World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:18, No:12, 2024

Controlling Shape and Position of Silicon Micro-nanorolls Fabricated using Fine Bubbles during Anodization

Authors : Yodai Ashikubo, Toshiaki Suzuki, Satoshi Kouya, Mitsuya Motohashi

Abstract : Functional microstructures such as wires, fins, needles, and rolls are currently being applied to variety of high-performance devices. Under these conditions, a roll structure (silicon micro-nanoroll) was formed on the surface of the silicon substrate via fine bubbles during anodization using an extremely diluted hydrofluoric acid (HF + H_2O). The as-formed roll had a microscale length and width of approximately 1 µm. The number of rolls was 3-10 times and the thickness of the film forming the rolls was about 10 nm. Thus, it is promising for applications as a distinct device material. These rolls functioned as capsules and/or pipelines. To date, number of rolls and roll length have been controlled by anodization conditions. In general, controlling the position and roll winding state is required for device applications. However, it has not been discussed. Grooves formed on silicon surface before anodization might be useful control the bubbles. In this study, we investigated the effect of the grooves on the position and shape of the roll. The surfaces of the silicon wafers were anodized. The starting material was p-type (100) single-crystalline silicon wafers. The resistivity of the wafer is 5-20 □• cm. Grooves were formed on the surface of the substrate before anodization using sandpaper and diamond pen. The average width and depth of the grooves were approximately 1 µm and 0.1 µm, respectively. The HF concentration {HF/ (HF + C_2H5OH + H_2O)} was 0.001 % by volume. The C2H5OH concentration {C_2H5OH/ (HF + C_2H5OH + H_2O)} was 70 %. A vertical single-tank cell and Pt cathode were used for anodization. The silicon roll was observed by field-emission scanning electron microscopy (FE-SEM; JSM-7100, JEOL). The atomic bonding state of the rolls was evaluated using X-ray photoelectron spectroscopy (XPS; ESCA-3400, Shimadzu). For straight groove, the rolls were formed along the groove. This indicates that the orientation of the rolls can be controlled by the grooves. For lattice-like groove, the rolls formed inside the lattice and along the long sides. In other words, the aspect ratio of the lattice is very important for the roll formation. In addition, many rolls were formed and winding states were not uniform when the lattice size is too large. On the other hand, no rolls were formed for small lattice. These results indicate that there is the optimal size of lattice for roll formation. In the future, we are planning on formation of rolls using groove formed by lithography technique instead of sandpaper and the pen. Furthermore, the rolls included nanoparticles will be formed for nanodevices.

Keywords : silicon roll, anodization, fine bubble, microstructure
Conference Title : ICMSE 2024 : International Conference on Materials Science and Engineering
Conference Location : Kuala Lumpur, Malaysia
Conference Dates : December 09-10, 2024

Open Science Index, Materials and Metallurgical Engineering Vol:18, No:12, 2024 publications.waset.org/abstracts/192444.pdf