# NANOPOROUS ALUMINA MEMBRANES FOR LIGHT ENHANCEMENT IN LCDs

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**1. Introduction.** Nanochannel-array materials have attracted considerable scientific and commercial attention due to their potential utilization in magnetic, electronic, and optoelectronic structures, and devices. Nanoporous anodic alumina was originally considered as insulating component of semiconductor silicon microchips with metal aluminum conductors. It can be developed by electrochemical anodizing of aluminum to get free membranes with thickness up to 1 mm. Depending on the anodization regimes, pore size can be made from a few nanometers to hundreds of nanometers. Though structural properties and basic electrochemical routes are subject of extensive research during last five decades, only in the recent years unique optical properties of nanoporous anodic alumina have been discovered: a high transmission along pores with simultaneous high reflection from cut-edges [1], an optical birefringence [2], etc. So, nanoporous anodic alumina films are promising to control a light propagation in liquid crystal display devices.

**2. Experimental.** The 100 mm thick 40×48 mm$^2$ sized aluminum foils were subjected to the two-stage porous anodization from the front side of the sample to form layers of porous anodic alumina. The pore diameters and spacings are dictated by parameters of the anodization process, specifically by the electrolyte composition and the anodization voltage. The alumina film thickness is defined by the anodization time and the anodization current density. The rest un-anodized aluminum substrates were etched to provide free-standing films of porous alumina. We found that the additional removal of alumina bottoms in pores can be reasonable to get hollow cylindrical pores throughout the sample.

**3. Results and discussion.** The effect of the luminance enhancement was observed with the free-standing anodic alumina film by the naked eye because of anisotropic light scattering by spatially arranged nanometer-size pores. Fig. 1 demonstrates a high transparency of the free-standing anodic alumina film produced as compared to the reference Kimoto PF-90S M/M scattering film.


Fig. 1 – The opaque scattering commercial Kimoto PF-90S M/M film (left) and the anodic alumina film (right)

In more detail parameters of the free-standing anodic alumina films are described in the Figs. 2–3. Fig. 2 clearly shows a 5-fold higher transparency of the porous anodic alumina as compared to the reference Kimoto film at the normal incidence ($\alpha = 0$) and more than 2-fold enhancement for $\alpha = 20°$.

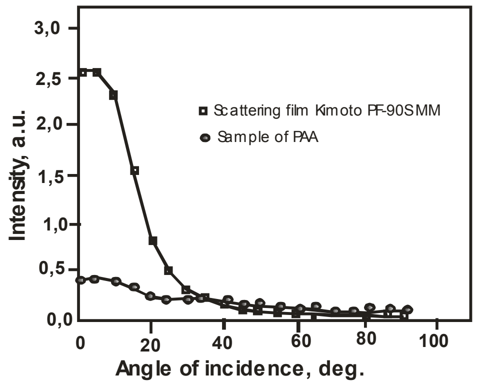


Fig. 2 – Intensity of light scattered normally to the sample plane versus angle of incidence

To get more detail on the light transfer by the anodic alumina oxide film, the light intensity enhancement from a flat white light emitting diode panel was examined. The porous anodic alumina film was placed between LEDs and a detector at a variable LED – film distance and the light intensity $I_{PAA}$ was measured by the detector and compared with the light intensity registered without the alumina film. The 22% intensity enhancement was provided at the 100 mm distance between the sample and the LED panel as shown in Fig. 3.

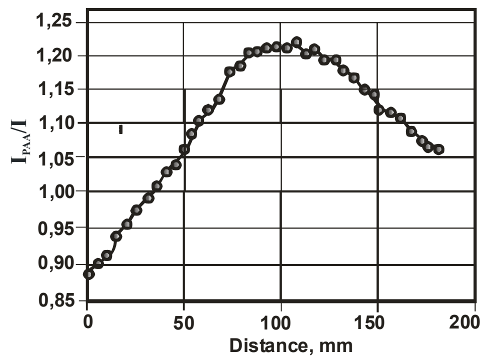


Fig. 3 –The ratio of light intensities with and without the alumina film between the LED panel and the detector depending on the distance between the film and the LED panel

**Conclusions.** The results obtained show that nanoporous structure of electrochemically anodized alumina films can be purposefully used to control light propagation, namely, to perform anisotropic light scattering in LCD backlight systems as well as potential modification of light polarization.

## References


[1] Lutich, S. Gaponenko, N. Gaponenko, I. Molchan, V. Sokol, V. Parkhutik, NanoLett. 4, No.9, 1755 (2004).

[2] Lutich, M. Danailov, S. Volchek, V. Yakovtseva, V. Sokol, S. Gaponenko, Applied Physics B – Lasers and Optics (2006).