Vertically oriented graphene electrical double layer capacitors on Ni substrates RF-PECVD synthesized from C_2H_2

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Characterization of thin film EDL capacitors synthesize by RF-PECVD directly on Ni foil electrodes using acetylene feedstock is presented. The introduction of acetylene as a feedstock gas significantly reduced the growth temperature required for graphene deposition, due to a greater density of C and C_2 ions/neutrals in the plasma. The vertically oriented graphene sheets have a more uniform sheet height distribution, a more vertical orientation, a sheet thickness ~ 2.5 nm and an I_D/I_G ratio < 0.4. The morphology of these films offers open channels for electrolyte access resulting in fast frequency response with a phase angle of -45° at 13 kHz. The acetylene graphene EDLCs on Ni foil substrates have demonstrated a low equivalent series resistance of ~ 0.06 ohms, a higher specific capacitance of ~ 190 $\mu F/cm^2$ (2 μm films height at 1 kHz), than previously reported using methane feedstock. Offering electrical behavior similar to electrolytic capacitors, but with the potential for substantially reduced size and mass and greatly increased reliability, this new thin film EDLC shows great promise to ultimately replace today's aluminum electrolytic capacitors.