

Functional properties of porous anodic alumina

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Abstract

Porous anodic alumina (PAA) has emerged as a highly versatile platform for developing advanced functional materials, with promising applications in photonics, photovoltaics, and optical sensing [1]. Produced via the electrochemical oxidation of aluminum in various electrolytes, PAA features remarkably uniform and tunable porous structures, offering precise control over pore size and spacing (Figure 1a,b). This exceptional degree of morphological precision distinguishes PAA from other anodized metals, making it not only a model system for anodization studies but also an important porous material in nanotechnology and materials engineering.

One particularly exciting direction is the fabrication of porous photonic crystals. Through pulse anodization - applying alternating low and high voltage (or current) pulses in patterns such as sawtooth or sinusoidal waveforms - PAA can be engineered to form alternating low- and high-porosity layers. This periodic modulation of porosity results in a corresponding variation in the refractive index (RI), enabling the creation of photonic crystal-like structures [2]. Electrochemical synthesis offers a cost-effective, scalable alternative to traditional lithography-based methods, avoiding issues like thermal expansion mismatch and crystal lattice incompatibility common in conventional photonic crystals.

Moreover, the ability to finely tune pore morphology positions PAA as an exceptional template for the controlled synthesis of other nanostructured materials (Figure 1c,d) and devices. By adjusting pore diameter and interpore distance, the size and arrangement of nanostructures can be precisely engineered, enabling the exploration of critical phenomena such as charge transport and energy transfer [3,4]. These processes directly impact the efficiency of light or electric current generation, making PAA-based templates highly valuable for developing nanomaterials with optimized functional properties. Consequently, PAA holds significant promise for advancing next-generation optoelectronic applications.

References

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Figures

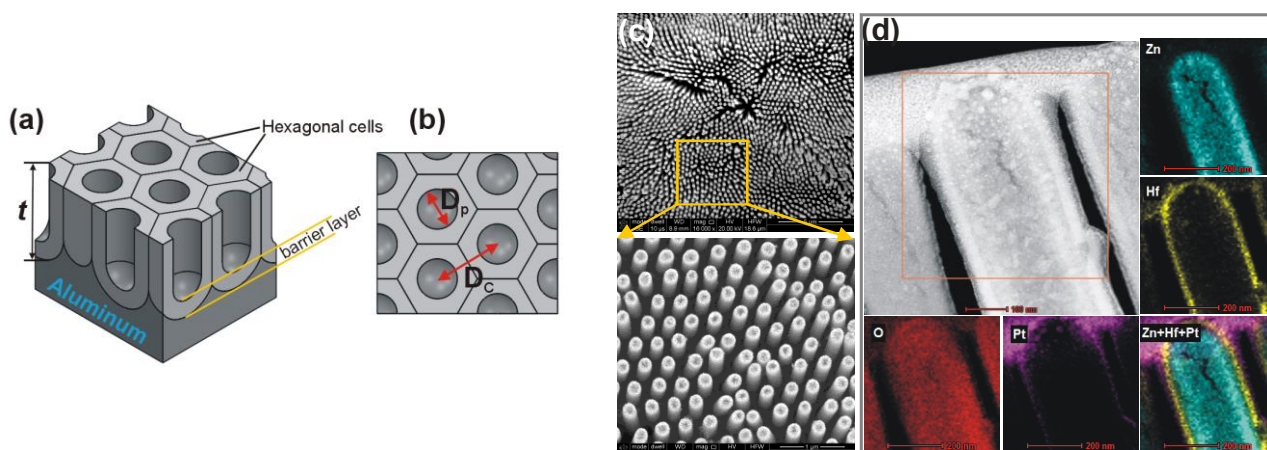


Figure 1: A scheme of a cross sectional (a) and a top view (b) of PAA (D_p - pore diameter, D_c - interpore distance, and t - PAA thickness); an array of ZnO nanotubes fabricated by PAA template-assisted atomic layer deposition (c), and the same ZnO nanotubes coated with a HfO₂ shell (d).