



SMENA

Tech AB

[www.smena-tech.com](http://www.smena-tech.com)

Browse our website to overview our offers. Contact us in case you have questions or would like to order our products.

## WE FABRICATE NANOSTRUCTURED LAYERED MATERIALS

We work with van der Waals materials known as transition metal dichalcogenides (TMDs). TMDs is an emerging class of materials for new research frontiers and future applications.

Nanopatterning can change TMD properties in a structure-dependent manner. Our service is to fabricate and deliver such structures.

We offer a variety of unique nanostructured TMDs, including atomically sharp edges and exclusive zigzag terminations. These samples are obtained using our

patented AtomicEdge technology, which combines reactive ion etching with subsequent anisotropic etching.

Nanostructured TMDs are attractive for multiple applications, ranging from structural colors, nanophotonics and optoelectronics to mechanical filters and catalysis. We welcome custom designs to fit your application.

Our service is based on a long-term experience of working with TMDs and nanofabrication.

# NANOSTRUCTURED TMDs

# OUR PRODUCTS

## TABLE OF TECHNICAL SPECIFICATIONS

- Pitch = 200 nm
- TMD thickness = 10-100 nm (specified by customer)
- Flake size approximately 100x100 microns
- Substrate = thermally oxidized silicon

## PRODUCT DESCRIPTION

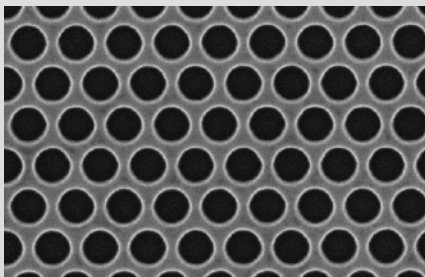
We offer nanostructured TMDs fabricated using a combination of electron beam lithography and reactive ion etching.

The standard list of available TMDs include:  $\text{MoS}_2$ ,  $\text{WS}_2$ ,  $\text{MoSe}_2$ ,  $\text{WSe}_2$ ,  $\text{MoTe}_2$ ,  $\text{ReS}_2$  and  $\text{TaS}_2$ .

The nanostructured pattern is predefined by the electron beam lithography file, which can be both made by us or provided by a customer.

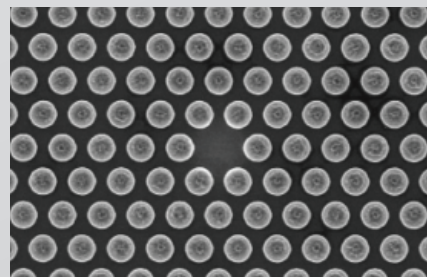
Other TMDs are available upon request or can be provided by a customer.

### 1 STANDARD HEXAGONAL HOLE ARRAY



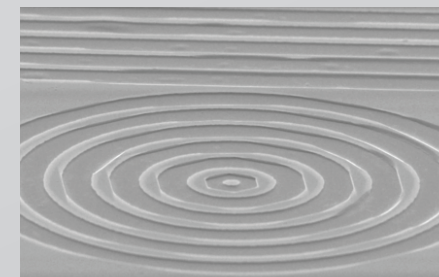
Hole diameter = 100 nm

### 2 STANDARD HEXAGONAL DISK ARRAY



Disk diameter = 100 nm

### 3 STANDARD TMD GRATING



Groove width = 100 nm

## NANOSTRUCTURED MoS<sub>2</sub> WITH ATOMICALLY SHARP EDGES

### TABLE OF TECHNICAL SPECIFICATIONS

- Pitch = 200 nm
- MoS<sub>2</sub> thickness = 10-100 nm (specified by customer)
- Flake size approximately 100x100 microns
- Substrate = thermally oxidized silicon

### 4 STANDARD HONEYCOMB HEXAGONAL HOLE ARRAY



Hole diameter = 100 nm

### PRODUCT DESCRIPTION

MoS<sub>2</sub> belongs to a class of layered van der Waals materials known as transition metal dichalcogenides (TMDs). Monolayer MoS<sub>2</sub> is the first known monolayer TMD that has proven to have unique optical and electronic properties, thanks to its large exciton binding energy and direct bandgap. Our company offers a special type of nanostructured MoS<sub>2</sub> with atomically sharp edges and exclusive zigzag terminations. Zigzag edges are metallic and ferromagnetic, which makes them very different from semiconducting MoS<sub>2</sub> planes. Such zigzag edges are also known for their high catalytic activity in e.g. hydrogen evolution reaction. These unique properties make nanostructured MoS<sub>2</sub> attractive for multiple applications, ranging from structural colors, nanophotonics

and optoelectronics to mechanical filters and catalysis.

