ABSTRACT

Microstructuring on copper anodes has been reported to expand the effective surface area and improve the adhesion quality of the active layer, while annealing can enhance crystallinity and layer homogeneity, thereby influencing interfacial characteristics and impedance. This study investigates the effects of microstructuring and annealing on a prototype coin cell battery based on silicon nanoparticles. Microstructuring was performed using a femtosecond laser to create patterns, and silicon nanoparticle coating was carried out via Pulsed Laser Deposition (PLD). Characterization included morphology (SEM), elemental composition (EDX), crystal structure (XRD), and initial electrochemical tests (Cyclic Voltammetry/CV, Electrochemical Impedance Spectroscopy/EIS, and specific capacity measurements based on charge–discharge tests).

The results showed that laser-patterned microstructuring produced a more uniform silicon layer and improved contact with the substrate, while annealed samples exhibited better crystallinity and homogeneity of the active layer. SEM analysis revealed that the average silicon particle size ranged from ~1.2 to 2.7 μm, depending on the pattern and deposition parameters. EDX confirmed the presence of silicon on the copper surface. XRD after annealing indicated changes in peak intensity, suggesting an increase in crystallinity compared to the non-annealed state. In CV testing, the peak potential difference (ΔEp) ranged from 0.542 to 1.639 V, while EIS showed series resistance (Rs) values between ~4.34 and 12.22 Ω. The measured specific capacity ranged from 30 to 515 mAh/g. Microstructuring alone, with a circular pattern (CIRC-PLD), reduced Rs from 5.54 Ω (NONE-PLD) to 4.34 Ω, decreased ΔEp from 1.121 V to 0.542 V, and increased specific capacity from 30 mAh/g to 515 mAh/g. Annealing alone on copper without microstructuring (NONE-PLD-ANN) increased capacity to 200 mAh/g, although ΔEp slightly increased to 1.196 V and Rs rose to 12.22 Ω. The combination of microstructuring with a grid pattern and annealing (GRID-PLD-ANN) yielded a capacity of 400 mAh/g, with ΔEp of 2.345 V and Rs of 7.8 Ω, indicating that annealing primarily contributed to capacity enhancement, while microstructuring reduced Rs and ΔEp but could also lower capacity.

Keywords: coin cell; copper anode; silicon nanoparticles; laser *microstructuring*; Pulsed Laser Deposition (PLD); *annealing*.