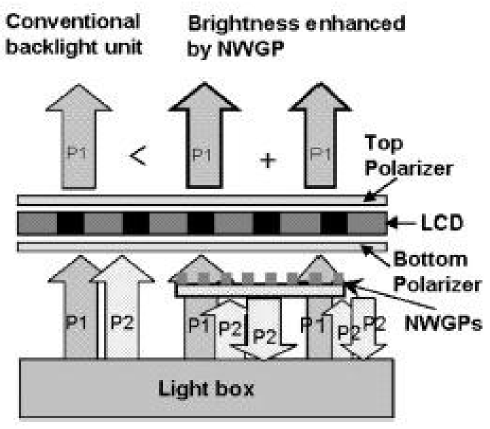
LCDs get brighter with nano polarization recycler



On the left side of this drawing, P1 light is transmitted through the LCD panel, while a conventional bottom polarizer absorbs P2 light. On the right, the scientists' new nano-wire grid polarizer recycles some of the otherwise-absorbed P2 light back to the light box, where it is partially converted to P1, and the process repeats. Image credit: Sang Hoon Kim et al.

LCDs (liquid crystal displays) provide a popular method for lighting screens on everything from computers and TVs to watches, clocks, cell phones and more. However, as scientists Sang Hoon Kim, Joo-Do Park and Ki-Dong Lee from Korea report, the light efficiency of LCDs is below 10%. Realizing there's room for improvement, the team developed a way to brighten LCDs by recapturing much of the lost light using a technique called polarization recycling.

In the past decade or so, a competition between LCDs and plasma screens has brewed for mainstream users, exciting as well as confusing many TV and computer buyers who want to own the best and latest technology. It's pretty clear that LCDs, with their low power consumption, have won out for computer screens. For TVs, however, plasma screens have remained in the race largely due to their high quality in brightness and color contrast. If LCDs can improve in this area, it's highly likely that they will dominate the TV market, as well.

Kim, Park and Lee recently made a large step in enhancing the brightness of LCDs by taking a nano-wire grid polarizer (NWGP), a device known to reflect polarization, and inserting it between the LCD panel and backlight.

"The problem with current LCDs is a low light efficiency," Lee told *PhysOrg.com*. "Therefore, one needs more power to be supplied for light sources like LEDs or fluorescent lamps, or more light sources to be used in order to increase the brightness of LCDs. If one uses reflective polarizers like NWGP, one can get higher brightness in a given power consumption."

An LCD unit contains several thin films of glass and filters placed back-to-back, notably two polarizing films placed perpendicular to each other. In between these polarizers, liquid crystal molecules lie in a twisted helix, normally creating a lighted screen. However, typical polarizers transmit only some of the light from the light box, and absorb some light. Kim et al.'s new polarizer, on the other hand, reflects the otherwise absorbed light back to the light box so it can be transmitted again, effectively recycling the light polarization and increasing the brightness (see figure).

"The amount of recycled polarization depends on the way the BLU [backlight unit] is constructed, said Lee. "In the paper, we assumed 0.5 percent in a single return after each reflection at the NWGP. Since non-converted light will reflect again and again by NWGP, the total conversion ratio should be calculated by summing the sequence. However, the actual ratio will be less than the number since some light will be lost by absorption."

One component of brightness in LCDs is overall light transmission. With their set-up, Kim and his colleagues achieved transmission above 90%, noting that a trade-off exists between transmission and contrast ratio, another parameter of brightness.

Contrast ratio is the ratio of the luminosity of the lightest color to that of the darkest color a system produces. When an electric field is applied to the liquid crystals between the films, the crystals align with the electric field rather than the films, cutting off the light's path and creating a dark spot on the screen. The closer to true black a display can reach, the higher its contrast ratio (complete black would result in an infinite contrast ratio). With higher light transmission, blocking all the light becomes more difficult, although the scientists found that the lighter colors that high transmission created outweighed the not-as-dark black in terms of overall brightness.

"The contrast ratio used in the paper [which was 12.5] differs from the contrast ratio in a TV," Lee explained. "The contrast ratio of NWGPs indicates the extinction ratio of the polarizer. It doesn't determine the contrast ratio advertised for LCD TVs."

To build their nano-wire grid polarizer, the team used laser interference lithography to deposit aluminium onto a film. Using computer simulations, they found that maximum brightness enhancement is achieved with 20-nanometer-thick aluminium films deposited at a 50 degree angle on a nano-wire grid. Further, Kim and his team reported that their recycling polarizers can be fabricated by nanoimprinting for increased volume production, as well as be extended to larger surfaces.

Citation: Kim, Sang Hoon, Park, Joo-Do and Lee, Ki-Dong. "Fabrication of a nano-wire grid polarizer for brightness enhancement in liquid crystal display." *Nanotechnology* 17 (2006) 4436-4438.