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Nanowire Formation Using Templates of Self-Assembled Nanofold Networks on Surfaces of Layered Crystals

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The vacuum deposition of Cu onto flat surfaces of layered VSe_2 crystals is known to induce a self-assembled formation of hexagonal networks of nanostructures (Fig. 1), which have recently been identified as nano-sized surface folds ("nanofolds"). These nanofold networks form as result of compressive stress that builds up upon Cu-intercalation [1-3]. In order to explore the potential of such network structures for nanoscale engineering, the effects of UHV deposition of (non-intercalating) gold onto these pre-patterned surfaces has been investigated for different deposition parameters (Au coverage 1 nm - 2.5 nm, temperatures RT - 400°C) by methods of high-resolution and analytical TEM, including HAADF/STEM and spatially-resolved EDXS measurements, and by FESEM.

The nucleation and growth of gold nanostructures turned out to be strongly affected by the substrate temperature. Deposition at ambient temperature results in largely interconnected Au layers and the absence of wire formation along surface nanofolds. The Au layers show an epitaxial orientation relationship to the VSe_2 substrate, characterized by Au[111]/VSe_2[0001] and Au{220}/VSe_2{11-20}. Deposition at T = 400°C leads to formation of a homogeneous distribution of small Au-clusters with the same orientation relationship on the surface, also largely unaffected by the presence of the nanofold network. In the medium temperature range, at 200°C and 300°C, the network shows a pronounced template behavior for the growth of Au nanostructures (Figs. 2,3). At 200°C the nanofolds are decorated by larger Au-clusters (Fig. 2A), which are often elongated along the network segments. The clusters are already partly interconnected but still do not form continuous nanowires. In addition small Au-clusters are homogenously distributed in the mesh regions of the network. Both large and small clusters show the same epitaxial orientation relationship (Fig. 2B). At 300°C the same type of Au nanostructures are observed as for 200°C. In addition many nanofold segments show wetting with a thin Au-rich layer (Fig. 3), which often extends over nodes of the network. These results suggest that the formation of complete nanowire networks on these surface structures may be achievable by further optimizing the conditions of metal deposition [4].

References

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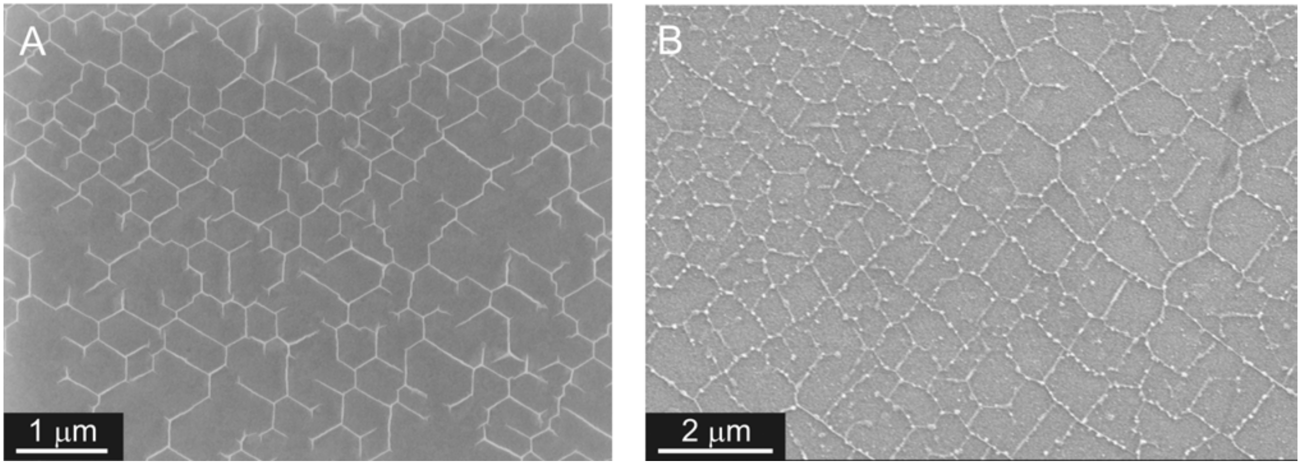

Fig.1 A: Hexagonal networks of surface nanofolds on layered VSe_2 (template). B: Decoration of the nanofolds with Au-clusters after deposition at 200°C. (SEM-images)

