Study of Optical Conductivity of Highly Disordered MoC Films by Spectroscopic Ellipsometry

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Abstract. A set of 5nm thick molybdenum carbide films were deposited by reactive magnetron sputtering on sapphire substrates. Changing the deposition parameters, the sheet resistance of the films was varied in the range from 390 to 3900 Ω/square at room temperature. The sheet resistance is enhanced by intrinsic disorder in the metallic films. Starting from room temperature, the DC conductivity of the samples decreases with decreasing temperature, following $T^{1/2}$ dependence due to quantum corrections to the conductivity. Furthermore, we extended the studied range of the conductivity by optical spectroscopic ellipsometry, which enables to evaluate both the real and the imaginary part of the frequency-dependent complex conductivity. The real part of the conductivity further follows the root mean square corrections in the frequency domain and smoothly merges with the Drude response at the scale of the Drude relaxation time Γ, which is approximately 3000 THz for our films. The dependences are analyzed by a simple formula, which allows us to determine the absolute measure of the strength of the quantum corrections on an extended scale. The strength of the quantum corrections increases with the disorder, and they significantly alter the optical conductivity from the Drude response up to the ultraviolet region. Moreover, we employ a numerical extrapolation method for complex conductivity of disordered metals, which enables us to extrapolate the conductivity from the visible frequency range down to far-infrared and up to the ultraviolet region.