FABRICATION OF Al/AlO OPTICALLY ABSORBING FILMS USING A FILTERED CATHODIC VACUUM ARC.

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A Filtered Cathodic Vacuum Arc (FCVA) deposition system [1] has been used to produce multilayer thin-films of aluminium and aluminium oxide for use as optically absorbing coatings (also known as 'black mirrors') [2]. Characterisation of these layers has been performed using ellipsometry, X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM) and electrical conductivity measurements.

For the intended application, a single aluminium layer of 6-8 nm thickness (accounting for 3-4 nm surface oxide thickness) was required to be sandwiched between aluminium oxide layers of ~120 nm and ~70 nm thickness. These multi-layers are supported on silicon substrates. The surface roughness and continuity of the aluminium and aluminium oxide films are critical parameters in the design of the coatings and the focus of our study was to minimise roughness in these films and in particular, to minimise island type growth in the thin aluminium films.

The FCVA system used for these experiments was supplied by Nanofilm Technologies International Pte. Ltd. The system is equipped with a double-bend filter which prevents deposition of macro-particles and a substrate holder which was connected to an electrical feed-through for application of substrate bias. The effect of the substrate bias, process gas mix and ultimate film thickness on the RMS roughness of the aluminium and aluminium oxide films was investigated using AFM. It was found that with an applied pulsed substrate bias of -500V, aluminium films of 6-8 nm were produced with an average RMS roughness of less than 0.2 nm (see Figure 1).

Ellipsometry and XPS were used to verify the optical constants of our AlO films and these measurements allowed us to select Ar/O gas flow-rates which produced stoichiometric Al_2O_3.

Electrical conductivity measurements showed that Al films of 6-8 nm could be produced with resistivities approximately one order of magnitude larger than the bulk. The oxidation of these films self-limits (with a final thickness at room temp of ~3 nm) and therefore FCVA deposition of aluminium/aluminium oxide stacked layers with prescribed thicknesses is possible. Several aluminium/aluminium oxide multilayers have been produced with various layer thicknesses and their simulated and experimental absorption characteristics have been compared. In Figure 2, simulated and experimentally obtained optical responses of Al_2O_3-Al-Al_2O_3 trilayer black mirrors are shown. (The optical CAD package Filmstar supplied by FTG software was used for the simulations).

Acknowledgements:

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References:

[1] J. Mouchart, Applied Optics, **16** (1977) 3237.
[2] I.I. Aksenov, V.A. Belous, V.G. Padalka and V.M. Khoroshikh, Fiz. Plazmy, **4** (1978) 758.

Figures:

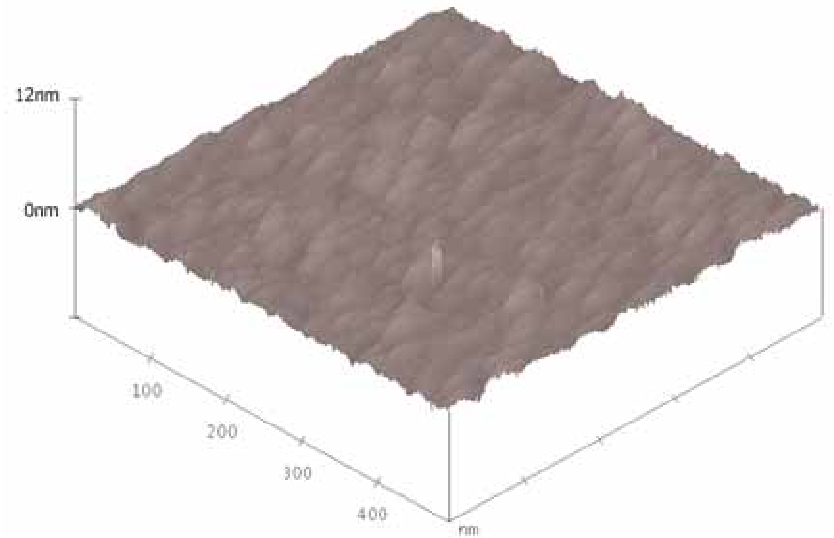
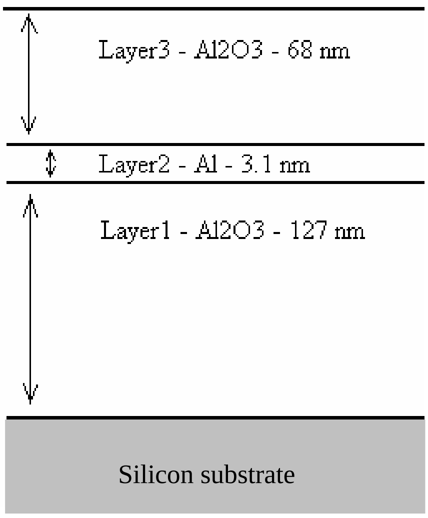
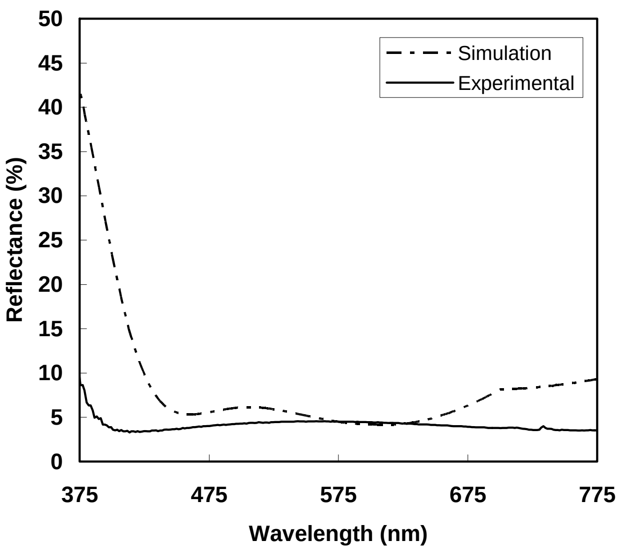


Figure 1. An AFM image of a FCVA deposited 7.0nm thick Al film supported on a Si substrate and with RMS roughness 0.35nm.





(a) (b)

Figure 1. (a) Schematic showing an Al_2O_3-Al-Al_2O_3 black mirror formed on silicon and (b) its simulated and experimentally obtained reflection characteristics.