Raman mapping few-layer MoS_2 to develop flexible electronics

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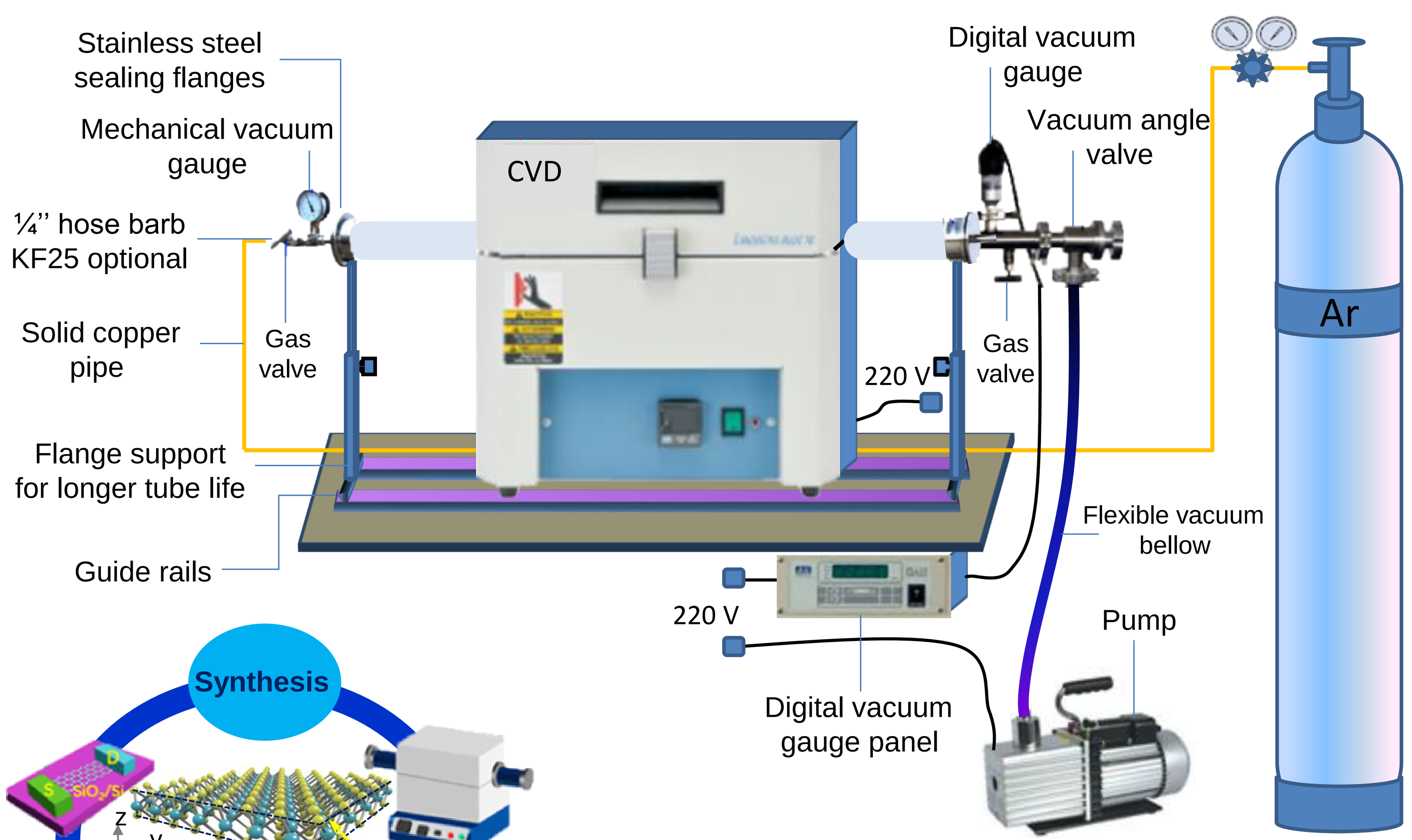
INTRODUCTION

Molybdenum disulfide (MoS_2) as the most typical member of the transition metal dichalcogenides family has attracted increasing attention recently due to its extraordinarily different material properties compared with conventional bulk materials. The MoS_2 possesses a high Young's modulus, high strength, and outstanding carrier mobility. By exploiting the unique mechanical and mechanoelectrical transduction properties, MoS_2 can be used in wide-ranging applications, including flexible electronics and strain sensors.

