# Coloring of injection molded plastic plate by surface nanostructures without pigment

**Doo-Sun Choi**, Yeong-Eun Yoo, Jae-Sung Yoon

Korea Institute of Machinery and Materials, #171, Jang-dong, Yusung-gu, Daejeon-city, Korea
choids@kimm.re.kr

## Abstract

Painting is a typical method for coloring diverse articles. Another common way is molding the plastic articles directly without painting using thermoset resin compounded with pigments or dye through compounding process. Coloring methods like these are based on chemical pigments or dye.

Compared to these colors, some colors in the nature arise from nanostructure, not from the pigment. For example, the wing scales of butterfly are showing very diverse colors result of the scales micro- and nanostructure[1].

One of typical structures of the wing scales of butterfly is shown in Fig. 1, which consists of multi-layer micro- and nanostructure[2]. These multi-layer structures are very efficient for coloring, but very difficult to realize for engineering applications.

Instead of applying the same structures in nature to engineering applications, some variants should be introduced for mass production. As a variant, a multi-step nanostructure is designed to investigate the coloring effect for plastic articles injection molded.

A model for structures is designed to have three steps as shown in Fig. 2. For moldability of nanostructures and the article itself with nanostructures on the surface, no undercut structure is used and all structures are designed to be intaglio. This intaglio structure turns out to be better for durability of surface structures which is one of drawbacks of nanostructures

A pattern master and nickel stamper(Fig. 3)is fabricated to be applied for injection molding of nanostructured plastic plates. A black colored PMMA(Poly MethylMetha Acrylate) is injection molded to see the color effect with the nanostructures. The injection molded nanostructures and the color of the area with nanostructures are shown in Fig. 4 and Fig. 5. As shown in Fig. 4, the nanostructures molded at higher mold temperature are replicated better.

As a result of this study, we could see the possibility of coloring with nanostructures without pigment.

## References

[1] Pete Vukusic and J. Roy Sambles, “Photonic structures in biology”, *Nature,* 2003, Vol. 424 14

[2] L. P. Biró et al. “Role of photonic-crystal-type structures in the thermal regulation of a Lycaenid butterfly sister species pair”, *Physical Review,* 2003, E 67, 021907

[3] Y.E. Yoo et al., “Injection molding of a nanostructured plate and measurement of its surface properties”, *Curr. Appl. Phys*., 2009, Vol. 9 e12-e18,

## Figures

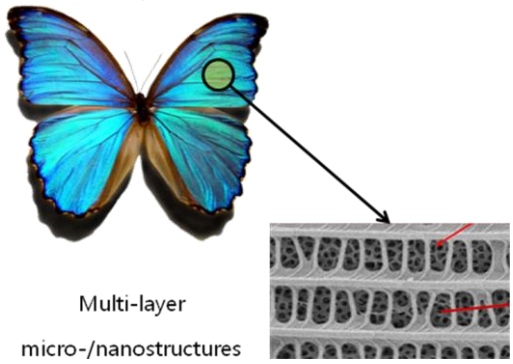


*FIG. 1: Structures of the wing scales of butterfly.*

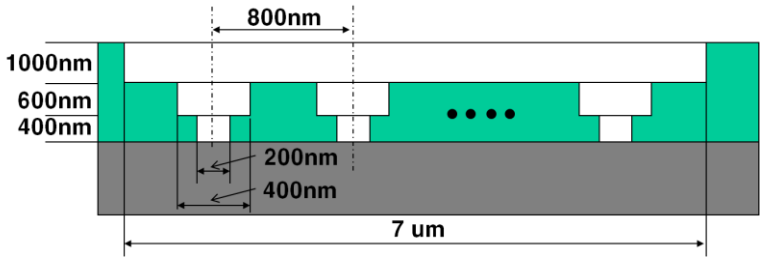


*FIG. 2: A three-step model design for structural coloring*

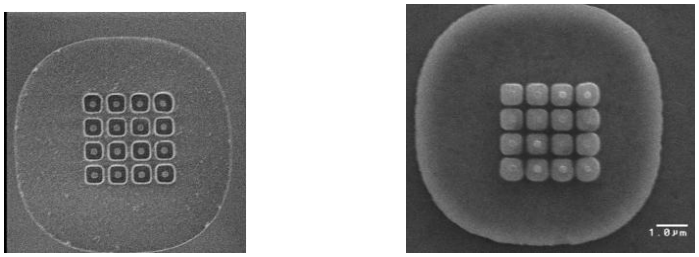

*FIG. 3: Pattern master(left) and stamper(right) for three-step model design for structural coloring*

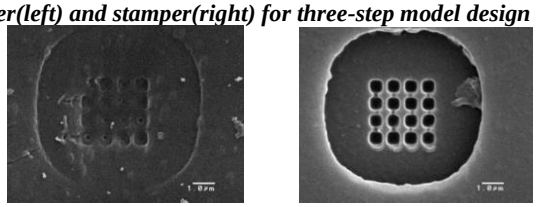

*FIG. 4: Injection molded nanostructures at different mold temperature [mold temp. : 40oC (left), 150oC (right)]*

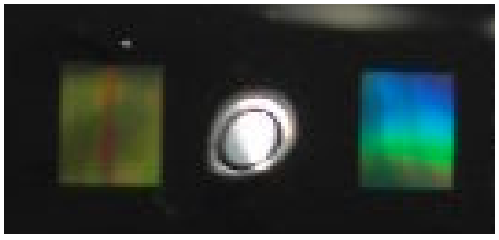

*FIG. 5: Structural color for injection molded nanostructures*