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**The roles of Ag layers in regulating strengthening-toughening behavior and tribochemistry of the Ag/TaC nano-multilayer films**

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**Abstract**

Though the high hardness nature of transition-metal carbides or nitrides TMC(N) has been extensively exploited in protective films for various tools and wear-resistant films for the machine parts, improving toughness and reducing friction continue to be immensely challenging. Herein, we prepared the Ag/TaC nano-multilayers with various Ag thickness ( $l_{\text{Ag}}$ ) ranging from 2 nm to 14 nm by magnetron sputtering, successfully achieving enhanced hardness, toughness and wear-resistance ability, together with reduced friction at  $l_{\text{Ag}} = 2$  nm. In addition,  $l_{\text{Ag}}$ -dominated growth, strengthening-toughening behavior, and tribochemistry of the Ag/TaC nano-multilayers were investigated. These studies revealed that as very thin Ag layers ( $= 2$  nm) are alternatively inserted into TaC layers, discontinuous Ag/TaC nano-multilayer structure constructs in term of poor wetting induced the growth of discontinuous Ag layers, remarkably enhancing the hardness to  $\sim 42$  GPa associated with the Orowan mechanism and improving toughness and wear-resistance ability. Together with all these remarkable properties, the coefficient of friction (CoF) rapidly drops to  $\sim 0.227$ , because of the formation of lubricious Ag nanoclusters and  $\text{AgTaO}_3$  phase on the contact surface during sliding. However, at thicker  $l_{\text{Ag}}$ , continuous soft

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