Our samples are obtained using a patented AtomicEdge technology, which combines reactive ion etching with subsequent anisotropic etching. This allows to produce highly ordered nanostructures of predefined complexity with atomically sharp edges and over areas limited only by the initial MoS<sub>2</sub> flake size (which can be up to a few millimeters). The excitonic properties of MoS<sub>2</sub> remain as in the unpatterned material just a few nanometers away from the edge.

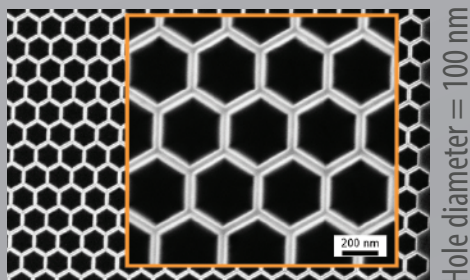
The nanostructured pattern is predefined by the electron beam lithography file, which can be both made by us or provided by a customer.

## NANOSTRUCTURED WS<sub>2</sub> WITH ATOMICALLY SHARP EDGES

### TABLE OF TECHNICAL SPECIFICATIONS

- Pitch = 200 nm
- WS<sub>2</sub> thickness = 10-100 nm (specified by customer)
- Flake size approximately 100x100 microns
- Substrate = thermally oxidized silicon

### 5 STANDARD HONEYCOMB HEXAGONAL HOLE ARRAY



### PRODUCT DESCRIPTION

WS<sub>2</sub> belongs to a class of layered van der Waals materials known as transition metal dichalcogenides (TMDs). Monolayer WS<sub>2</sub> has unique optical and electronic properties, thanks to its large exciton binding energy and direct bandgap. We offer a special type of nanostructured WS<sub>2</sub> with atomically sharp edges and exclusive zigzag terminations. Zigzag edges are metallic and ferromagnetic, which makes them very different from semiconducting WS<sub>2</sub> planes. Such zigzag edges are also known for their high catalytic activity in e.g. hydrogen evolution reaction. These unique properties make nanostructured WS<sub>2</sub> attractive for multiple applications, ranging from structural colors, nanophotonics and optoelectronics to mechanical filters and catalysis.

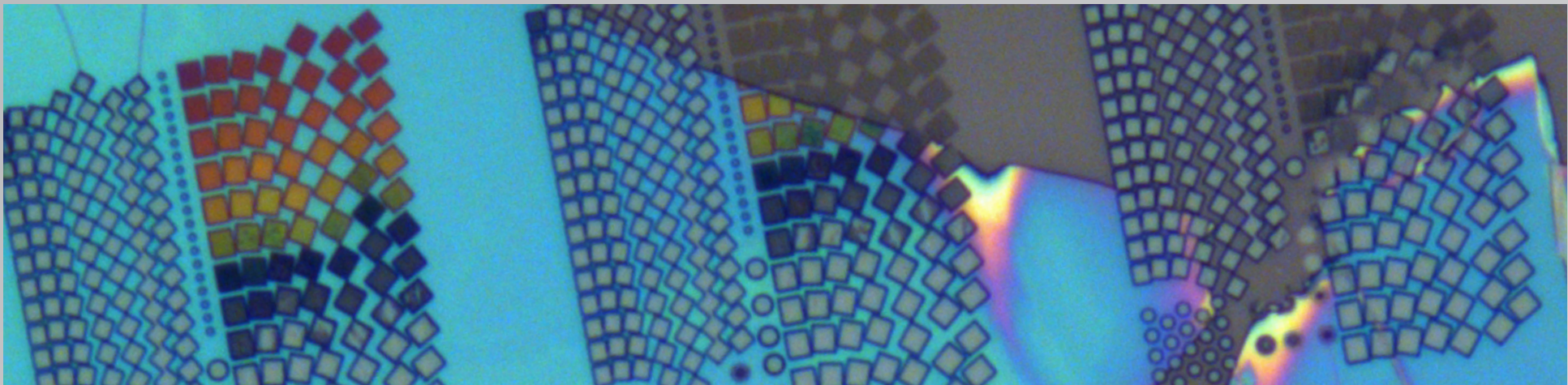
Our samples are obtained using a patented AtomicEdge technology, which combines reactive ion etching with subsequent anisotropic etching. This allows to produce highly ordered nanostructures of predefined structure and complexity with atomically sharp edges and over large areas limited only by the initial WS<sub>2</sub> flake size (which can be up to a few millimeters). The excitonic properties of WS<sub>2</sub> remain as in the unpatterned material just a few nanometers away from the edge.