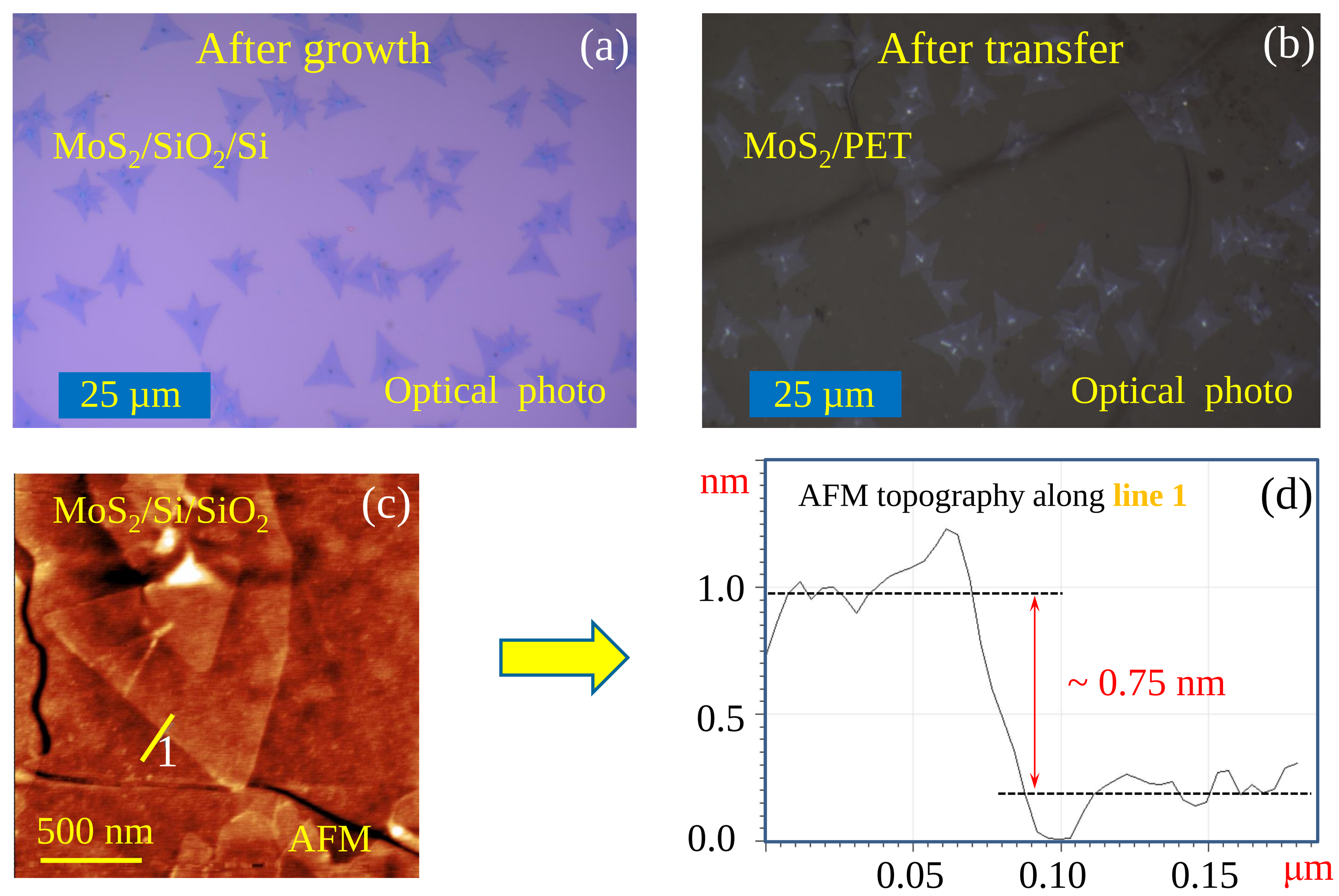
One of the main tasks at the beginning of the investigation was to optimize the parameters of the synthesis of MoS_2 monolayer without defects over a large area. The synthesis of a high-quality defect-free monolayer depends on many factors, such as the type of substrate, the quality of the starting material, pressure, temperature, gas flow, and so on. The chemical vapor deposition (CVD) method was used for the synthesis. Another direction was the development of a protocol for the transfer of these layers on the prepared flexible substrate. One of the transfer methods was the use of a layer of poly-(methyl methacrylate) (PMMA) coated by spin coating method on MoS_2 and growth substrate (SiO_2/Si) to lift off the PMMA/MoS_2 stack.

