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 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 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

[1] G. Wang, A. Chernikov, M. Glazov, T.Heinz, X. Marie, T. Amand, B. Urbaszek. *Rev. Mod. Phys.* 90:021001, 2018.
[2] M. Magnozzi; M. Ferrera; G. Piccinini; S. Pace; S. Forti; F. Fabbri; C. Coletti; F. Bisio; M. Canepa. *2D Mater.* 7:025024, 2020.

Figures

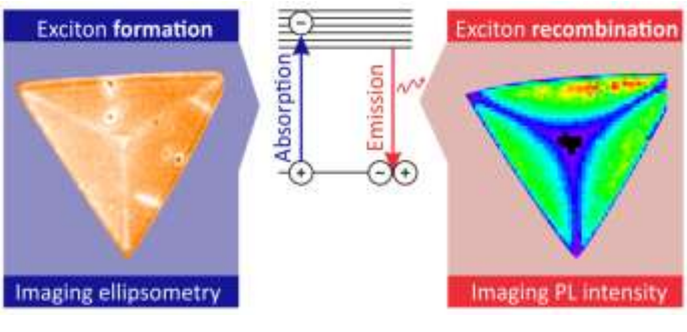

Figure 1: Microscopic spectral analysis of exciton formation (left) and recombination (right). We found that the two phenomena might lack spatial correlation within individual WS_2 flakes. Notably, the absorption and emission maxima may be located in different parts of the flake.