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Heat flux investigation of the low temperature oxidation of a titanium thin film freshly deposited by magnetron sputtering

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Understanding the mechanisms of oxide thin films formation is of high interest for various applications (catalysis, dielectrics,…) and there have been numerous experimental and theoretical efforts from mid- 20th century [1] to nowadays [2,3]. At ambient temperature and low O_2 pressure, the oxidation mechanism are well-described by the Cabrera-Mott models. The oxide growth rate is high initially due to the O_2 chemisorption at the surface and the Mott potential formation. As the oxide thickness rises, the effect of the Mott field decreases and the oxidation diminishes down to a limited thickness (few nm). But, the metal oxidation is also influenced by the metal properties (morphology, defects,…) and the understanding of these factors is still unsatisfactory.

Because the chemisorption/oxidation process releases an energy (enthalpy of the oxide formation), we investigated the chemisorption/oxidation mechanisms of a freshly deposited thin film by the measurement of the energy flux φ with a thermopile [4]. Ti thin films have been firstly deposited by sputtering and secondly submitted to O_2. The thin film thickness has been varied between few nm and 1 µm and the O_2 pressure has been changed from 0.1 to 15 Pa. φ displayed a rapid increase right after the O_2 introduction. This peak was followed by a logarithmic decrease. Such measurement is in accordance with the Cabrera-Mott models. Moreover, it has been observed that the energy was strongly dependent to the Ar pressure fixed during the Ti deposition step (between 0.5 and 5 Pa). The released energy increases when the Ar pressure decreases which means that porous thin film leads to thicker oxide formation. Finally, this study showed that in situ flux measurement can help to better understand of the chemisorption/oxidation mechanisms.

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