PREPARATION

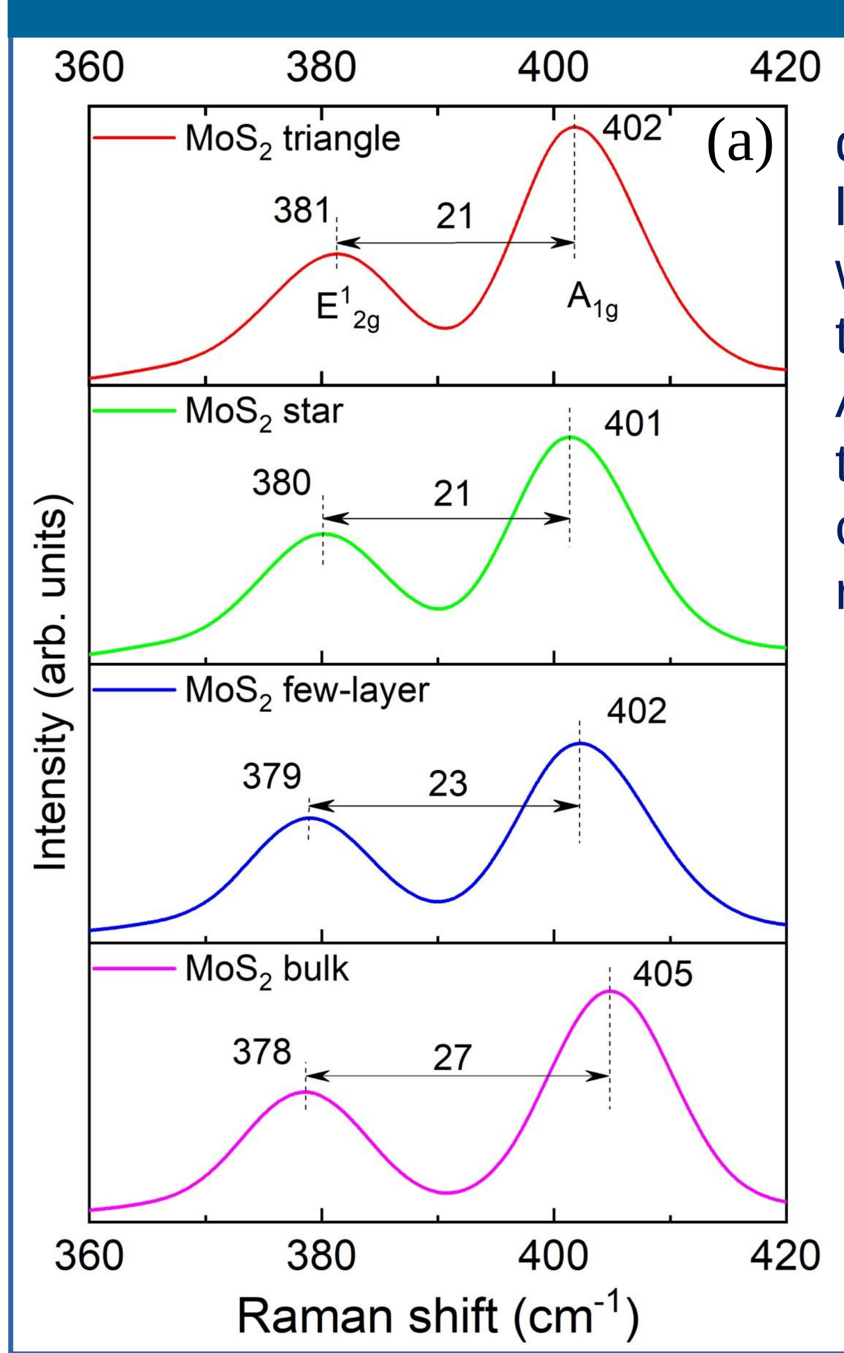


The high-quality 2D semiconductor by chemical vapor deposition was grown. At each stage, we determined material quality using Raman spectroscopy and atomic force microscopy (AFM).

