TMD Nanopillars for non-linear optics

Nanoscale structures promise great advances for the technologies of future, but sometimes their fabrication becomes challenging. In a recent work published at Advanced Applied Materials, researchers from Conesa-Boj Lab, at the Quantum Nanoscience department of the TU Delft create nanopillars of Transition metal dichalcogenides (TMD) materials with amazing non-linear optical properties.

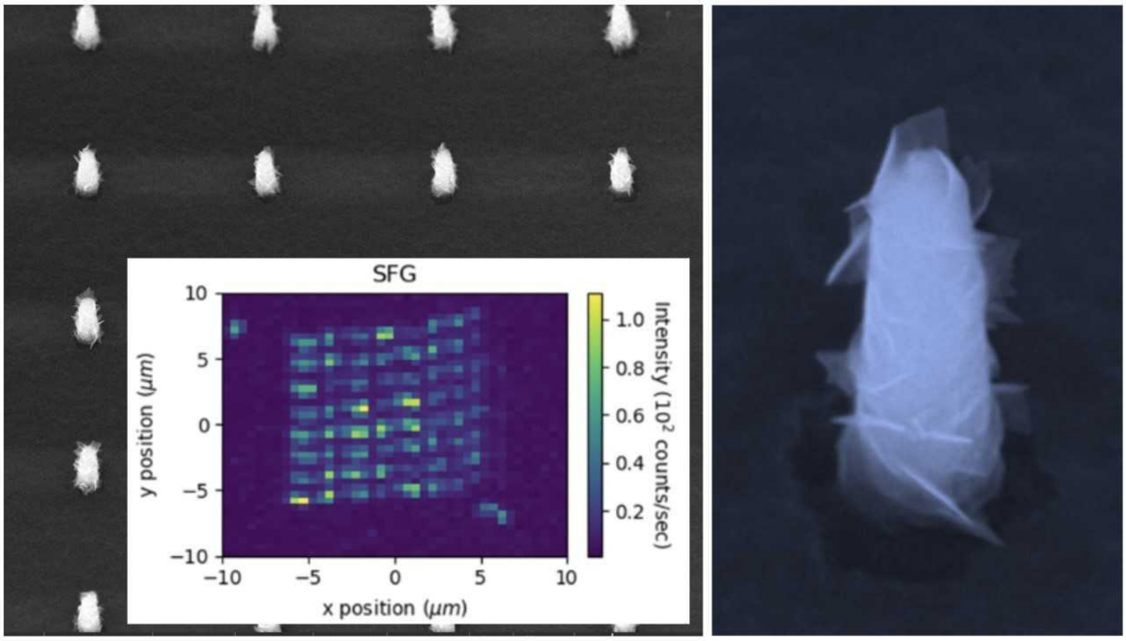
What are TMDs? You have probably heard about graphene, a monolayer of carbon atoms in a honeycomb lattice, and therefore a pure 2D material. This awesome material is obtained by peeling off the atomic layers that form graphite (such as the one in a pencil!). After graphene, researchers found out that they could turn other materials into monolayers, for example, transition metal dichalcogenides (TMD). The bonding forces in these crystals are very strong in-plane, but very weak out of plane, thus favouring the formation of thin layers.

This electronic configuration is great to create monolayers, but what if we want to build other structures? This becomes challenging because TMDs really like to form flakes, but Conesa-Boj and collaborators found a way to overcome this problem and create beautiful new structures. In their work, they create nanopillars (NP) whose core is made of molybdenum (Mo) and the shell of molybdenum disulfide (MoS2), a TMD. One-dimensional structures made from graphene such as carbon nanoribbons have been studied and show great properties, but similar structures out of TMDs remained unexplored. To build these one-dimensional TMD structures they start growing thick Mo layers. After this, electron beam lithography is used to create the basic pattern that will serve as a basis for the nanopillar. Once the Mo nanopillars are done, they are exposed to a sulfur-rich environment, giving rise to the MoS2 shell.

