

## Physical and Electrochemical Properties of Vanadium Nitride and Copper Films with High Copper Content

Vanadium nitride and copper (VN-Cu) films with differing high Cu contents were deposited using reactive magnetron co-sputtering and by varying the nitrogen partial pressure. A literature review, indicated that the Cu content in the films affects the mechanical film properties significantly. The ratio of low Cu in the films can improve the mechanical and electrical properties. A high Cu ratio degrades the film mechanical properties. VN-Cu films with a high Cu content had the maximum hardness and the mechanical properties of the VN-Cu films improved compared with the VN film. The presence of Cu in the VN-Cu films was confirmed by energy-dispersive X-ray spectroscopy, X-ray photoelectron spectroscopy, and transmission electron microscopy. X-ray diffractometry confirmed that Cu<sub>3</sub>N results in no external energy growth of the VN-Cu film. Because of the mixed structure, the VN-Cu film hardness with a maximum Cu ratio of 40.55% or Cu content of  $26.37 \pm 0.22$  at.% varied as 9.346, 17.157, and 26.300 GPa. The development of new materials with varying mechanical properties based on Cu content provides for many new potential applications. However, limited information exists on the effect of Cu content on the electrochemical properties. Here we show that the electrochemical properties and conductivity of VN-Cu with a high Cu content can be improved. Therefore, the VN-Cu film can serve as a new anode material for rechargeable batteries.

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