The nanostructured pattern is predefined by the electron beam lithography file, which can be both made by us or provided by a customer.

# ABOUT PRODUCTION

## OPTICAL MICROSCOPY

Nanostructured TMDs support vivid colors across the whole visible spectrum and beyond. An example of true-color optical dark-field and bright-field images of nanopatterned TMD is shown below.



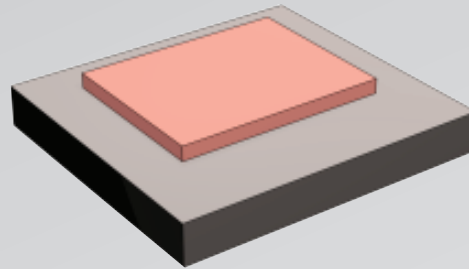
## ABOUT PRODUCTION

### PROCESS DESCRIPTION

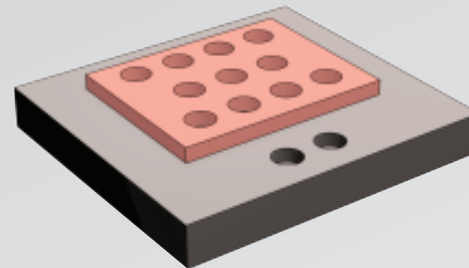
Nanopatterning of TMDs that we offer consists of two optional steps:

1. electron beam lithography (EBL) with subsequent reactive ion etching (RIE).

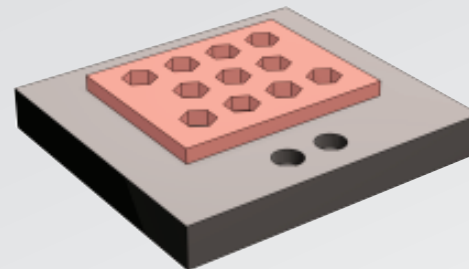
2. patented AtomicEdge technology, which forms atomically sharp hexagonal edges in our structures and allows to control the resulting pattern down to a precision of just a few nanometers.



1

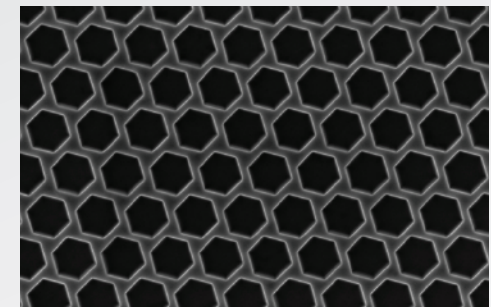
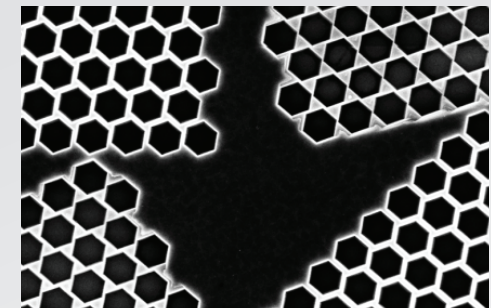
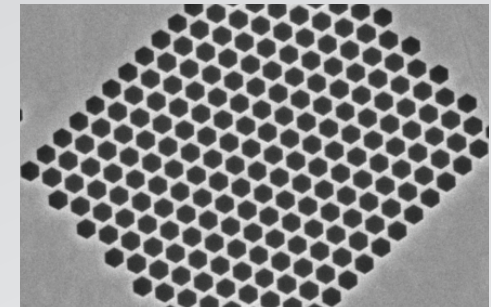


2



### ELECTRON MICROSCOPY

Here you find a selection of high-quality electron microscopy images, which exemplify our products and may inspire your application:



WE OFFER TMD NANOSTRUCTURES  
WITH NEARLY ATOMIC PRECISION.

OUR DESIGNS AND PRODUCTS  
ARE VERY FLEXIBLE AND  
CUSTOMER-ORIENTED.

PLEASE CONTACT US  
TO GET FURTHER  
ASSISTANCE.

## ABOUT US

- Email: [sales@smena-tech.com](mailto:sales@smena-tech.com)
- Address: SMENA Tech AB, Gothenburg, SWEDEN
- Organisation number: 559214-7242

[sales@smena-tech.com](mailto:sales@smena-tech.com)

Contact us at to discuss the price  
of our service. Note that samples  
can be fabricated in a customer-  
specific manner.



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