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Injection molding antireflective black silicon nanostructures

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Nanostructured surfaces offer new or improved surface properties, such as antireflection, super hydrophobicity and anti-fog surfaces[1]. While these functionalities have been shown on lab-scale, there are still great challenges in developing high-volume production methods that can reduce the cost of such nanostructured materials. Here we present a low cost method for fabricating antireflective polymer surfaces, based on mask-less reactive ion etched "black silicon" masters, and low cycle-time injection molding from anti-stiction coated, electroplated nickel (Ni) shims. The reflectance of injection molded polypropylene is reduced from 4% to 1%, in the visible spectrum.

Saarikoski *et al.* previously reported injection molding of antireflective nanostructures in polycarbonate, from Ni shims electroplated from porous anodic aluminium oxide. The authors report a decrease in reflectance from 5% to below 1% in the visible spectrum [2]. Black silicon can likewise be used as a template for fabricating antireflective structures, despite the random nature of the structures. We have previously shown that black silicon can be optimized in order to minimize the scattering of light on the structured surface [3].

In this study, a black silicon master was fabricated using mask less reactive ion etching. A Ni shim was fabricated from the master using electroplating. The shim was anti-stiction coated and used for injection molding polypropylene and polyamide parts, with 30 second cycle times. The Ni shim and the fabricated samples were characterized using scanning electron microscope and atomic force microscope, and the total reflectance of the injection molded parts was measured using an integrating sphere.

Scanning elelctron micrographs show that the nanostructures have been transfered to the injection molded parts (see Fig. 1). The height of the injection molded nanostructures was measured with AFM, and compared to the Ni shim. The results show that the filling of the injection molded structures is 70% and 60% for polyamide and polypropylene respectively, when comparing to the Ni shim (see Fig. 2). The total reflectance of the polypropylene is reduced from 4% for a planar sample, to 1% for the injection molded nanostructured sample (see Fig. 3).

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[3] A. B. Christiansen, J. Clausen, N. Asger Mortensen, A. Kristensen, Appl. Phys. Lett. 101 (2012) 131902.

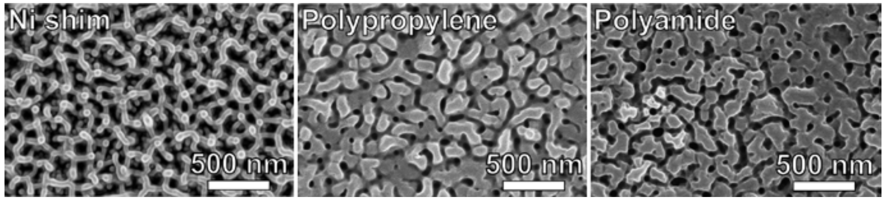

Figure 1. Scanning electron micrographs of nanostructured surfaces. From left: The nickel shim which was electroplated from a silicon master. Injection molded polypropylene. Injection molded Polyamide.

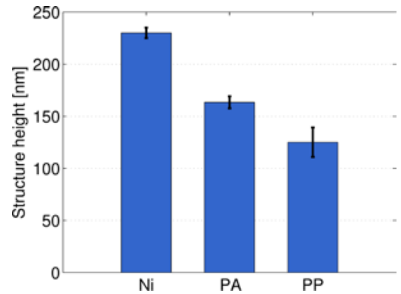

Figure 2. Height of replicated nanostructures compared to the Ni shim. The height was measured using AFM. The samples are from the left: the nickel shim, injection molded polyamide and injection molded polypropylene.

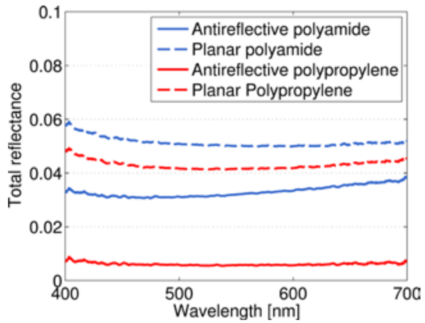

Figure 3. Total reflectance of injection molded parts, measured using an integrating sphere. For polypropylene, the reflectance is lowered from 4% to below 1% in the visible spectrum.