Visualization of localized field in single MoS_2 nanoflakes by cathodoluminescence

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I. Introduction

Transition metal dichalcogenides (TMDs) materials such as molybdenum disulfides MoS_2 are one of the most promising semiconductors for next-generation photovoltaic solar cells due to its great excitonic recombination property and high carrier mobility. TMDs materials with nanostructures have been reported to have the optical properties highly dependent on their dimensions such as their size and shapes, therefore, nano-scale characterization is a demand for understanding. In this study, we experimentally map localized field in a triangular MoS_2 nanoflake with nanometer spatial resolution by cathodoluminescence technique and identify individual existent modes analyzed by a spectral deconvolution method [1,2].

II. Measurement and analysis

We use a JEM-2100F scanning transmission electron microscope (STEM) combined with a light detection system. The specimen is placed inside a parabolic mirror that collimates the light emitted from the specimen (Fig.1a). While the electron beam scans over the specimen, the CL signals generated through optical excitation by fast electrons are collected at each electron beam position to obtain a CL photon map. We also conducted a spectral deconvolution for the CL photon map data. The spectral data processing can separate the broad overlapping peaks, which had been difficult to be identified in the raw spectra. We here present the deconvoluted CL mapping to show the original energy modes in the MoS_2 flakes [1,2].

III. Results and discussion

Fig 1c shows the line-scan spectra extracted from the mapping data along the line A-C in MoS_2 triangular flake indicated in the STEM image (Fig 1b). The peak at 3.1 eV was observed in all extracted positions and, whereas the intensity of the peak at 2.6 eV changes drastically depending on the positions in the triangular flake. The deconvoluted CL maps in Fig 1(d-g) present the peak intensity of the selected mode to reveal the distribution of the electric field of each mode within the MoS_2 flake. The energy at 3.1 eV is associated with intrinsic emission of the material which distributes homogeneous in the whole specimen. However, at the energy of 2.6 eV, related to dielectric resonance of MoS_2, strong intensities are found only at the corners. We also observed that the energy of the dielectric mode varies depending on the shape and size of individual MoS_2 nanoflakes, while the emission at the energy around 1.84 eV (in Fig 1g), which should be another intrinsic material fluorescence, is also strong at the corners, indicating a coupling to the dielectric mode.

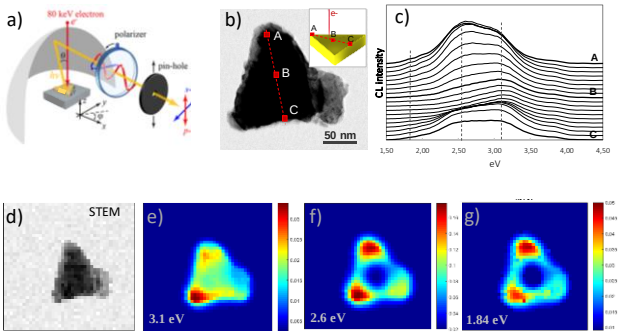

Fig.1: (a) Schematic representation of cathodoluminescence setup. MoS_2 nanoflakes lying on an ultrathin Carbon film during measurement.[1] STEM image of a triangular MoS_2 nanoflake with almost flat surface and bottom. c) Series of CL spectra along A to C in the triangular flake. (d) SEM image and (e, f, g) corresponding CL photon maps obtained after spectral deconvolution at 3.1, 2.6 and 1.84 eV respectively.

References:

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