Title: AR and AG in 3 dimensions

Abstract: Many applications, such as the lenses of mobile phones, involve complex 3D shapes. Delivering effective AR/AG surfaces in 3D is becoming an important challenge to the display industry. This paper shows how the combination of motheye structured AR hardcoats and In-Mold Decoration techniques can deliver this desirable functionality.

Keywords: Motheye, AntiReflection, AntiGlare, MARAG™, IMD, In-Mold Decoration, Mobile phones, Lenses.

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Objective and Background

Many options exist for making antireflection (AR) and antiglare (AG) surfaces for typical display surfaces. But many applications, such as the lenses of mobile phones involve complex 3D shapes. Delivering effective AR/AG surfaces in 3D is becoming an important challenge to the display industry.

If we concentrate on technologies that are mass producible (as opposed to specialist dip-coating or sputtering techniques) then an attractive technology is so-called In-Mold Decoration, IMD. In this technique the 2D film is formed into a 3D shape via vacuum or pressure forming techniques. Then that formed shape is placed into cavity of an injection-molding machine and the 3D surface made rigid through injection of PMMA or PC. This general technique is in routine use for mobile phones where the surface is not AR/AG but is a hardcoat tough enough to withstand the daily handling of a typical mobile phone.

There are 3 challenges applying this technique for making 3D AR/AG surfaces:

1 Many AR coatings cannot survive the forming process – they shatter under even modest deformation.
2 The high temperatures and pressures of the injection-molding process can destroy many AR/AG coatings
3 The AR/AG coating has to be tough enough to survive the aggressive tests for scratch and wear resistance of a mobile phone.

Recent joint work by Holotools and Autotype has shown that motheye and MARAG™ AR/AG systems can meet these tough criteria; conventional sputtered or solvent multilayer AR coatings have much greater difficulty.

As described in previous publications[1 2] the basic AR functionality is provided by a holographic origination at Holotools of a structure that mimics the extraordinary AR capability of a moth's eye. In addition, via a second holographic exposure an AG structure can also be built into the surface making the Motheye- AntiReflection-AntiGlare MARAG™ surface.

In both cases the surface is mass replicated by Autotype via a continuous UV-curing process to deliver an exact replica on the surface of PET, PMMA or PC film. The fact that it is UV-cured is important. The surface is hard enough for real-world handling (criterion 3) but it also means that the high temperatures and pressures of the molding process cause no degradation of the structure (criterion 2). Autotype is a leading supplier of formable hardcoat IMD films to the mobile phone industry and has been able to engineer the required formability without cracking (criterion 1).

As an alternative to pre-forming the 3D shape, In-Mold Shaping (IMS) can be performed where the heat and pressure forces the flat AR film to form to the shape of the cavity. A further advantage of this system is that the rear surface of the AR coating can be printed (in the 2D state) with suitable graphics. After forming and injection molding, the print is fully encapsulated and adds essential design flexibility to the overall package.

In both IMD and IMS the lens can be made 2-sided AR by placing two films in the cavity. The overall IMD system is shown in Fig 1.

Results

As an example of the system in practice a generic 3D curved mobile phone lens was produced by IMS. A MARAG™ hardcoat on 180µm PC film was die-cut to the required shape, placed in the injection mold tool and a further 1mm of PC was injected. A control using an unstructured film with similar chemical properties was also produced by the same process. The machine used for the experiments was not fitted with suitable handling equipment to allow us to produce 2-sided AR.

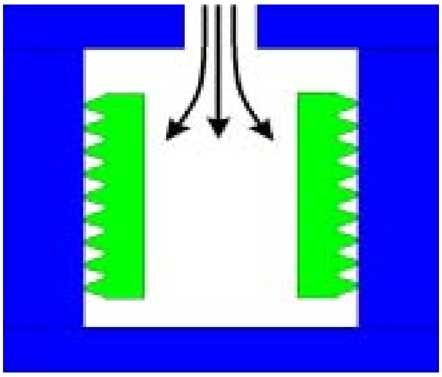

Fig 1: The two motheye films are placed with their structured surface against the mold tool wall and the resin is injected in behind them

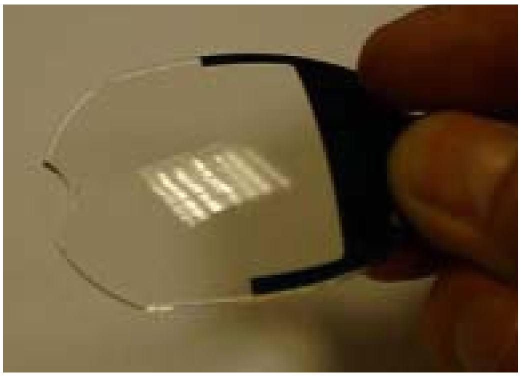

Fig 2: The reduction in light intensity and the desired diffusion of the reflected light are apparent in the half that includes the molded MARAG ™ component.

When the motheye AR was used the % transmission increased from about 91% (control) to >94%. The MARAG™ gave identical results. The low level of haze (7%) of the MARAG™ produced a significant reduction in specular reflection, reducing distraction from reflected images. Fig 2 shows a sample of a generic lens where only half the surface was structured (and backprinted); the reduction in the intensity of the reflected light and the diffusion of the specular image are both apparent.

Impact

By taking AR and AG into the third dimension designers have a greater freedom to provide display systems with a look and feel that can be targeted towards specific audiences in the mobile phone and other high resolution colour portable devices. The choice of single/double sided and AR and/or AG adds further design versatility. Other applications for this approach to AR/AG can readily be envisaged.

References

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