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Influence of backscattered neutrals on the grain size of magnetron-sputtered TaN thin films

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Abstract

A side effect of magnetron sputtering is the production of neutral working gas atoms backscattered from the cathode. Their influence on the morphology of sputter-deposited thin films, though, is usually neglected, which may not always be justified. In particular, for high-power impulse magnetron sputtering with its high negative cathode potential during the discharge pulse in combination with heavy metal targets, this effect can be important. In this work, we find experimentally that the grain size of magnetron-sputtered δ -TaN films is considerably reduced at high negative cathode potential and without the use of a substrate bias. For these deposition conditions, computer calculations show a high rate of backscattered neutrals with energies > 100 eV, which is only a factor of 10 to 20 lower than the total deposition rate of sputtered species. Such a significant fraction of energetic backscattered neutrals can readily impede grain growth by the incorporation of defects followed by renucleation. Thermalization of the energetic neutrals by the process gas is shown to be insufficient for typical magnetron operating pressures and cathode-substrate distances. The methodology presented here can be used to explain similar results of shrinking grains with increased negative cathode potential for other material systems.

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