Heidelberg Test on Grayscale Lithography

Introduction: *This is a document concerning the test writing on the grayscale lithography technique provided by the Heidelberg µPG 101 machine.*

Test Writing Process

1. Sample Preparation
   a. Prepare an RCA cleaned 3-inch glass substrate.
   b. Spin coating HMDS on glass, 60sec @ 5500rpm.
   c. Spin coating AZ P4210 (AZ4562) photoresist, 60sec @ 3000rpm.
   d. Soft bake in oven, 1hr @ 110^{o}C.

2. Grayscale Exposure
   Heidelberg µPG 101 machine provides the grayscale lithography function. The parameters for exposure are listed here:
   a. Laser power: 16mW; Duration factor: 40%
   b. Grayscale: 50
   c. Design size: 2.5mm X 2.5mm with uniform grayscale
   d. Number of designs: 25 (5 X 5 array)

3. Development
   a. Develop in 352 developer for 2min.
   b. Rinse in DI water for 1min.

Optical Microscopic Images

The optical microscopic images of the test exposures on glass substrate under front illuminations are given in Fig. 1. Four magnification factors are used. The exposure #1 with default parameters (2.1MHz for 8um line width) has randomly distributed stripes (Fig.1 (aa)). And the artifact is manifested in #21 and #25 (Fig.1 (fa) and (ga)). The exposures #5, #9, #13 and #17 seem to be good in terms of suppressing the artifact. And #5 and #9 look better (Fig.1 (ba) and (ca)).

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Figure 1 | Optical microscopic images of the test exposures.

(aa) – (ad) #1.

(ba) – (bd) #5.

(ca) – (cd) #9.

(da) – (dd) #13.

(ea) – (ed) #17.

(fa) – (fd) #21.

(ga) – (gd) #25.

(aa) (ba) (ca) (da) (ea) (fa) and (ga) are 5X magnification.

(ab) (bb) (cb) (db) (eb) (fb) and (gb) are 10X magnification.

(ac) (bc) (cc) (dc) (ec) (fc) and (gc) are 20X magnification.

(ad) (bd) (cd) (dd) (ed) (fd) and (gd) are 60X magnification.

Profilometer Measurement Results

The Profilometer measurements are summarized in Figure 2. Based on the measurements, #1 and #21 and #25 has evident stripes with periodic of around 8um, which is obviously artifact. For #1, the stripes appear as bumps (50~80nm height difference), and they are almost arbitrarily distributed. However, for #21 and #25, the stripes are trenches (40~60nm height difference), and they look more periodic and occur more often. Between them, #5, #9, #13 and #17 are better exposures, as indicated in the microscopic images in Fig.1. Therefore, we can say the parameters between #5 and #17 may work the best for grayscale lithography.

