FORMATION OF HIGH-ASPECT RATIO SILICON NANOPILLARS USING DEEP REACTIVE ION ETCHING

C. Fischer,[1] C. Veríssimo,[2] S. A. Moshkalev,[2] J. W. Swart[1]

[1] Faculty of Electrical Engineering – FEEC, State University of Campinas - UNICAMP, Campinas, SP, Brazil
[2] Center for Semiconductor Components – CCS, UNICAMP, Campinas, SP, Brazil

Formation of high-aspect ratio (height/diameter) nanopillars in monocrystalline silicon (known also as "black silicon") attracts much attention due to numerous possible applications in, solar cells[1], chemical analysis[2] and mechanical assembling[3]. Various methods of nanosilicon structures have been reported, including chemical wet etching[2] and deep reactive ion etching (DRIE)[4]. This paper presents a method for black-silicon formation by a Bosch process using an inductively coupled plasma (ICP) source and electroless deposited Ni-P films as a hard mask material.

Silicon wafers were processed using the following sequence: (1) BHF dip; (2) Paladium thin film electroless deposition; (3) Nickel-Phosforus electroless deposition solution (about 1μm thick layer of Ni-P hard mask for etching is deposited), 4) photolithography for sampel surface pattering, and (5) Nickel-Phosforus etching for pattern tranfer. After these steps, the silicon wafers were etched by a Bosch process in an ICP plasma source using alternating etching/polymerizing ($Ar+SF_6$ /$Ar+C_4F_8$) gas mixtures. Plasma process parameters: ICP power and bias power (both 13.56 MHz) of 500 and 100 W, respectively, pressure of 50 mTorr, sample holder temparature of 20° C, mean etch rates up to 1 μm/min. As a result of etching, formation of very dense arrays of vertical silicon pillars in the Si areas not protected by Ni-P hard mask can be observed, see Fig. 1. The pillar diameters vary in the range of 100-300 nm, their aspect ratio can be as high as 100:1 and mean distance between pillars is 300-800 nm. Special experiments were performed to prove that the origin of pillars is micromasking due to re-deposition of Ni from the hard Ni-P mask. Currently, experiments are in course to get better control over the size distribution of pillars, looking for applications in photonics, in particular for solar cells.

---

1 K. Nishioka et al., Solar Energy Materials & Solar Cells 92 (2008).
2 L. Sainiemi et al., Nanotechnology 18 (2007).
3 M. Stubenrauch *et al.*, J. of Micromech. Microeng. 16 (2006).
4 H. Jansen et al., J. of Micromech. Microeng. 16 (1995).

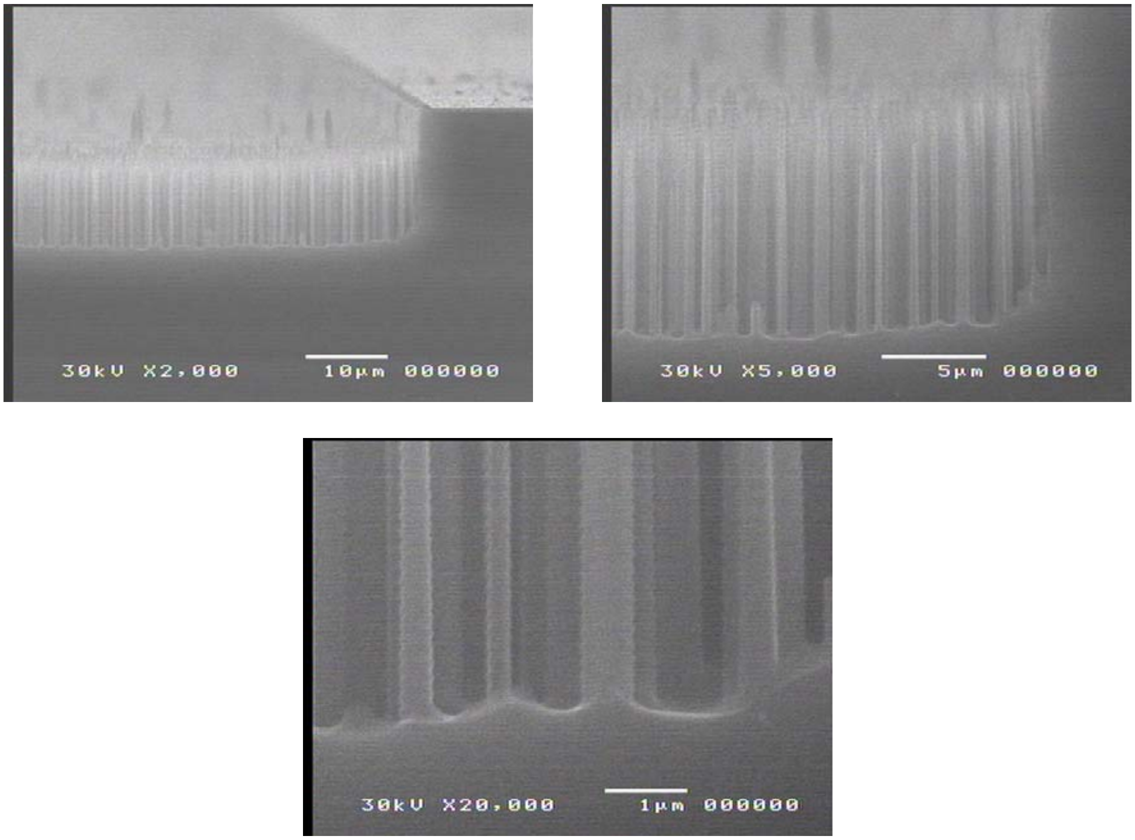

figure 1 – SEM images of silicon pillars forming the black-silicon.