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Single Step Synthesis of Ge-SiO_x Core-Shell Heterostructured Nanowires

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Supplementary Information

In addition to the 6:2 and 4:1 Si:Ge precursors a 7:1 precursor material was also investigated. All TEM images collected showed Ge-Au nanoparticles as shown in figure SI1. Due to the small amounts of Ge present in the precursor material there is insufficient Ge to result in nanowire growth. This is further confirmed by the EDX analysis which demonstrates the particles were predominantly made up of Au and Ge (figure SI1(c)).

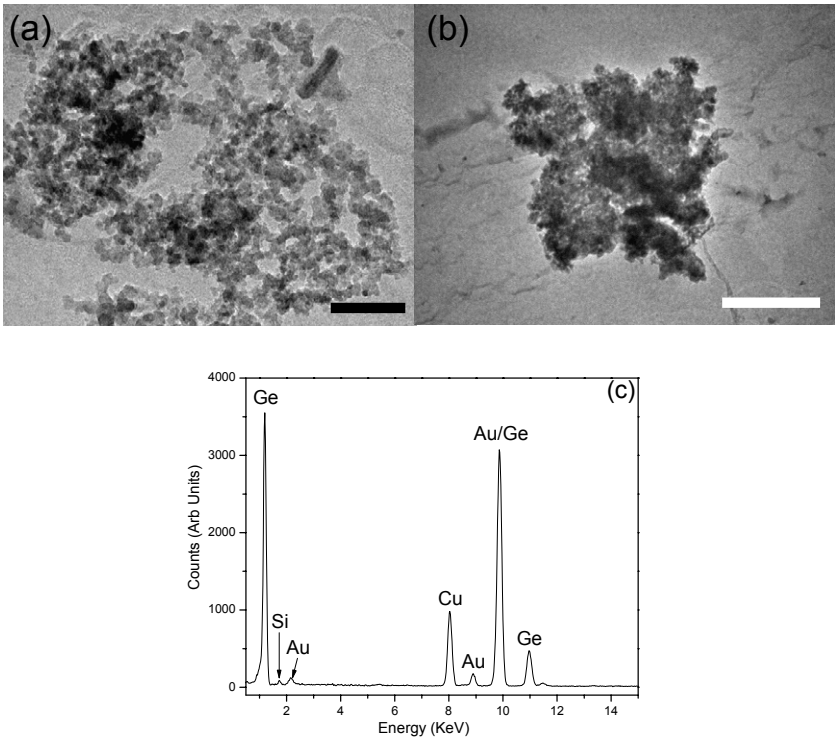


Figure SI1: (a) and (b) typical TEM images collected for materials synthesised using the Si:Ge ratio of 7:1 in the precursor. These images clearly show the Au particles with no evidence of nanowire growth observed. (a) Scale bar represents 100 nm, (b) Scale bar represents 500 nm and (c) typical EDX spectrum collected for these materials showing the presence of Au and Ge. Note the contribution of Cu comes from the Cu grid used for TEM analysis

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Fig. 1 (c) shows an XRD pattern for the material produced from the 7:1 precursor. Notably this pattern includes a graphite reflection at ~ 25 °2θ. The presence of this reflection can be attributed to the formation of graphite due to the cracking of the hexane solvent.

In the experiments conducted here with high oxygen and water contents (i.e. experiments conducted in air with 'bench-top' solvent) it can be seen that using Ni- or Au-seed crystals results in very different shell thicknesses. It can be considered that under these conditions, after the formation of the Ge nanowire, the formation of amorphous silica particulates competes with the formation of the shell. In the case of the Au-seeded nanocables only a thin shell is deposited suggesting that this competing reaction favours the formation of particulates. However, in the case of the Ni-seeded nanocables the reaction kinetics shifts such that the system now favours the deposition of a silica shell. It is possible that these observed differences result from the different growth rates associated with the different seeding mechanisms. However when the oxygen/moisture content is much lower (i.e. experiments conducted in the glovebox with 'bench-top' solvent) the reaction kinetics in the Au-seeded sample now favour the formation of shells as apposed to particulates consistent with observations of Tuan et al with CuS seed crystals.[1] These differences in the reaction kinetics are not well understood and further investigations are required in order to fully elucidate the mechanisms involved here. However, it can be suggested that both the interactions of the different seed crystals used with the single source precursor material as well as different Ge-seed growth mechanisms and rates play a key role in the resulting nanocable morphology. Furthermore, it would be expected that control of the precursor:seed crystal ratio and further enhancement of the reaction conditions will further exert control on

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the system resulting in nanocable growth from the Si rich precursors as well as materials with alternative morphologies.

(1) H.-Y. Tuan, A. Ghezelbash, B. A. Korgel, *Chem. Mater.*, 2008, **20**, 2306.