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Au-Al₂O₃ thin films for optical applications by reactive sputtering

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Thin composite films containing metal nanoparticles in a ceramic matrix (nanocermets) are of interest for the electronics, glass, detectors, catalysis, semiconducting, computing and bio industries. It is well known that when Au is confined it shows strong absorption near the UV-VIS region due to surface plasmon resonance. Alumina (Al₂O₃) by its turn is a dielectric material that exhibits high thermal stability and corrosion resistance. By controlling mainly the volume fraction of Au (pre-deposition) and its cluster size (by thermal annealing) it is possible to produce Au-Al₂O₃ nanocomposites with tweaked absorptivity. Au-Al₂O₃ thin films were produced by reactive sputtering and its structure, chemical composition, optical properties and mechanical properties (nano-hardness) was studied.

Au-Al₂O₃ thin films were deposited on Si(111) and glass substrates by pulsed d.c. reactive magnetron sputtering by using a pure Al target incrustated with different amounts of Au and O₂ as reactive gas. Target power and partial pressures of Ar/O₂ were kept constant. The samples were analysed by x-ray diffractometry, electron probe micro-analysis, scanning electron microscopy, UV-Vis spectrophotometry and depth-sensing indentation technique.

Different amounts of Au were incorporated into the alumina matrix, up to a maximum of 11 at.%, having also influence on the Al/O ratio. No SPR phenomenon was observed for the as grown samples, although a decrease in the band gap was evident with the Au increase. All the as grown coatings presented hardness values between 9 and 13 GPa, regardless of the amounts of gold incorporated. Regarding the structure all the coatings kept the alumina matrix amorphous even at the highest annealing temperature (1000°C). However, with the annealing treatment Au cluster growth was promoted, although only for temperatures greater than 400°C, XRD Au peaks could be detected.

Keywords

Plasmon resonance
Au-Al₂O₃
Optical properties
UV-Vis absorbance
clusters