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Dark-exciton driven energy funneling into dielectric inhomogeneities in two-dimensional semiconductors

The optoelectronic and transport properties of two-dimensional transition metal dichalcogenide semiconductors (2D TMDs) are highly susceptible to external perturbation, enabling precise tailoring of material function through post-synthetic modifications. Here we show that nanoscale inhomogeneities known as nanobubbles can be used for both strain and, less invasively, dielectric tuning of exciton transport in bilayer tungsten diselenide (WSe_2). We use ultrasensitive spatiotemporally resolved optical scattering microscopy to directly image exciton transport, revealing that dielectric nanobubbles are surprisingly efficient at funneling and trapping excitons at room temperature, even though the energies of the bright excitons are negligibly affected. Our observations suggest that exciton funneling in dielectric inhomogeneities is driven by momentum-indirect (dark) excitons whose energies are more sensitive to dielectric perturbations than bright excitons. These results reveal a new pathway to control exciton transport in 2D semiconductors with exceptional spatial and energetic precision using dielectric engineering of dark state energetic landscapes [1].

References

[1] Su, H.; Xu, D.; Cheng, S.; Li, B.; Liu, S.; Watanabe, K.; Taniguchi, T.; Berkelbach, T. C.; Hone, J.; Delor, M. Dark-Exciton Driven Energy Funneling into Dielectric Inhomogeneities in Two-Dimensional Semiconductors. Nano Lett. 2022, in press.

Figure

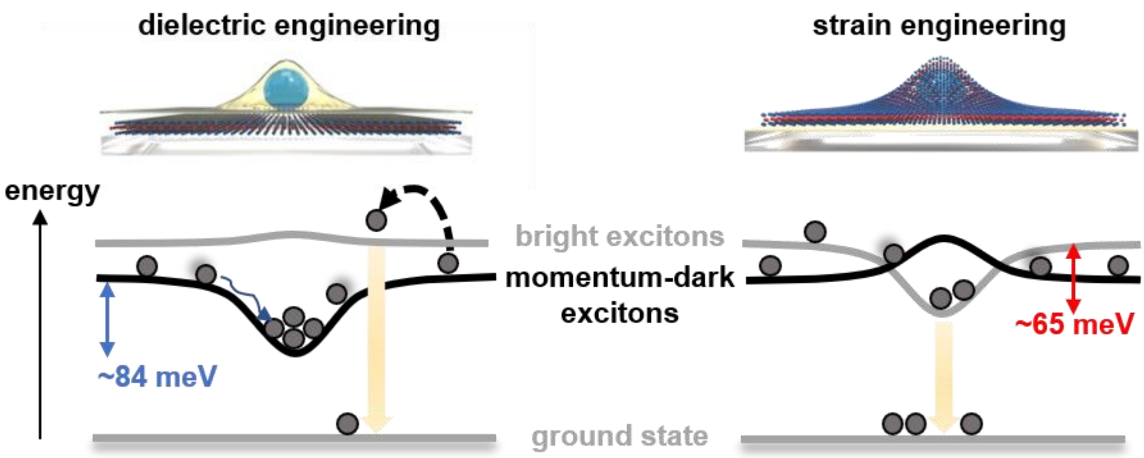

Figure 1: Energy-level diagrams illustrating exciton dynamics in bilayer WSe_2/hBN heterostructures in the presence of dielectric (left) and strain (right) nanobubbles.