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Coarsening of Nanosized Polycrystalline Thin Films

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Abstract –The thermal evolution of the experimental Grain-Size-Distribuitions is discussed on the basis of two growth processes describing the intra-layer and the inter-layer growth. The results obtained from the intra-layer growth are well fitted by an Analitical Size Distribution Function. The inter-layer growth triggers an abnormal growth behavior resulting into micrometer sized grains with the total film thickness.

We study the thermal evolution of nanosized polycrystalline (typical diameters of ≈ 30 nm) Aluminum thin films presenting 4 layers of planar mosaic-like grain arrangement. Each layer is separated by a monolayer of aluminum-oxide. The experimental data [1] suggests that, for temperatures T≤400 ^{o}C, only intra-layer growth occur because inter-layer atomic fluxes are negligible. For T≥462 ^{o}C, inter-layer growth develops, disrupting the oxide monolayer. Assuming that intra-layer growth follows an Arrhenius behavior, the isochronal evolution of the experimental Grain-Size-Distribution (GSD) can be described analytically using an adapted Ostwald Ripening formalism, considering atomic fluxes dependent to number of specific diffusion path N determined by the grain boundary arrangements. N is a size depended of the characteristic grain radius R, which presents a growth rate defined as $dR/dt = KR^{-2}(R^{*-2} - R^{-1})$, where R^* is the critical radius and K a constant. The analytical se treatment following the growth rate leads to a GSD presenting a broad tale towards large grain sizes in asymptotic quasi-steady-state conditions. Figure 1 shows a comparison between reduced experimental and analytical GSD from samples annealed at 300, 350, 400 and 462 °C (Fig. 2). For the three lowest temperatures there system presents an autosimilar behavior which is well fitted by the analytical GSD deduced from the growth rate. In this case, the time dependence of R^*, as obtained from the growth rate [2], can be expressed as $R^{*-4} - R^{*-4} = Kt/\nu$, where ν characterizes the growth mode.

For the 462°C case, however, the experimental GSD is distinct, presenting an onset of bimodal behavior indicating the change of growth process towards the vertical direction, resulting in columnar grains (see Fig. 2). This GSD is better described by a quasi-stationary behavior, predicted from classic coarsening processes [3]. For T=475 ^{o}C abnormal growth occurs. This is discussed assuming interface instabilities due to nanometer curvature sizes and strain relief processes.

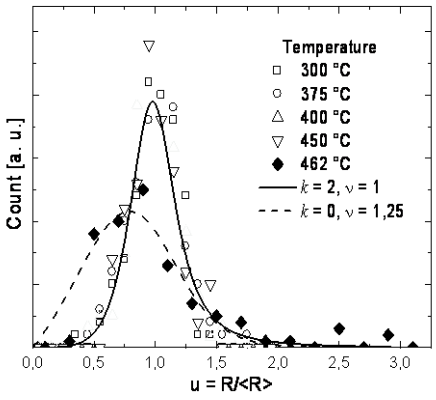

Figure 1: Fit between experimental and analytical GSD.

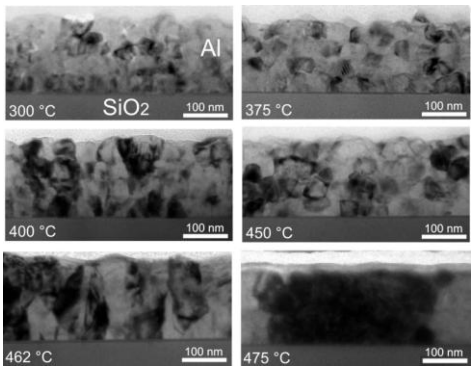

Figure 2: TEM images of polycrystalline Al under SiO_2 substrate in different temperatures of annealing.

References

[1] LUCE F. P. Nucleação e Crescimento de Grãos em Filmes de Al Nanoestruturados. Porto Alegre: Departamento de Física - UFRGS. Dissertação de mestrado em física (2008).
[2] ARDELL A. J. Acta Metallurgica. Vol. 20, 601-609, 1972.
[3] RIOS P. R. Scripta Materialia, Vol. 40, No. 6, 665–668, 1999.


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