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Effect of power density on the microstructure and properties of titanium diboride thin films by radio frequency magnetron sputtering method

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ABSTRACT

Thermoelectric generators directly convert heat into electricity and offe r a unique and very promising pathway for generating power. Titanium diboride, TiB_2, is an ideal candidate for use as an electrode material in thermoelectric systems because of its refractory characteristic and excellent electrical conductivity. This study reports the effect of sputtering power density on microstructural, electrical and mechanical properties of TiB_2 films fabricated by radio frequency magnetron sputtering. The TiB_2 thin films were deposited at 500 °C with power densities of 5.1–12.7 W/cm^2. As the power density increased, X-ray diffraction analysis showed a formation trend of highly crystallized hexagonal TiB_2 with a (001) preferential orientation. X-ray photoelectron spectroscopy data revealed that only T–B chemical bonding states were present in the TiB_2 phase. TiB_2 films also exhibited a denser microstructure with a larger grain size. All three factors led to a lowering of the films' electrical resistivity. A minimum electrical resistivity of 6.5x10^{-4} Ωcm was obtained with a free-electron concentration of 1.2x10^{20} cm^{-3} and carrier mobility of 86.7 cm^2 V^{-1}s^{-1}. The hardness and elastic modulus were also found to increase with discharge power density from 19.5 to 26.6 GPa and from 165.2 to 196.8 GPa, respectively. This study demonstrated that the combination of high melting point and excellent electrical and mechanical properties makes TiB_2 an ideal electrode material for thermoelectric applications.

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