Low- and High-Porosity Nanoporous Anodic Alumina Photonic Structures for Enhanced Optical Sensing

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Nanoporous Anodic Alumina (NAA) is a material of significant interest in the nanotechnology field due to its multifaceted applicability, the cost-effective viability and scalability of its fabrication methodologies [1, 2]. Its utility spans diverse nanotechnological domains including, energy systems, nanofabrication processes, and biotechnological platforms [3]. NAA exhibits particular prominence in biomedical applications, especially in optical sensing due to its intrinsic properties: transparency across the visible electromagnetic spectrum, photoluminescence, and high and tuneable surface area [4-5]. Furthermore, when synthesised under precisely controlled anodization parameters, NAA develops a self-ordered hexagonal pore architecture (**Figure 1**) and by modifying the anodization parameters (potential, charge, type of electrolyte and temperature) we can obtain different NAA morphologies [6]. Through a pore widening chemical reaction we can modify the effective refractive index of our nanoporous structures and in consequence we also modify the porosity of the nanostructure. We can estimate these two parameters by studying the effective media using different approximation models (Maxwell-Garnett, Bruggeman, Loyenga). In this work we have fabricated different photonic structures by applying an apodized current profile consisting of a sinusoidal component with variable current density amplitude. We performed different times of pore widening reaction to obtain different porosities and refractive indexes, and we evalutated these two parameters through the Loyenga-Landau-Lifshitz (LLL) model [7]. Through optical characterization we evaluated the optical parameters of our nanostructures like the photonic band or the effective optical thickness, observing how changing the porosity of our nanostructures the photonic band shifts. We studied the changes in the effective optical thickness by injecting different solutions with different refractive indexes, this data was evaluated applying the LLL effective media model [8]. Moreover we performed an experiment with SpA, IgG antibody and IgG antigen to study how the saturation of the system and the speed of infiltration changes depending on the porosity of the system, and how the porosity affects to the performance of the system. These preliminary results indicate the capability of altering the physical properties of NAA-RF for optical sensing and the possibility to study the saturating and time diffusion of different biomolecules.

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Figures

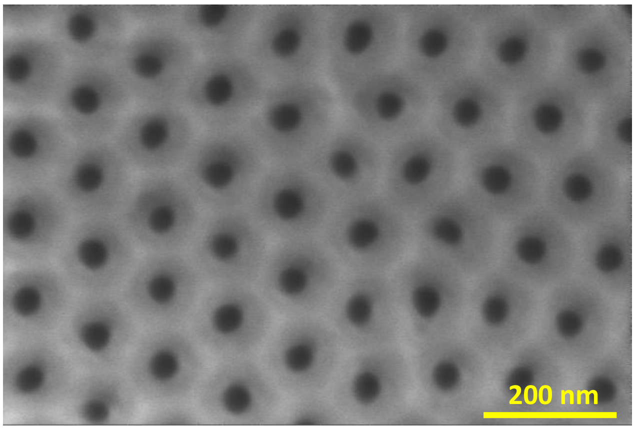

Figure 1: FESEM image of top-view of self-ordered nanoporous anodic alumina rugate filters.