# Two Ways of Arriving at the Same Result: *carrier lifetime of a GeSn alloy*

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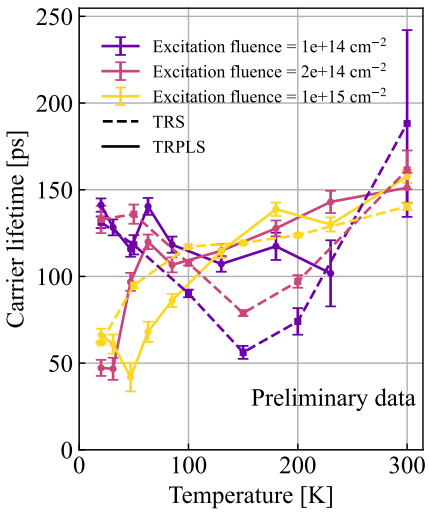
The alloy of $Ge_{1-x}Sn_x$ has been the subject of much research in the last decade [1] due to it being a group-IV material with a tunable, direct bandgap, enabling photonic devices grown monolithically on Si [2]. However, although very promising, GeSn has still not been introduced into industry [1]. The main reasons for this are the short lifetime of excited charge carriers and the low directness of the bandgap. These shortcomings make the characterization of GeSn parameters, especially the carrier lifetime, important as it might guide the improvement of material manufacturing. In this presentation, we will compare two characterization methods: time-resolved photoluminescence spectroscopy (TRPLS) and transient reflectivity spectroscopy (TRS) and use them together to eliminate their respective blind spots.




The method of TRPLS allows for direct detection of the photoluminescence (PL), i.e., a very important aspect for laser materials, while the underlying dynamics is "hidden" away and does not interfere with the measured quantity. Also, GeSn luminesce in the mid-IR range, which requires specialized methods to circumvent the thermal noise of detectors.

TRS does not have the same issues, as the reflected probe provides a large enough signal to overcome the thermal noise. By tuning the probe, TRS may also provide information on charge carriers away from the direct transition involved in the luminescence, but it provides no information on the photoluminescence itself.

Both methods require careful analysis to make the right interpretations, but even then, by TRS alone, it would not be viable to make conclusions on the effectiveness of the sample as a laser material; here TRPLS is needed. However, TRPLS alone would only give indirect information on the general carrier dynamics; for this TRS is needed. Instead, by using both methods, we are much better off. The preliminary data, shown in the figure, confirm that both methods show similar results for the carrier lifetime, thereby providing overall credibility to the analysis. A somewhat surprising result is the tendency of an increasing lifetime towards room temperature. In the presentation, we will discuss how to interpret the data correctly and thereby obtain insight into the underlying material dynamics.

**References**:

[1] A. Giunto and A. Fontcuberta i Morral, Applied Physics Reviews **11**, 041333. (2024)
[2] O. Moutanabbir, S. Assali, X. Gong, E. O'Reilly, C. A. Broderick, et al., Applied Physics Letters **118**, 110502. (2021)