Directional Etching of Silicon by Silver Nanostructures

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Introduction:
Metal-assisted chemical etching (MACE) of Si is defined as etching of Si in an aqueous solution of an etchant, in the presence of metal particles. The metal particles act as a source of etchant, and are oxidized, which causes a release of etchant into the etchant pool. In this study, we have used Ag nanowires as a metal source to etch Si. The etching process was studied by scanning electron microscopy (SEM) and Raman spectroscopy. The etching process was found to be more effective in the presence of Ag nanowires than in the absence of them. The etching rate was found to increase with increasing silver content in the etchant solution.

Abstract:
We report directional etching of nanostructures (nanowires, nanotubes) into the Si(100) substrate in aqueous HF and HCl solutions by lithographically defined Ag nanoarrays as etching masks. The etching mechanism involves the formation of a thin Ag-Si-O film at the interface of the Si(100) substrate and Ag nanoarrays that acts as a hard mask. SEM images show the formation of Si nanostructures with nanowire and nanothread geometries. The etching rate increases with increasing silver content in the etchant solution. The etching process is found to be more effective in the presence of Ag nanoarrays than in the absence of them. The etching rate was found to increase with increasing silver content in the etchant solution.

Results:

![SEM images of Ag thin film (thick in ~ 5 nm) sputter-deposited on Si (a) SiO2 (b) Ag (c) SiO2/Ag (d) SiO2/Ag/Si]

![SEM images of Ag nanowires on Si (a) Ag nanowires (b) Ag nanowires on SiO2 (c) Ag nanowires on SiO2/Ag (d) Ag nanowires on SiO2/Ag/Si]

![Raman spectra of Si (100) in 4 M HF + 0.9 M H2O2 solution (a) in solution (b) in solution with Ag nanowires]