Large surface epitaxial $MoSe_2$ layers grown on $Si0_2/Ti0_2$ Bragg mirrors

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Two-dimensional transition metal dichalcogenides (2D TMDs) are very attractive for modern optoelectronics because of their unique physical and optical properties. In particular, large exciton oscillator strength and valley degree of freedom are advantageous for photonic applications. Exploitation of light-matter coupling effects enhances the magnitude of optical phenomena providing a perspective for 2D TMDs-based devices working at room temperature.

A typical approach to production of 2D TMDs is exfoliation of 2D flakes from a bulk material. However, a typically small surface (not exceeding 100 μm^2) of flakes obtained in this process hinders systematic studies, e.g., as a function of detuning between the exciton and optical mode of the microcavity. The solution for this problem would be production of 2D TMDs monolayers by the molecular beam epitaxy that offers orders of magnitude larger surfaces as compared to flakes produced by exfoliation.

The aim of the present work is to study effects of the light-matter coupling involving 2D TMDs by embedding an epitaxially grown $MoSe_2$ monolayer inside of an optical microcavity. The $MoSe_2$ monolayers are grown directly on a dielectric Bragg mirror or a fused silica substrate at the temperature of 200°C and then annealed at the temperature of 700°C. The Bragg mirrors are made of 11 alternating $\lambda/4n$ layers of $Si0_2/Ti0_2$ surrounded by $\lambda/8n$ $Si0_2$ layers deposited using electron beam evaporation on fused silica substrate (size 12.7 mm x 27 mm). The mirror's stopband is centered at 750 nm (1.65 eV) and it ranges from 650 nm to 930 nm (1.91-1.33 eV, see Figure 1a) to match A and B exciton resonance in $MoSe_2$.

Transmission and Raman scattering spectra are measured at room temperature in the spectral range from 400 nm to 1000 nm. The contribution from excitons A and B to the absorption is seen at around 1.56 eV and 1.76 eV, respectively (see Figure 1b). Raman scattering measurements also confirm the presence of characteristic $MoSe_2$ line at 240.5 cm^{-2}. Impact of the dichalcogenide monolayer deposited on the surface of the Bragg mirror on transmission spectra is clear.

Our work shows that the epitaxial growth of the $MoSe_2$ monolayer on a dielectric substrate is feasible. The next step of the work will be studies of a wedge-type microcavity embedding such monolayer.

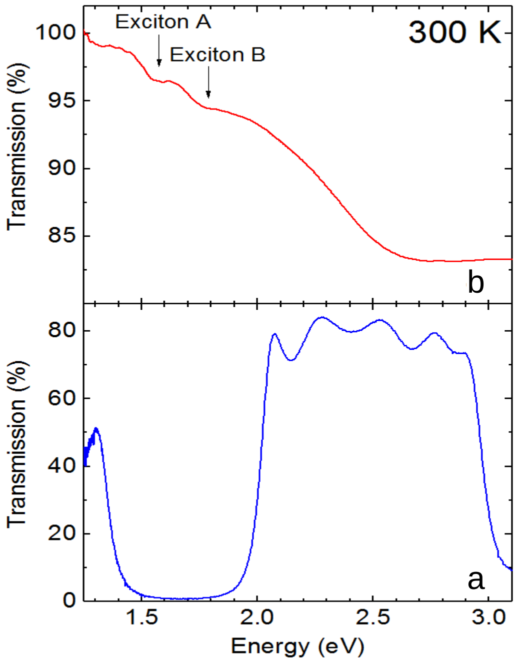

Fig.1. Transmission spectrum at 300 K (a) of a dielelectric Bragg mirror and (b) of $MoSe_2$ monolayer grown on fused silica.