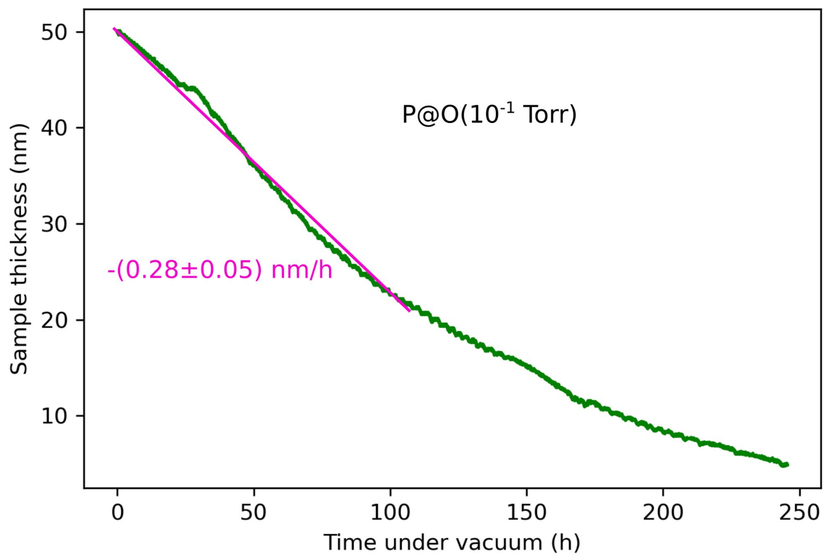
The sublimation rate varied throughout the experiment. It significantly slowed for very thin films and exhibited minor fluctuations. To gain a clearer understanding, we calculated the sublimation rate on an hourly basis. At 10^{-6} Torr, the rate was determined to be -(1.46±0.36) nm/h. In contrast, at a higher pressure of 10^{-1} Torr, the rate was reduced to -(0.28±0.05) nm/h. As the film becomes thinner, the interaction between pTP and the substrate strengthens, leading to a decrease in the sublimation rate.

p-Therphenyl spontaneous sublimation

The thickness of the samples, grown under similar conditions, was monitored as a function of time while in a vacuum. Measurements were taken for initial thicknesses of 150 nm (blue), 100 nm (red), and 50 nm (green), with chamber pressures maintained at 10^{-6} Torr for the first two samples, and 10^{-1} Torr, for the third. Thickness data was collected every second until the samples sublimated completely.



As illustrated in the figure above, the samples demonstrate a clear trend of sublimated when subjected to vacuum conditions. Additionally, by comparison with the figure below, it is evident that the evaporation rate is pressure-dependent, since higher pressure indicates a lower sublimation rate



Future measurements

THe next steps on this research are:

- **Is this phenomenon temperature-dependent?**
  Despite indication, more measurements are necessary
- **Full sublimation rate vs pressure characterization**
  Characterize the full range of pressures, including ambient
- **Is this phenomenon present in other wls as well?**
  We intend to assess the presence of evaporation on TPB

1. Li, P. H., & Chu, P. K. (2016). Thin film deposition technologies and processing of biomaterials. In *Thin film coatings for biomaterials and biomedical applications* (pp. 3-28). Woodhead Publishing.

Acknowledgement

We thank the *LIDINE 2024: LIght Detection In Noble Elements* for the great opportunity and the support.

LIDINE 2024: LIght Detection In Noble Elements
São Paulo, Brazil