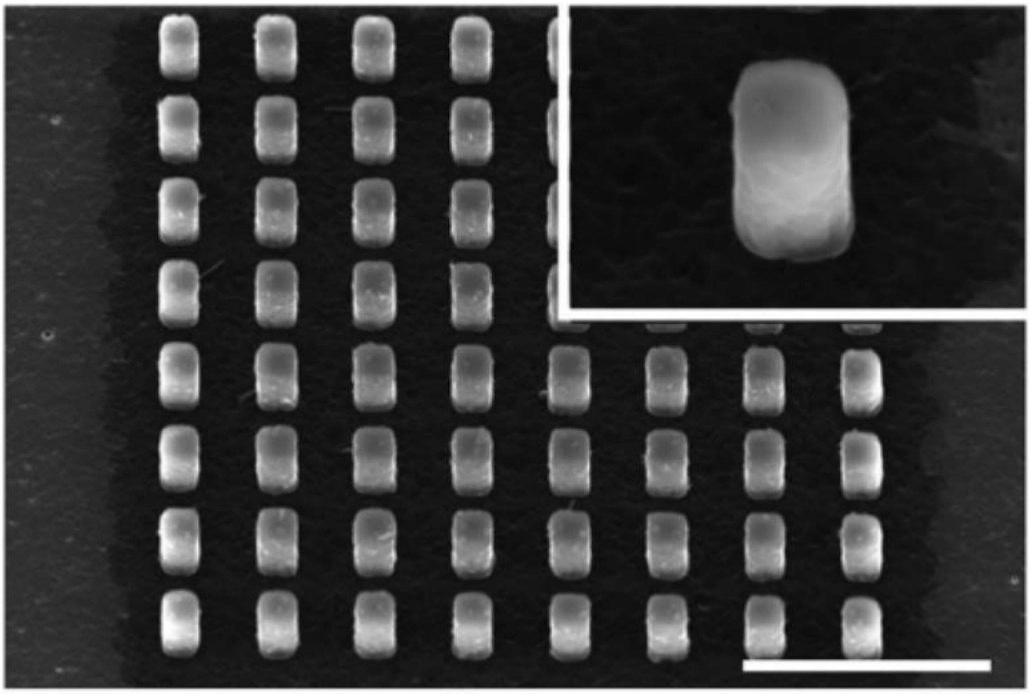
Why are these structures useful? MoS2 is well known for his special non-linear optical properties. One of these is the presence second harmonic generation: the process in which a material can combine two photons into a new more energetic one. What Conesa-Boj and collaborators find is that these properties are still present in nanopillars, and they can be tuned by how these are grown! The time of exposure to the sulfur environment and the thickness of the initial Mo plays a role on the final properties of the nanopillars.

Their work shows a way of using the optical properties of TMDs with the great advantage of controlling where these processes take place, thanks to their 1D structure. It also serves as a steppingstone for follow up works on 1D TMDs structures and their properties. You can read the original work *Position-Controlled Fabrication of Vertically Aligned Mo/MoS2 Core–Shell Nanopillar Arrays* from Advanced Applied Materials: https://doi.org/10.1002/adfm.202107880

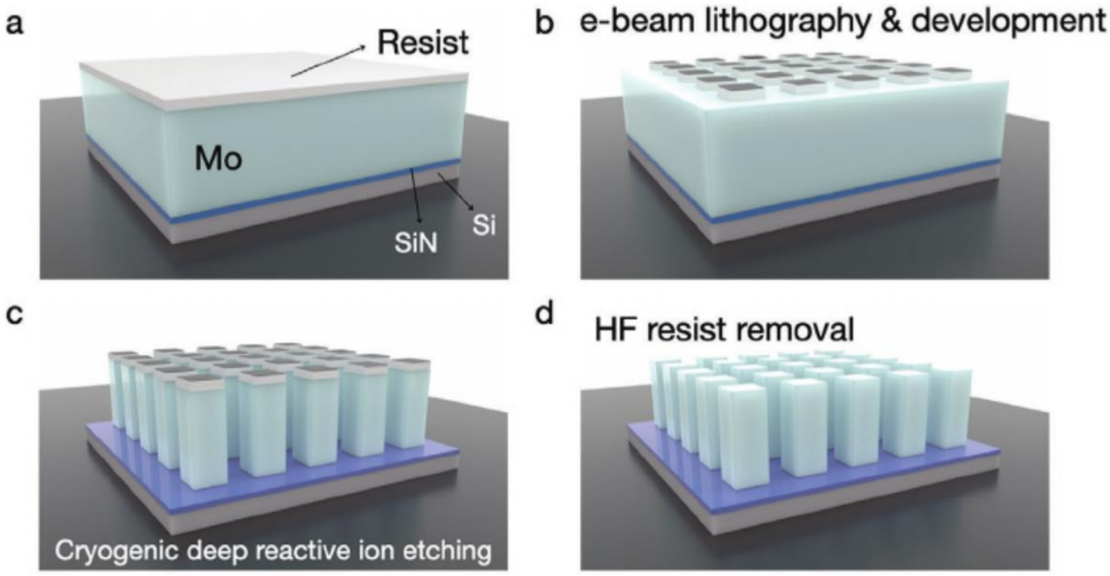
IMAGES



Summary picture containing results and electron microscope images of the nanopillars [1].



Nanopillars array [2]



Fabrication process [2].

[1] Courtesy of Prof. Conesa-Boj.

[2] *Position-Controlled Fabrication of Vertically Aligned Mo/MoS2 Core–Shell Nanopillar Arrays* from, Advanced Applied Materials, https://doi.org/10.1002/adfm.202107880