The sensitivity of these targets to mask making tolerances were examined. An example for an improved coma target is shown in Figure 4. The target now wraps completely around the probe and changes phase by 180 degrees in crossing the vertical axis. Excellent orthogonality to trefoil results. The misalignment (displacement) of the probe with respect to the center introduces an increase in the intensity at the probe position with no aberration present. For a rotated (oppositely phased) target there is a corresponding decrease. The shift between the two orientations is about 15% of the clear field value per 0.1λ/NA displacement. To measure coma to an accuracy of 0.01λ RMS this undesired signal should be less than 1/5 the 30% net shift between the two targets when 0.1 waves coma at the pupil edge is introduced. An alignment of 0.04λ/NA or 1/15 of a feature size is thus needed.

The general guidelines for programmed-probe based aberration targets are as follows. Ordinary features can be used such as a minimum feature size of L_MIN = 0.6λ/NA. The linewidth variation is not critical and the usual linewidth control is adequate. The probe should be about 2/3 of the minimum printable feature size L_MIN. The exact size, while an important parameter, is not critical, since the effective probe area can be determined by printing isolated probes due to high (0.96 or better) Strehl ratio of the lens. The separation between the feature and the probe is typically 0.4λ/NA and this allows a chrome etch stop to be used in mask making. The alignment of the probe to the feature axis needs to be within L_MIN /15 of the minimum feature size. The alignment of the phase area to the feature need only be L_MIN /8. The accuracy of the phase depth, sidewall angle, etch bias, and even the reduction of transmission with repair staining are also only of second order in importance. It is recommended that the phases be rotated such that the probe is not phase shifted. This prevents the electromagnetic edge effects that are proportionally stronger for small features from occurring on the on the sub-resolution probe feature.

1 For more details, see SPIE Proc. 4409, “Simulation of image quality issues at low k1 for 100nm lithography,” Andy Neureuther, Kostas Adam, Shoji Hotta, Tom Pistor, Garth Robbins, and Yunfei Deng, 2001