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One-step plasma synthesis of nanostructured silicon surfaces

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Helium plasma exposure is an effective method of growing nanostructures on silicon surfaces, where nanostructure morphology can be controlled by varying substrate temperature and the incident energy of helium ions. This can produce a wide range of surface features including nanoscale roughening, nanowires and porous structures. Nanostructure sizes varied from ~10 nm to over 100 nm in diameter, depending on exposure conditions. The effect of these structures on surface reflectivity for photovoltaic and photocatalytic applications is also investigated. Broad-band suppression of photo-reflectivity (Figure 1) is achieved across the 300-1200 nm wavelength range studied for silicon exposed to helium plasma at 600 °C, with an average reflectivity of 3.2% and 2.9% for incident helium ion energies of 42 eV and 62 eV, respectively.

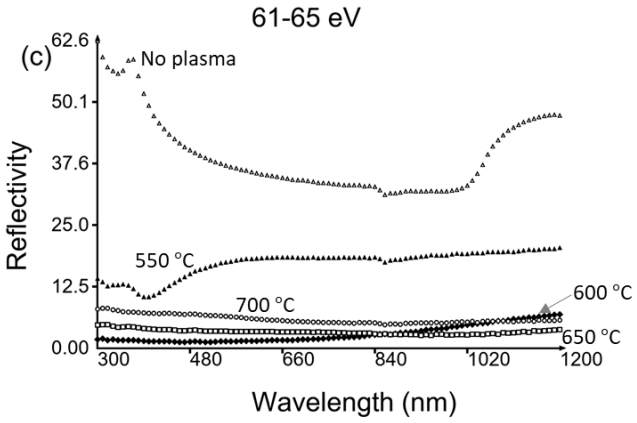

Figure 1: Reflectivity of nanostructured silicon surfaces across visible-to-near infrared wavelengths.

Examples of the resulting silicon morphology are presented in Figure 2. Broad-band reflectivity suppression is attributed to the formation of wire-like nanostructures on the silicon surface, as shown in Figure 2 (a,b). The nanowires themselves show evidence of some crystallographic influence in their growth. Specifically, bridges were observed to form between adjacent nanowires in some samples, which is consistent with anisotropic surface adatom diffusion along the {110} direction which corresponds to the orientation of silicon dimer rows on the {100} surface.

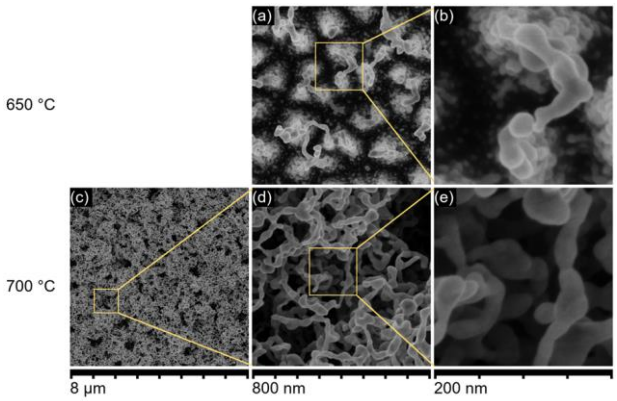

Figure 2: Examples of nanosture morphologies observed in this work.

At 700 °C more complex surface nanostructures are observed, which form a network of wire-like structures reminiscent of the tungsten “fuzz” structure widely observed by nuclear fusion researchers.

References

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