Optical cavities for WSe$_2$ monolayers

M. Król$^1$, R. Mirek$^1$, K. Lekenta$^1$, K. Nogajewski$^2$, M. Koperski$^{1,2}$, P. Kossacki$^1$, A. Babiński$^1$, M. Potemski$^2$, J. Szczytko$^1$ and B. Piętka$^1$

$^1$Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Poland

$^2$Laboratoire National des Champs Magnétiques Intenses, CNRS-UJF-UPS-INS, Grenoble, France

Thin layers of transition metal dichalcogenides like MoS$_2$, MoSe$_2$, WS$_2$, or WSe$_2$ have recently emerged as a new class of materials that show great potential in optoelectronics. Of particular importance for device applications are their monolayer forms which exhibit a direct bandgap that gives rise to pronounced emission of light. Emission form the monolayer can be enhanced by its incorporation with the optical cavity as it was shown for MoS$_2$ [1,2].

In this work we demonstrate a design of an optical cavity optimized for monolayers of WSe$_2$. Our cavity comprises two dielectric mirrors composed of subsequent SiO$_2$/TiO$_2$ layers, whose parameters have been established in the course of numerical simulations based on a transfer matrix method. The whole structure has been designed in a way to obtain the maximum electric field exactly at the position of the monolayer, which should ensure the most effective coupling conditions.

Before fabricating a complete cavity with the WSe$_2$ monolayer in the middle, we first realized a half-cavity structure. Single flakes of WSe$_2$ deposited on top of the bottom dielectric mirror are shown in Fig. 1a. The emission from the single WSe$_2$ layer is shown in Fig. 1b. The quality and tunability of the complete but empty cavity (with no flakes between the mirrors) are illustrated in Fig. 1c, which demonstrates the reflectivity spectra of two mirrors brought into mechanical contact and subjected to stress of different intensity. The position of the narrow resonance in the stop-band region can be conveniently tuned by adjusting the force acting on the cavity. The mechanical tuning of the resonance emerges therefore as a possible approach to provide the match between the resonance and the energy of the excitons in WSe$_2$ monolayers.

![Figure 1: a) Dark field image of a WSe$_2$ layers deposited on a half-cavity. Single layer is visible as a matt triangular shape. b) Photoluminescence spectrum of a single WSe$_2$ flake at the half-cavity (T = 4.2 K). c) Reflectivity spectra of SiO$_2$/TiO$_2$ cavity with different stress applied to it (T = 300 K).](image)


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