3D Silicon Micro- and Nanostructures for Photonic Devices and Applications

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Two kinds of plasma etching-based techniques are introduced for fabricating 3D silicon micro- and nanostructures. The first technique is to combine anisotropic Bosch etch process with isotropic etch process, thus 3D periodic structures can be fabricated; the second technique is based on oblique-angled plasma etching, where the ion incoming angles are modulated, thus tilted or even wiggling structures can be realized. To demonstrate the applications of 3D silicon structures for nanophotonics, 3D photonic crystal membranes are fabricated, giving a complete photonic bandgap at near-infrared wavelength, planar cavities can also be included to enable applications like solvent sensors or optical bandpass filters. Another example shows the self-assembly behavior of 3D stacked silicon nanowires driven by electrostatic forces, the attached tips give a strong coupling of optical resonance from each nanowires.

Plasma etching-based advanced 3D fabrication techniques

- Combining anisotropic etching with isotropic etching;
- Well defined structure geometries;
- Easy way to define 3D periodic structures (pillars, holes, stacked SiNWs, etc).

Tilted or wiggling silicon micro- and nanostructures

- Oblique-angled plasma etching;
- Tilted incident angle of incoming ion flux by manipulate the local electric field;
- Dimension of structures from few microns down to 40 nm;
- Simple fabrication process;

Nanophotonics applications with 3D silicon nanostructures

3D Photonic Crystal (PhC) membranes

- 3D silicon membranes;
- PBG at 1100 nm;
- Adding planar cavity to enable resonance mode on top of stopband;
- Easy to transfer on to other substrates (glass, polymer, structured surface, etc).

Electrically driven self-assembly of 3D silicon nanowires (SiNWs)

- Combining anisotropic etching and isotropic etching;
- Direct self-assembly of stacked 3D SiNWs by electrostatic forces;
- Regular pattern formation by controlling the geometries of the SiNWs;

Reference: