Patterned growth of transition metal dichalcogenides monolayers for electronic and optoelectronic device applications

Antony George[1], Ziyang Gan[1], Emad Najafidehaghani[1], Seung Heon Han[1], Sai Shradha[2], Fatemeh Abtahi[2], Christof Neumann[1], Julian Picker[1], Tobias Vogl[2], Uwe Hübner[3], Falk Eilenberger[2] and Andrey Turchanin[1] [1]*Institute of Physical Chemistry, Friedrich Schiller University Jena, 07743 Jena, Germany,* [2]*Institute of Applied Physics, Friedrich Schiller University Jena, Albert-Einstein-Str 15, 07745 Jena, Germany,* [3] *Leibniz Institute of Photonic Technology (IPHT), Albert-Einstein-Str. 9, 07745 Jena, Germany*
antony.george@uni-jena.de

Abstract

We present a simple, large area and cost effective soft lithographic method for the patterned growth of high-quality two-dimensional transition metal dichalcogenides (TMDs). Initially, a liquid precursor (Na_2MoO_4 in aqueous solution) is patterned on the growth substrate using micro-molding in capillaries (MIMIC) technique. Subsequently, a chemical vapor deposition (CVD) step is employed to convert the precursor patterns to monolayer, few layers, or bulk TMDs, depending on the precursor concentration. The grown patterns were characterized using optical microscopy, atomic force microscopy, Raman spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy, and photoluminescence spectroscopy to reveal their morphological, chemical, and optical characteristics. Additionally, we have realized electronic and optoelectronic devices using the patterned TMDs and tested their applicability in field effect transistors (FETs) and photodetectors. The photodetectors made of MoS_2 line patterns shows a very high responsivity of 7674 A/W and external quantum efficiency of 1.49×10^6%. Furthermore, the multiple grain boundaries present in patterned TMDs enabled the fabrication of memtransistor devices. The patterning technique presented here may be applied to many other TMDs and related heterostructures, potentially advancing the fabrication of TMDs based device arrays.

References

[1] Ziyang Gan, Emad Najafidehaghani, Seung Heon Han, Sai Shradha, Fatemeh Abtahi, Christof Neumann, Julian Picker, Tobias Vogl, Uwe Hübner, Falk Eilenberger, Antony George and Andrey Turchanin, Submitted (2022)

Figure

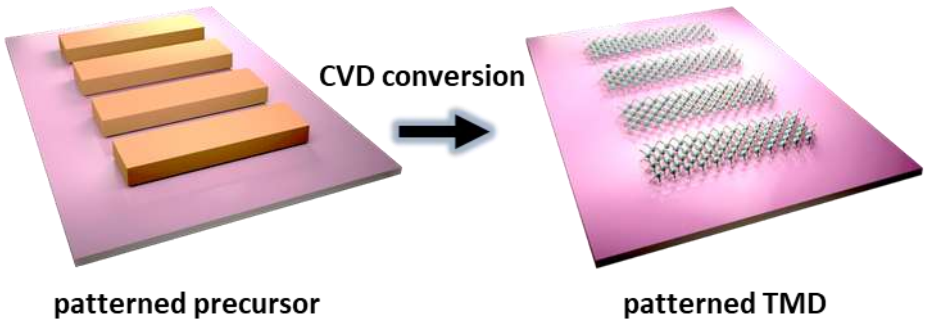

Figure 1: Schematic representation of the patterning process for transition metal dichalcogenides (TMDs)