Upgrade of optical security by combining techniques

Holtida JSC specializes in development of advanced optical security means. Established in 2014 as spin-off company, which extends over 20 years of experience developed by a team of scientists in the field, the company successfully produces the holographic security labels, www.holtida.lt

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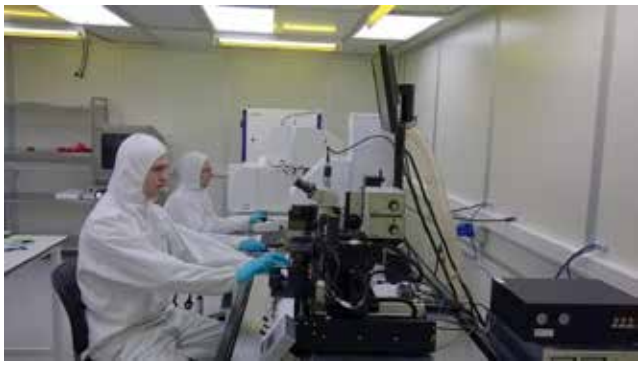
Industrial need

The company was exploring the way to upgrade its product quality by using analytical and technological facilities. It searched for research proposals of measuring the product material, and the research response was to create the advanced optical security device by combining the dot-matrix and electron beam lithography techniques in a single master image.

Experiment

The main objective of the experiment was to develop the combined dot-matrix and electron beam lithography technology taking benefits of both techniques in a single product. The patterning of holopixels arranged with different grating orientations and pitches was performed using a dot-matrix master shooting machine equipped with a laser diode PMMF 608-G operating at a wavelength of 405 nm. For the patterning of nanotext and diffraction gratings in the specified areas of the same sample, the Raith e-LiNEplus high resolution electron beam lithography and ultrahigh resolution imaging & analysis system was applied. The ratio of areas patterned by dot-matrix technique and e-beam lithography is about 16:1, thus relatively more expensive and the slower e-beam writing time was not sufficient for forming a combined image. The layout of the combined image was investigated by optical, scanning electron and atomic force microscope. It was proved, that e-beam patterned gratings have smooth and steady edges, while the slopes and the ridge surface of the dot-matrix patterned gratings are inclined and uneven. Measurements demonstrated differences in spatial frequency



The photos of the clean room at Material Science Institute at the Kaunas University of Technology where the measurements were performed

and shape of the grooves as well as profile depth between the e-beam and dot-matrix patterned gratings. These differences can be easily recognized at the expert level, thus providing a very high security degree and preventing counterfeiters.

Technique and materials used in the experiment

The experiment included the use of the dot-matrix master shooting machine equipped with a laser diode PMMF 608-G operating at a wavelength of 405 nm; Raith e-LiNEplus high resolution electron beam lithography and ultrahigh resolution imaging & analysis system; OAI Model 200 IR Mask Aligner; Atomic force microscope NanoWizard®3 (JPK instruments AG); Optical microscope with a micrometer scale and a digital video camera (OptikaTM Vision Pro).

As regards the materials used at the experiment, then the measurements included Photoresist, KOH developer, polymethyl methacrylate (PMMA) 4% solution in Anisole, conductive polymer L1_XP, methyl isobutyl ketone (MIBK) and isopropyl alcohol, CR-14 type chromium etchant.

Findings

The essential finding in the conducted research was the precise alignment of topographies patterned by different techniques. The diffraction gratings fabricated by dot-matrix and e-beam patterning techniques were investigated by scanning electron microscope. It was discovered that e-beam patterned grating has smooth and steady edges, while the slopes and the ridge surface of the dot-matrix patterned gratings are inclined and uneven. Furthermore, the atomic force microscope measurements identified that a spatial frequency of the grooves and profile depth in the e-beam recorded gratings are somewhat higher, than dot-matrix patterned gratings, whereas dot-matrix gratings have much more sinusoidal-type shape of the groove profile. Combination of the two technologies in a single master image provides a very high protection level, as both techniques can be recognized at the expert level, therefore preventing counterfeiters. The findings of the successfully performed experiment led to the conclusion that the created technique can be used for the origination of optical devices with the increased level of security.