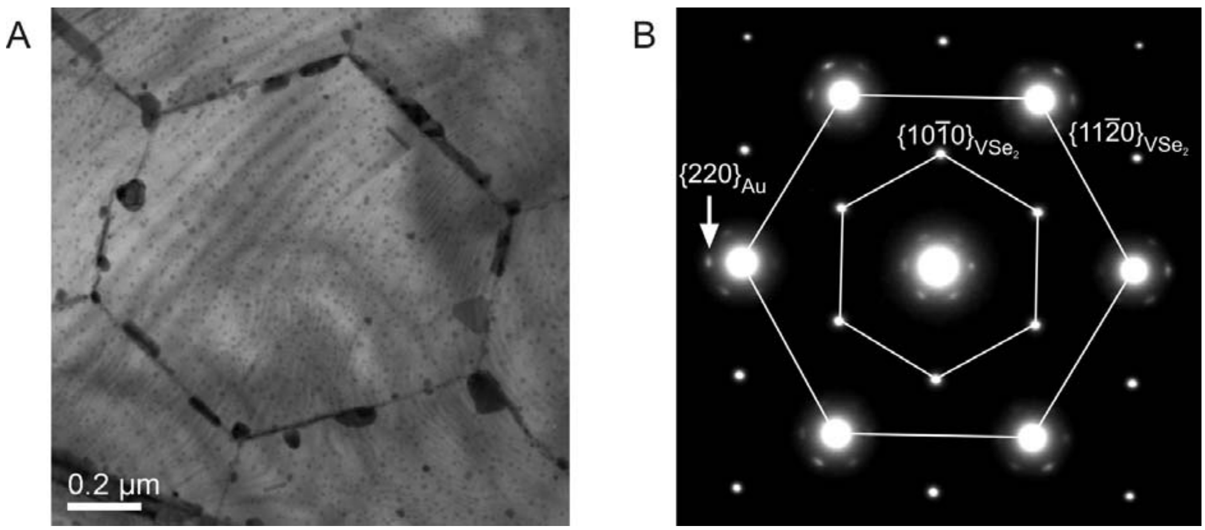

Fig.2 Decoration of nanofold networks with Au-clusters upon 1nm Au deposition at 200°C.
A: SEM-image, B: Transmission electron diffraction pattern.

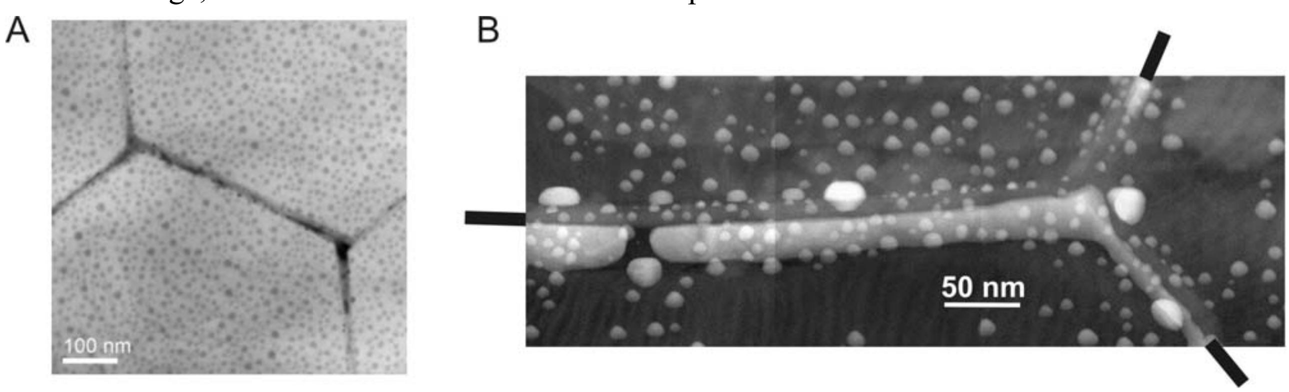

Fig.3 Au-rich "wetting" of nanofolds observed at a deposition temperature of 300°C. The film often covers whole network segments and even extends across nodes. A: Plan-view TEM image, B: HAADF/STEM Z-contrast image (the three nanofolds meeting at the node are marked).

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