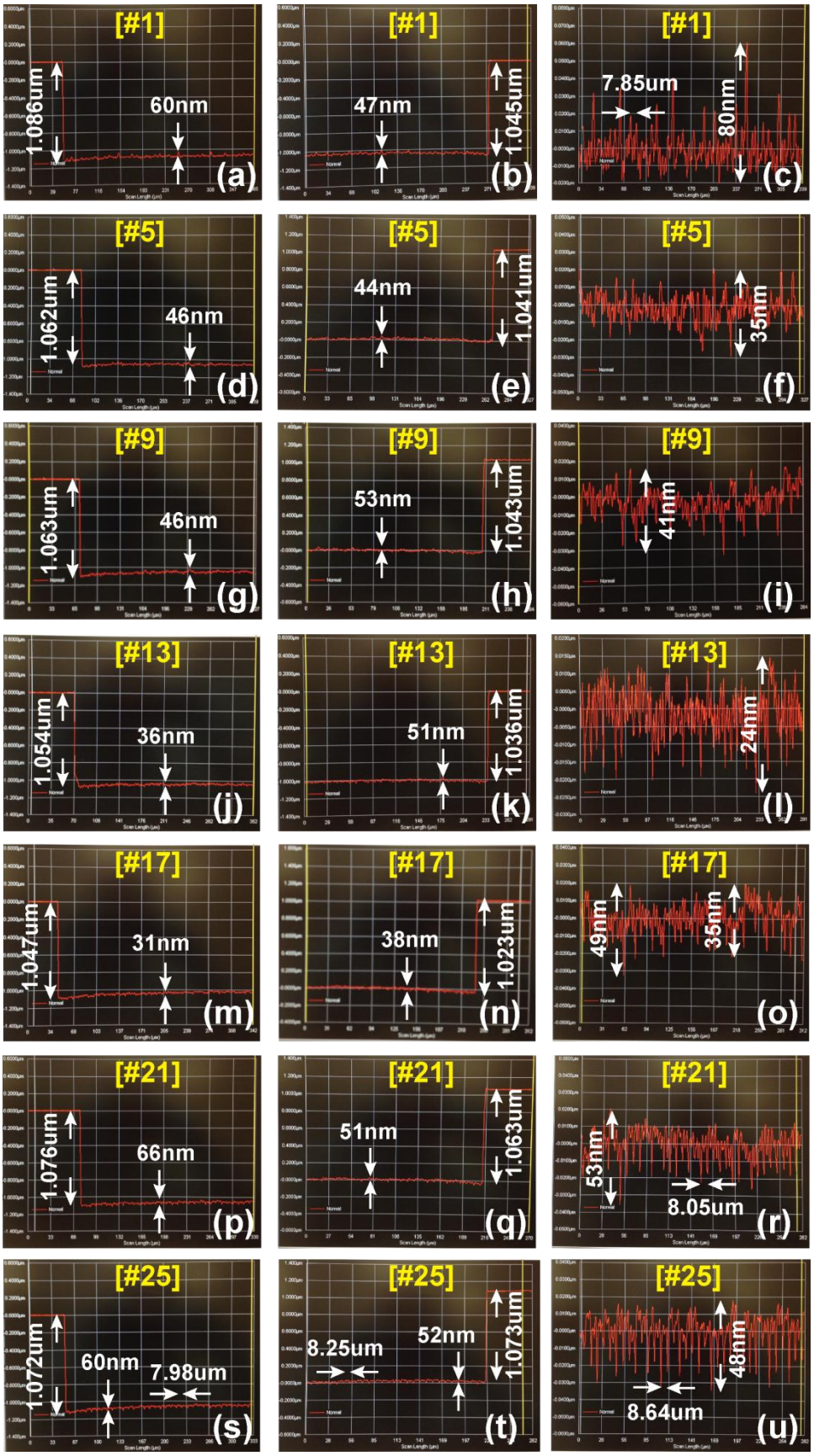

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Figure 1 | Optical microscopic images of the test exposures.

(a) – (c) #1.

(d) – (f) #5.

(g) – (i) #9.

(j) – (l) #13.

(m) – (o) #17.

(p) – (r) #21.

(s) – (u) #25.

(a) (d) (g) (j) (m) (p) and (s) are left edges.

(b) (e) (h) (k) (n) (q) and (t) are right edges.

(c) (f) (i) (l) (o) (r) and (u) are central regions.

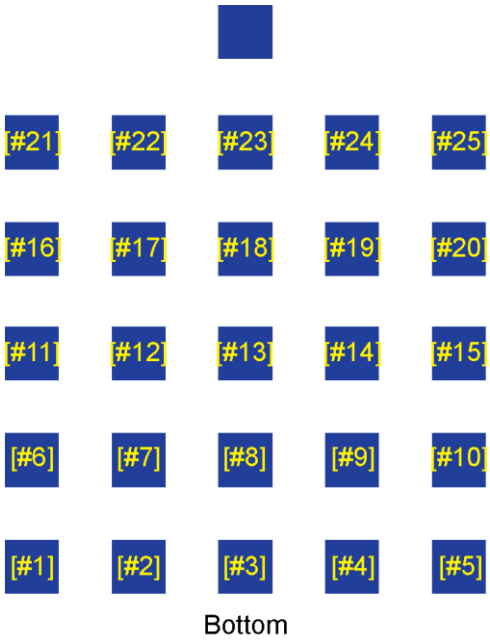

Figure 3 | Configurations of the exposures.