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The preparation and properties of the $UC_{1-x}N_x$ solid solutions by pulses laser Carbonitriding

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Abstract

The $UC_{1-x}N_x$ solid solution modified layers that improve corrosion resistance and surface hardness of uranium were prepared by pulsed laser irradiating the surface uranium in the mixed atmospheres where the partial pressure ratios of CH_4 to N_2 are 1:2, 1:1 and 2:1, respectively. The SEM images show that the distribution of micro-cracks in the modified layers decreases significantly with the increase of partial pressure of CH_4 in the mixed atmospheres. The phase structure and chemical composition of the modified layers were investigated by XRD and AES. XRD results show that the composition of the carbonitride modified layers is mainly $UC_{1-x}N_x$ solid solution, only with a small amount of free uranium and uranium dioxide. AES results reveal that the C and N contents in the $UC_{1-x}N_x$ solid solution can be adjusted by the respective partial pressure of CH_4 and N_2. The U 4f, N 1s and C 1s core-level also confirmed that the $UC_{1-x}N_x$ solid solution is the main component in the laser modified layers. Electrochemical polarization tests were conducted in 0.02 mol/L NaCl solution and the results indicated that the carbonitride modified layer prepared in an atmosphere where the ratio of CH_4 to N_2 at 1:2 have excellent corrosion resistance, its self-corrosive potential and self-corrosive current are -2.28×10^{-1}V and 5.56×10^{-8} A/cm^2, respectively, while the values of the uranium are -5.67×10^{-1} V and 8.08×10^{-7} A/cm^2, respectively. Nano-indentation measurement results show that the average hardness at different depths of these modified layers is between 7 GPa and 9 GPa, while the average value of the uranium is 4.1 GPa.