GROWTH OF SILICON NANOWIRES BY LASER-ASSISTED CVD OF SILANE

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The low-dimensional electron confinement effects in nanostructures is one of motivation for development of new research areas in growth technologies and materials engineering. To test this fundamental concept, one-dimentional nanostructures, such as nanotubes and nanowires stay good candidates. Thus nanoelectronics is certainly now the branch with the most significant commercial impact as predictable and controllable conductance is critical to many nanoscale electronics applications. Up to now a very important work has focused on electrical transport in carbon nanotubes. However, there are important inconvenient due to the uncontrollable characteristics, metallic or semiconducting, of carbon nanotubes [1]. Furthermore, the controlling doping of semiconducting carbon nanotubes is not possible. These two points are very critical for applications in the field of devices. However, semiconductor nanowires, as silicon, have no any limitation. It stays semiconducting independently of its diameter and there is the possibility to dope the nanowires [2]. However, to connect the nanowires for electrical characterization remains the technological 'bottleneck'. The goal of our experiments is the control of horizontal growth of silicon nanowires (SiNW) between two contact leads. This study is differentiated from the traditional growth of SiNW on its heating concept. We used Ar^+ ion laser to heat locally and control the growth direction.

Sample is prepared from 30nm thickness of silicon on insulator (SOI). At first the surface is passivated by dip etching in 2% HF in order to eliminate the native oxide. Then by tightly focused laser scanning, the sample is locally heated and, since the process is ran in oxygen atmosphere, oxidized. Oxide lines of 3µm of width and spaced 15µm apart are drawn on the SOI sample. Selective chemical etching of the sample by TMAH etches non-oxidized zone of silicon and the oxide pattern is transferred to the silicon top layer of the SOI sample. Consequently the test pattern consists of single crystalline silicon wires on silicon oxide (insulating) layer. The samples are then immersed into the 25nm diameter gold colloidal emulsion during 15 minutes. The SEM images of samples show that the colloids are mainly scratched along the edge of the silicon lines.

Growth of SiNW is carried out by Laser-induced Chemical Vapor Deposition (LCVD) of silane. The LCVD chamber is placed on XYZ micro-translation with 0.1 µm accuracy system which allows to move the sample surface in the focal plane of the lens used to focuse the laser beam. The experimental procedure is schematically presented in the Fig.1. Due to light absorption, the sample is locally heated. In presence of silane (SiH_4), the growth of SiNW is assumed by Vapor-Liquid-Solid (VLS) mechanism in which a liquid gold nano-cluster or catalyst acts as energetically favored site for absorption of silicon gas reactant, arising from silane decomposition [3]. Gold nano-clusters present on the edge of silicon parallel lines are favorite sites to make a connected SiNW with horizontal growth direction. A complementary scanning process in the perpendicular direction of silicon parallel lines will force this horizontal growth.

Two kinds of structures are observed during the laser-assisted CVD growth : silicon crystal grown without any nanowires and silicon crystal covered by silicon nanowires. Experiments with laser scanning process show that it is possible to make only one side connected silicon nanowires (Fig. 2). The experiments are compared with some experiments

effected on gold evaporated surface unless gold colloidal surface. Nanowires obtained with gold colloidal catalyst seems more regular than thus obtained with evaporated gold catalyst.

References:

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[3] Wagner, R.S. and D. C.J., *Controlled Vapor-Liquid-Solid growth of silicon crystals.* Journal of the Electrochemical Society, 1966. **113**(12): p. 1300-1305.

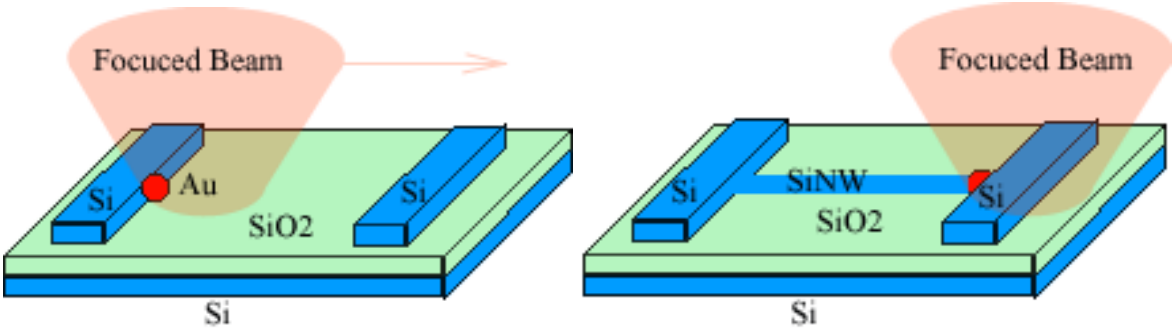

Fig. 1 Schematic presentation of laser-assisted growth.

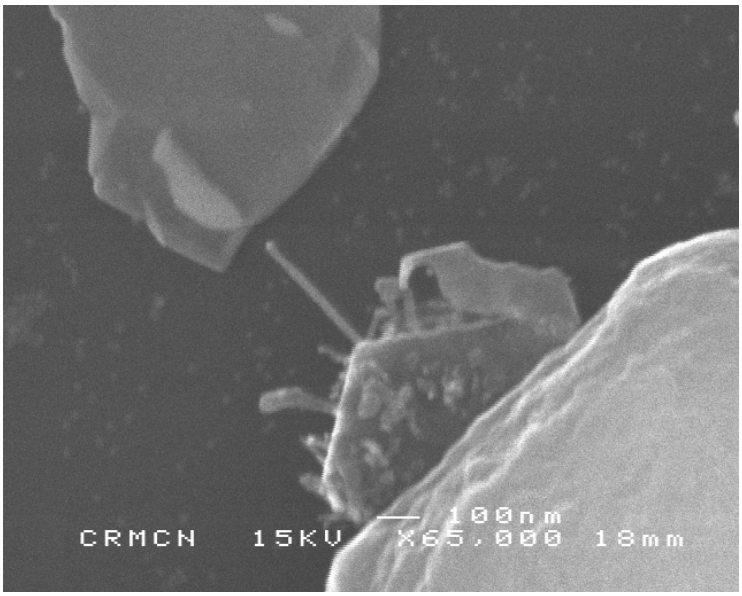

Fig. 2 SEM image of horizontal growth of silicon nanowires.