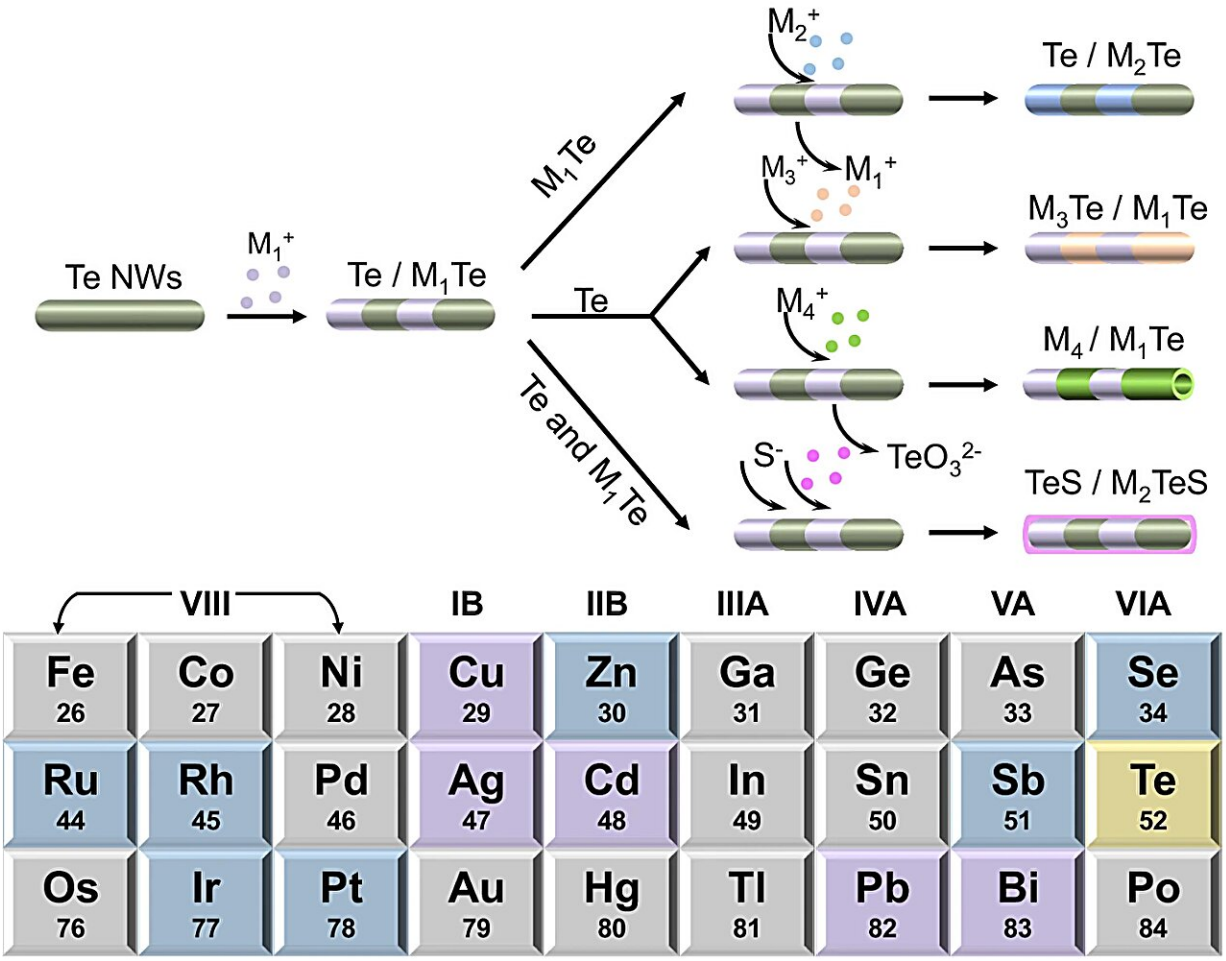
Synthesis method for 1D segmented heteronanostructures uses stress-induced axial ordering

July 3 2024, by Huang Rui



Above: Schematic illustration of the chemical conversion from Te/M1Te template, showing controllable reactions with the residual Te, the generated M1Te, and both. Below: Overview of the resulting 2nd (highlighted in purple)

and 3rd generations (highlighted in indigo) from the initial 1st Te template (highlighted in yellow). Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-47446-7

One-dimensional segmented heteronanostructures (1D-SHs) are promising candidates in fields such as photoelectrocatalysis (PEC) and thermoelectrics. Currently, the synthesis of 1D-SHs mainly focuses on sulfides and selenides, with relatively less research on telluride materials, yet tellurides have significant application prospects in energy storage and optoelectronics. However, a simple and controlled synthesis of telluride 1D-SHs materials has always been challenging.

A research team led by Academician Yu Shuhong from the University of Science and Technology of China (USTC) of Chinese Academy of Sciences (CAS) has developed a method for synthesizing 1D-SHs based on stress-induced axial ordering. They also tracked the changes in stress and strain energy during the evolution of periodic ordered structures using a continuous phase field model.

The study is published in *Nature Communications*.

First, the researchers selected tellurium nanowires (NWs) with high aspect ratio as the model structural units, and dispersed them in ethylene glycol, with the complexing agent NH_4SCN and a stoichiometrically deficient amount of silver ions Ag^+ added. Then the Te/Ag_2Te 1D-SHs with distinct regular segmented structures appeared quickly.

To verify its properties, the researchers used transmission electron microscopy and energy dispersive X-ray spectrometer to observe its segmented uniformity and determine the elemental distribution. The researchers further verified the biphasic nature of the Te/Ag_2Te

segmented heterostructures using methods such as X-ray diffraction spectra, Raman spectroscopy, and X-ray photoelectron spectroscopy.

In addition, through in-situ liquid phase transmission electron microscope, researchers summarized that the formation process of Te/Ag_2Te 1D-SHs went through three-stages evolution: island generation, stripe penetration and segment ordering.

To explore the energy change and stress distribution during the formation of Te/Ag_2Te 1D-SHs, the researchers reproduced the formation, growth, and ordering processes of Ag_2Te island structures.

The results showed that the initially generated Ag_2Te islands were affected by radial tensile stress and axial compressive stress, growing along the radial direction to form poor-ordered stripe structures. Subsequently, theses stripe structures gradually evolve into periodic segments.

Researchers also synthesized a series of 1D-SHs of tellurides, including materials like Pd, Cu, Bi, Cd, etc. In addition to this, by combining simple chemical post-transformations, the researchers constructed a library of axial 1D-SHs materials involving 13 elements in the periodic table.

Researchers also proposed a simple solution-phase method for synthesizing 1D-SHs, and combined with a simple chemical post-transformation process, 25 1D-SHs including 17 NW-NW and 8 NW-nanotube nanostructures.

This work not only enriches the material library of 1D-SHs, but also provides a new approach for the precise preparation of function-oriented nanomaterials and the exploration of ordered reconstruction of heteronanostructures.

More information: Qing-Xia Chen et al, Stress-induced ordering evolution of 1D segmented heteronanostructures and their chemical post-transformations, *Nature Communications* (2024). DOI: 10.1038/s41467-024-47446-7

Provided by University of Science and Technology of China