



DuPont Photopolymer & Electronic Materials

Printed Circuit Materials

Riston[®] and Stouffer Density Tablets

Photopolymer Film

Technical Bulletin TB-9526

DESCRIPTION

The Riston[®] 25-Step Density Tablet (step tablet) is a strip of MYLAR[®] polyester film containing 25 numbered blocks (steps) of increasing optical density. It is used to measure the degree of polymerization of DuPont Riston[®] photopolymer films from exposure to ultraviolet (UV) light in the imaging step of printed wiring board manufacture.

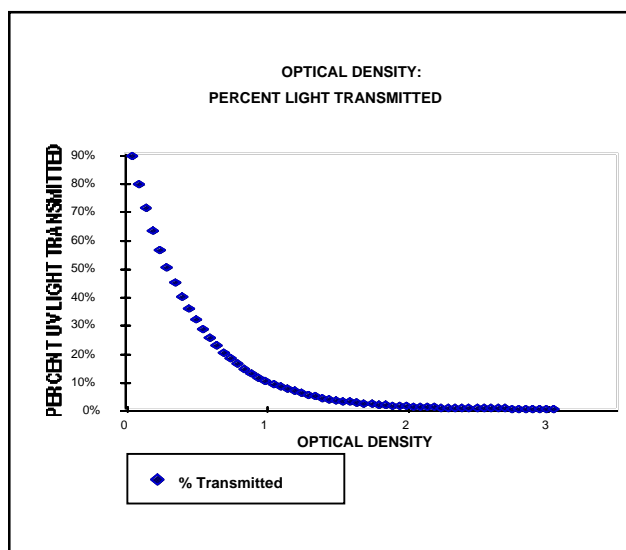
Optical density (OD) is the term used to relate the amount of light transmitted through a phototool to the amount of light it receives. It is a logarithmic function:

$$OD = \text{Log}_{10} \left[\frac{\text{Incident light intensity (I)}}{\text{Transmitted light intensity (T)}} \right]$$

or

$$OD = \text{Log}_{10} (I) - \text{Log}_{10} (T)$$

The graph below shows the percent light transmitted as a function of optical density.



Step tablets are made so that each step increases in optical density by a specific amount. As the step number increases, the amount of UV light passing through each step decreases. At a given exposure energy there will be a step where not enough light passes through the step tablet to polymerize the photoresist. Therefore, the step tablet is used as a measure of the total amount of light that the photoresist receives during exposure.

TABLE I STEP TABLET RELATIONSHIPS				
Optical Density	DuPont 25 Step Tab.	Stouffer 21 Step Tab.	Stouffer 31 Step Tab.	Stouffer 41 Step Tab.
0.00			1	
0.05		1		1
0.10			2	2
0.15				3
0.20		2	3	4
0.25				5
0.30			4	6
0.35		3		7
0.40			5	8
0.45				9
0.50	1	4	6	10
0.55	2			11
0.60	3		7	12
0.65	4	5		13
0.70	5		8	14
0.75	6			15
0.80	7	6	9	16
0.85	8			17
0.90	9		10	18
0.95	10	7		19
1.00	11		11	20
1.05	12			21
1.10	13	8	12	22
1.15	14			23
1.20	15		13	24
1.25	16	9		25
1.30	17		14	26
1.35	18			27
1.40	19	10	15	28
1.45	20			29
1.50	21		16	30
1.55	22	11		31
1.60	23		17	32
1.65	24			33
1.70	25	12	18	34
1.75				35
1.80			19	36
1.85		13		37
1.90			20	38
1.95				39
2.00		14	21	40
2.05				41
2.10			22	
2.15		15		
2.20			23	
2.25				
2.30		16	24	
2.35				
2.40			25	
2.45		17		
2.50			26	
2.55				
2.60		18	27	
2.65				
2.70			28	
2.75		19		
2.80			29	
2.85				
2.90		20	30	
2.95				
3.00			31	
3.05		21		

There are several different types of step tablets and each has a different optical density range. Table I, "Step Tablet Relationships," shows the relationship of optical density to the DuPont 25 Step Tablet, the Stouffer 21 Step Tablet and the Stouffer 41 Step Tablet.

RULES OF THUMB:

To compare the Stouffer 41 Step to Riston® 25 Step add 9 to the Riston® Step. For example, a Riston® Step 14 is equal to a Stouffer 41 of 23 (14 + 9).

