

MOCVD self-assembly and characterization of Sb_2Te_3 and Ge-doped Sb-Te Nanowires

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Sb_2Te_3 is a chalcogenide compound which can find application in the field of Phase Change Memories (PCM) and a more interesting alloy has been recently reported as Ge-doped Sb-Te, with a 10% Ge at concentration and a low Sb/Te ratio, granting a high-speed, low power memory device [1]. Among phase change nanomaterials, Sb_2Te_3 nanowires (NWs) exhibit an interesting memory switching behavior [2]; this kind of structures allow a defect-free scaling down in the fabrication of high performing PCM devices. While some works are present on the vapor transport deposition of Sb_2Te_3 nanowires (NWs) by the VLS mechanism and by catalyst-free methods [2,3], no report can be found on the MOCVD growth of Sb_xTe_y NWs, notwithstanding the high process control, large area deposition and industrially strategic interest of this technique.

Following our publications on the self assembly of GeTe NWs [4] and $\text{Ge}_1\text{Sb}_2\text{Te}_4$ NWs [5] by MOCVD, we present here the MOCVD-based self assembly of Ge-doped Sb-Te NWs, obtained through a VLS mechanism, assisted by Au catalyst nanoseeds.

The morphological analysis of the NWs was based on Field emission Scanning Electron Microscopy observations; structural and compositional analyses were performed by X-Ray Diffraction (XRD) and Total Reflection X-Ray Fluorescence (TXRF), respectively. Structural and compositional analyses were obtained also on single nanostructures by High Resolution Transmission Electron Microscopy (HR-TEM) with energy-dispersive X-ray (EDX) capabilities. Phase change properties were assessed through an electrical characterization of single NWs, thanks to the deposition of Pt electrodes, employing Focused Ion Beam (FIB). The NW phase change was observed through nanosecond pulsed current/voltage measurements.

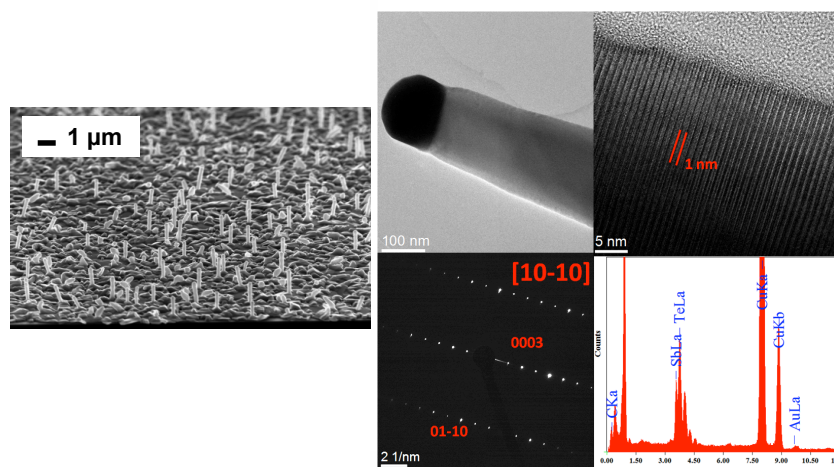


Figure 1 Left: SEM image of Sb_2Te_3 NWs, Right: HRTEM and EDX analysis of a single NW, showing the pure Sb_2Te_3 NW structure and composition.

The presence of the gold catalyst on the NWs tip confirmed that the growth is driven by the Vapor-Liquid-Solid (VLS) mechanism; no trace of Au was found inside the NWs. The typical diameter of the NWs resulted to be 50 nm and the length up to 3 μm . The type of Au nanoseeds influenced both the NW morphology and the Ge incorporation. In particular, TEM observations revealed that both pure defect-free Sb_2Te_3 (fig. 1) and Ge-doped Sb-Te (fig. 2) single crystal NWs can be obtained.

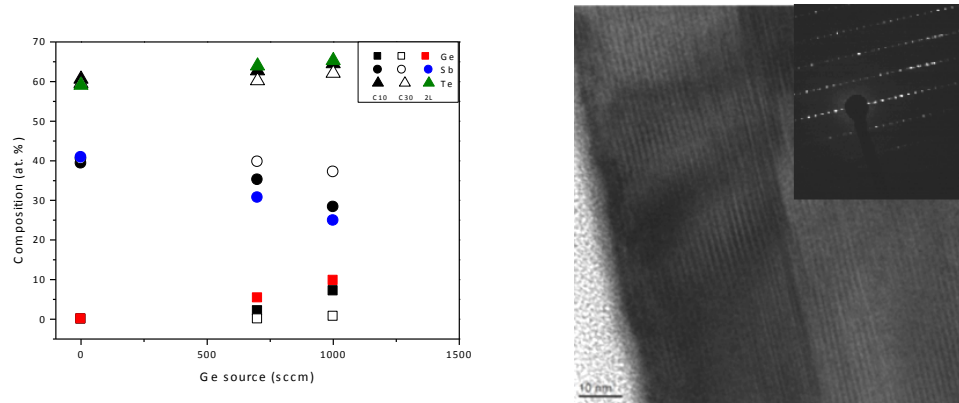


Figure 2: Left: TXRF analysis of the grown material as a function of Ge precursor source flow. Right: TEM analysis of a single NW, whose crystalline phase was identified as hexagonal $\text{Ge}_1\text{Sb}_2\text{Te}_4$ and chemical composition as $\text{Ge}_{0.09}\text{Sb}_{0.25}\text{Te}_{0.66}$.

Short voltage pulses (300 ns) triggered the electrical switching in the obtained NWs. It was found that the resistance of the wire was $\sim 14 \text{ k}\Omega$ in the as-grown (i.e., crystalline) phase, and $\sim 9.1 \text{ M}\Omega$ after amorphization, close to those obtained in nanoscale SbTe-line memory cells [6]. The results indicated that the MOCVD-growth of pure and Ge-doped Sb-Te NWs is a promising method, in view of future, highly scaled phase change memory devices.

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