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Combinatorial Materials Science on Study of Ag-alloy Thin Films for Sliding Electrical Contact Applications

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In this work, we demonstrate the strength of the combinatorial materials science approach to rapidly deposit and characterize the composition and structure of Ag-alloy thin films to improve the tribological properties of Ag for sliding electrical contact applications. Ag is a widely used material for many commercial contact products due to its excellent electrical properties. However, it is soft and the friction coefficient of Ag-Ag contact is far too high (>1), and thus giving a high wear rate. Alloying with other elements is one of the methods to improve the tribological properties of Ag. The challenging is very time-consuming to select appropriate alloying elements with correct composition and structure to simultaneously meet the contracting properties, such as low electrical contact resistance and low friction and wear for electrical contact applications. This problem can be solved by the combinatorial approach. We have constructed a combinatorial platform including a combinatorial sputtering system, which can deposit thin films with large composition gradients in a single experiment. The friction coefficient as well as the electrical contact resistance can rapidly be measured in custom-designed equipment directly on the gradient films. Following a series of automatic evaluation methods such XPS, XRD, nanoindentation, and four-point electrical resistance screening were employed to determine the chemical composition, structure and properties of Ag-alloy films in a rapid and high through-out way. Screening results with several binary and ternary alloys show a complicated pattern of solid solutions, immiscible multiphases of alloys, or even amorphous phases for some compositions. A dramatic decrease of friction and wear was observed in a potential alloy composition window. The results will be discussed based on comparison of properties related to composition and phase evolution during alloying.

Keywords
Combinatorial materials science
Ag alloy
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composition gradient
phase evolution