Local dielectric-function modulation and exciton recombination efficiency in monolayer WS_2 flakes

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Excitons dominate the light absorption and re-emission spectra of monolayer transition-metal dichalcogenides (TMD) [1]. Microscopic investigations of the excitonic response in TMD almost invariably focus on the radiative recombination, which only constitutes one-half of the picture. Here, we provide a comprehensive description of the excitonic effects in both the absorption and re-emission spectra of WS_2 flakes by originally combining state-of-the-art imaging ellipsometry (lateral resolution < 1 µm) and imaging photoluminescence spectroscopy (Figure 1). By relying on a proven methodology to maximize the amount of information extracted from ellipsometry data [2], for the first time we obtain the local dielectric function of monolayer WS_2, which constitutes a fundamental physical quantity to describe light-matter interaction on a microscopic scale.
By comparing the exciton-induced absorption and re-emission features, we observed correlated and uncorrelated spatial patterns, thus demonstrating that the two phenomena are not always proportional at a microscopic scale. Micro-structural modulations across the flakes, having a different influence on the absorption and re-emission of light, are deemed responsible for this effect. By revealing the possibility to locally decouple the exciton-induced absorption and emission properties, these findings advance the fundamental understanding of excitonic processes in TMD, and may be of use to engineer diverse optical properties within individual flakes.

REFERENCES

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FIGURES

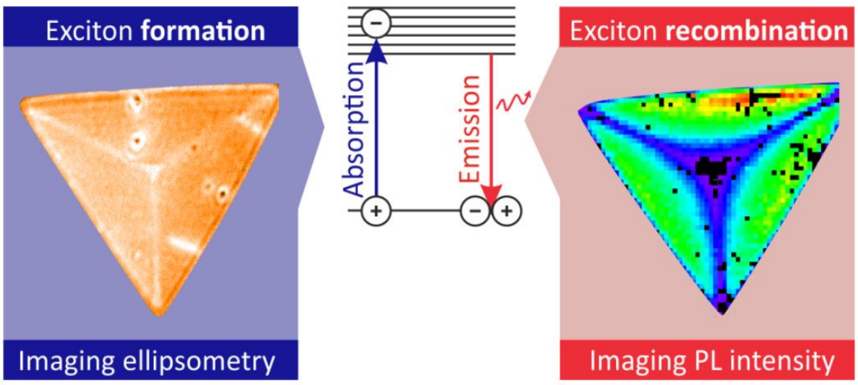

Figure 1: Microscopic spectral analysis of exciton formation (left) and recombination (right). We found that the two phenomena might lack spatial correlation within individual WS_2 flakes. Notably, the absorption and emission maxima may be located in different parts of the flake.