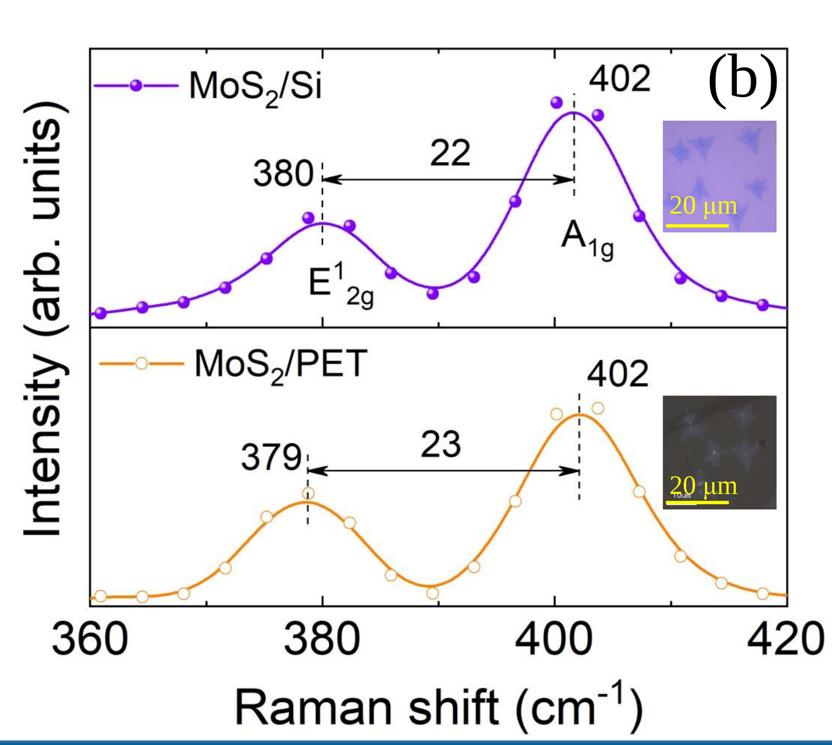
MORPHOLOGY

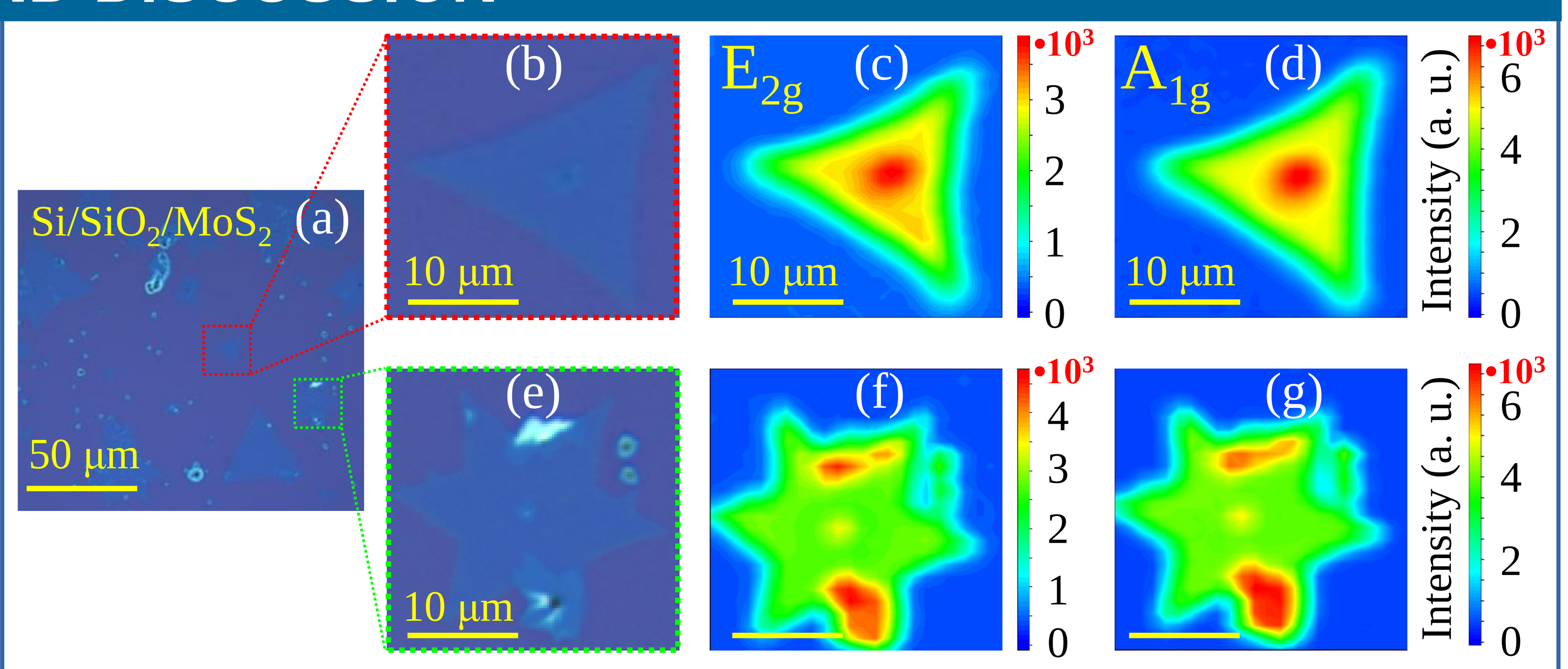


RESULTS AND DISCUSSION



Raman spectroscopy was used for demonstrated the mono- and few-layer MoS_2 (a) Also, MoS_2 monolayers were transferred to a flexible substrate to develop a flexible electronic device. As can be seen from figure (b) below, this was successfully carried out, as confirmed by optical and structural research methods.





(a) The optical photo of surface MoS_2 flakes grown on SiO_2/Si substrate by CVD method. (b, e) The Raman mapping area of MoS_2 flakes (triangle and star). The mapping of E_{2g} (c, f) and A_{1g} (d, g) bands corresponds to the area in the optical photo.

Raman mapping showed good quality MoS_2 monolayers, but that area is not large and only flakes. We need to continue studying the growth modes to get large monolayers, that are easier to use in flexible electronics.

CONCLUSIONS

1. The mono- and few-layer of MoS_2 flakes (triangles and stars) were grown. Raman spectroscopy and atomic force microscopy made it possible to clarify the number of layers and their quality.
2. MoS_2 flakes were transferred to a flexible substrate to develop a flexible electronic device.
3. The growth of a high-quality defect-free MoS_2 monolayer on large areas of more than 100 μm opens up prospects for implementation in flexible electronics.

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