Size tunable Si/SiGe nanowire heterostructures

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This paper reports the fabrication of Si/SiGe/Si quantum dot (QD) heterostructures, sandwiched between monocrystalline aluminium contacts using a thermally activated solid-state reaction between aluminium contacts on a SiGe NW. Such heterostuctures can have promising applications in opto-electrical devices operating in the infrared, both in detection or emission, as well as for the fabrication of spin qubits. The contacts on the NW were defined by electron beam lithography using an electron transparent silicon nitride membrane as substrate, allowing in-situ TEM combined with characterization by high resolution scanning TEM as well as energy dispersive X-ray spectroscopy.

Using electrical in-situ TEM, we monitor the propagation of a crystalline Al phase inside the NW, and observe the spontaneous formation of an epitaxial and mono-crystalline Al-Si-SiGe-Si-Al heterostructure. The advancement of the Al metal inside the NW pushes the Si atoms forward, creating a very silicon rich section between the Al metal and the original SiGe NW. First experiments indicate that the reaction stops when a segment of pure Si is created. The size of the created Si barriers appears to be depending on several parameters including the initial NW diameter, as well as the composition of the original SiGe alloy NW. In this paper we present a quantitative EDX study of the fabricated heterostructures.

Careful study of this interesting phenomenon may allow reproducible and self-limited fabrication of such heterostructures using a simple heating procedure. Moreover, the feature size of the created heterostructure does not depend on the spatial resolution of a lithography technique.

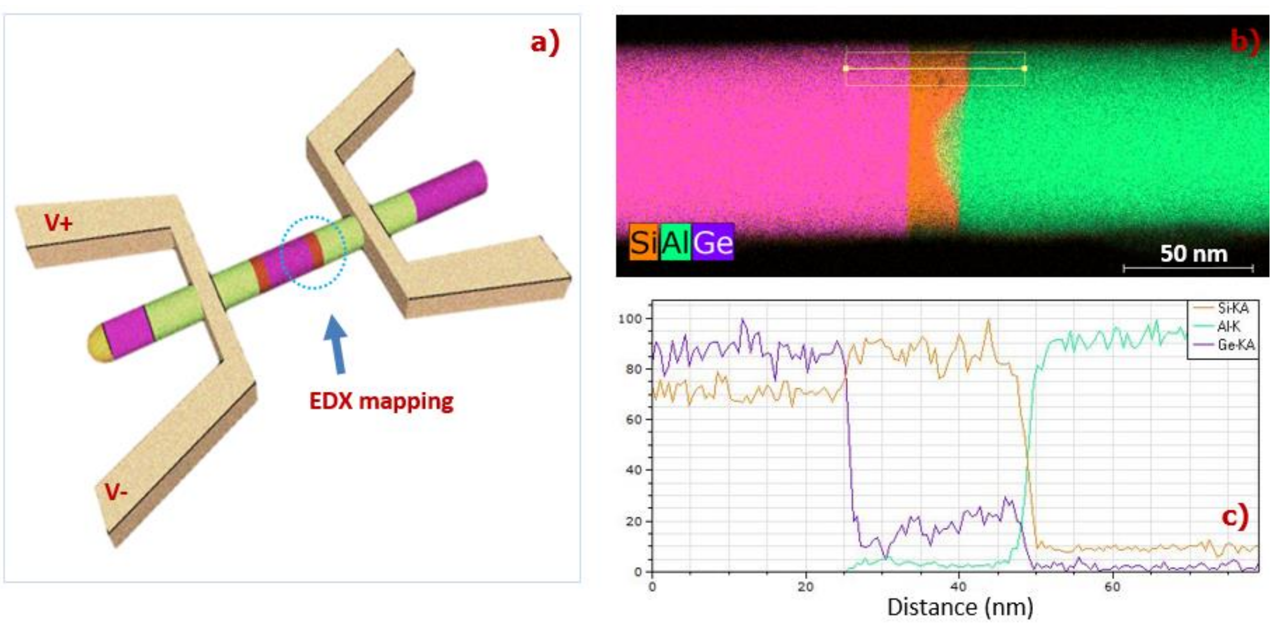

Figure 1. (a) Schematic illustration of the Si/SiGe/Si NW heterostructure formation after Aluminium propagation in the SiGe NW by Joule heating technique. The blue circle indicates the position of EDX analysis. (b) EDX mapping of elements at the interface shows the presence of Si, Ge and Al. (c) The line-scan crossing the interface demonstrates the Si "pile up" effect at the Al reaction interface.