MoSe₂ semiconductor indirect-to-direct transition by laser induced etching
Toyohashi Univ. Tech. EIIRIS¹, Toyohashi Univ. Tech.², Pil Ju Ko¹, Tran Viet Thu¹,
Tsukasa Takmaura¹, Abdelkader Abderrahmane², Adarsh Sandhu¹²
E-mail: ko@eiiris.tut.ac.jp

Two-dimensional (2D) layered materials like graphene exhibit unique electrical and optoelectronic properties [1-2]. In particular, single layers of transition metal dichalcogenides (TMDS) exhibit more interesting physical properties than bulk TMDS due to the indirect to direct bandgap transition due to quantum confinement [3]. In this research we demonstrate that layer-by-layer laser etching of molybdenum diselenide (MoSe₂) flakes leads to indirect to direct bandgap transition with characteristic photoluminescence (PL) spectra.

We prepared MoSe₂ flakes on a Si substrate covered with 300 nm of thermally oxidized SiO₂ by mechanical exfoliation of natural MoSe₂ using PDMS. The PL measurement and laser etching were carried out by a 532 nm laser with an estimated laser spot of around 1 μm.

Figure 1 is an optical image of the MoSe₂ flake on Si/SiO₂ substrate before and after laser etching. The number of MoSe₂ layers was reduced by their optical contrast in the area (red box) at 532 nm, 11 mW, exposure time : 0.04 sec, interval : 0.04 um, laser spot : ~ 1 μm. We observed an increase in the intensity of the MoSe₂ (1.54 eV) peak of laser thinned MoSe₂ areas by PL spectra (Fig. 2), indicating that the removal of several layers of MoSe₂ led to indirect bandgap to direct bandgap [3].


Fig. 1 Optical images of the MoSe₂ flake before and after etching.
Fig. 2 PL spectra before and after etching.