Free-Standing Si/SiGe Nano- and Microtubes

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Rigorous size miniaturization is one of the key features in many high technology areas, such as communication technology, biotechnology and micromechanics. Recently, the method of forming various kinds of micro- and nano-objects of arbitrary shapes by scrolling of strained layer structures was introduced.[1,2] This elegant method has potential applications in all the above mentioned fields. In particular the integration of Si/SiGe nanotubes with the mature Si microelectronics offers paths to integrate new functions into the chip as well as new fabrication methods for capacitors, coils and transistors with a wraparound gate. Micro- and nanotubes might also be used as pipelines in biotechnology and as high frequency resonators in micromechanics. However, further work is required to improve the fabrication technology and to study the mechanical and electrical properties of these nano- and micro-objects. Some of these applications would require truly freestanding tubes, i.e. tubes detached over certain portions of their length from the substrates. So far, the fabrication of so-called free-standing nanotubes typically resulted in tubes in contact with the substrate over their entire length.[3] Only very limited approaches have been published for truly free-standing tubes.[4]

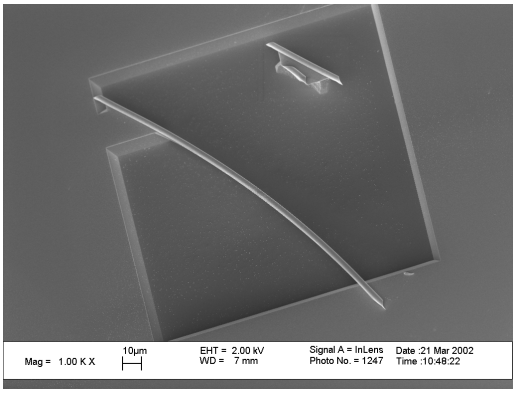

FIG. 1: 230 µm long, free-standing Si/SiGe/Cr nanotube.

We will describe a simple process to fabricate Si/SiGe nanotubes, which are attached to the substrate only at one end of the tube, as shown in Fig. 1. The length of the tube is >200 µm and the diameter amounts to 4 µm. About 80% of the length of the tube is completely detached from the substrate. The technology was found to be stable, thus all mesa structures fabricated exhibit similar tubes and no cracks or broken tubes have been detected.

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1 V. Y. Prinz *et al.*, *Proc. 24th ICPS*, Israel, 1998, p. Th3-D5.

2 V. Y. Prinz, D. Grützmacher, A. Beyer, *et al*, *Nanotechnology* **12**, 399 (2001).

3 O. G. Schmidt and N.-Y. Jin-Phillipp, *Appl. Phys. Lett.* **78**, 3310 (2001).

4 S.V. Golod, *et al.*, *Semicond. Sci. Technol.* **16**, 181 (2001).