To compare the Riston® 25 step to the Stouffer 21 step, multiply the Stouffer step by 3 and subtract 11. For example, a Stouffer step 8 is equal to a Riston® step 13 [(3 x 8)-11].

HOW TO USE THE 25-STEP DENSITY TABLET

PROCESSING TEST PANELS

1. Laminate test panels with Riston® film. Prepare test panels in the same manner as the production panels.
2. Set the photoprinter (exposure unit) for the time or integrator setting that should give the energy required for the photoresist used.
3. Place the production phototool on a test panel. Place the step tablet over a clear area of the phototool. If a double-sided vacuum frame is used, check both sides with step tablets.
4. Expose and develop the panel. Use the same hold times that are used for production panels.
5. After development, numbered blocks of resist (steps) will be evident.

INTERPRETING STEPS HELD

Unless the panel was drastically overexposed, the photoresist will have been completely removed from the highest numbered steps. The photoresist remaining on several of the high number steps may be wrinkled or partially removed. The "step held" is the highest number step which is more than 50% covered with photoresist.

It is not necessary to take pains to interpret the step held. If you are uncertain whether more than 50% remains at a particular step, assume it does not since the 25-Step Density Tablet is very sensitive, and most Riston® films have a broad exposure latitude operating range.

Note the following points to obtain consistent, reliable results with the DuPont 25-Step Density Tablet:

- Do not place the step tablet under the phototool. This lifts the phototool from the resist, causing off-contact printing, affecting the width of circuit lines and spaces.
- Small changes in developer temperature, as well as changes in development time or breakpoint, may change the steps held. Conditions must be kept reasonably constant to assure reproducible results.
- The recommended minimum hold times after lamination and exposure must be maintained. Hold times less than the minimum recommended for the photoresist may cause fluctuations in step tablet results.

EXPOSURE ADJUSTMENT

The desired exposure time, exposure energy, or integrator counts needed to expose to a desired step can be determined with good accuracy. The calculation is different for the Riston® 25 Step and the Stouffer 41 Step Tablets compared to the Stouffer 21 Step Tablet. The equation for the Riston® 25 and Stouffer 41 Step tablets is:

$$\text{Desired time, energy or counts} = \text{Reference time} \times (\sqrt[6]{2})^{[\text{Desired step} - \text{Reference step}]}$$

The equation for the Stouffer 21 Step Tablet is:

$$\text{Desired time, energy or counts} = \text{Reference time} \times (\sqrt[2]{2})^{[\text{Desired step} - \text{Reference step}]}$$

To determine the exposure time, energy or integrator counts needed to reach a desired step, determine the difference between the step held on a test panel exposed at known (or reference) time, energy or integrator counts and the new step you want to hold. Using this difference in steps, find the factor from Table 2 and multiply (or divide) the known (or reference) time by this factor. The factors in Table 2

are for use with the Riston 25 or Stouffer 41 Step Tablets. For the Stouffer 21 tablet, use the equation above.

Table 2
Exposure Adjustment Factors

Difference in Steps	Factor
1	1.12
2	1.26
3	1.41
4	1.59
5	1.78
6	2.00
7	2.24
8	2.51
9	2.82
10	3.16

EXAMPLES USING THE EXPOSURE ADJUSTMENT FACTORS

To INCREASE STEPS HELD:

Multiply the exposure time or integrator counts by the appropriate factor from Table 2.

For Example:

Time - A 15 second test exposure produces 5 steps held. If a step 8 is recommended, 3 more steps are required. Referring to Table 2, the factor is 1.41. Multiply the test exposure time by the factor (15 secs x 1.41 = 21.5 secs). An exposure of about 21 seconds should result in 8 steps held.

Integrator Counts - A test exposure with an integrator setting of 80 produces 5 steps held. If a step 8 is recommended, 3 more steps are required. Referring to Table 2, the factor is 1.41. Multiply the test exposure setting by the factor (80 x 1.41 = 113). A setting of about 113 should result in 8 steps held.

To DECREASE STEPS HELD:

Divide the exposure time or integrator counts by the appropriate factor from Table 2.

For Example:

Time - A 30-second test exposure produces 15 steps held. If a step 8 is recommended, 7 fewer steps are required. Referring to Table 2, the factor is 2.24. Divide the test exposure time by the factor (30 sec ÷ 2.24 = 13.4 secs). An exposure of about 13 seconds should result in 8 steps held.

Integrator Counts - A test exposure with an integrator setting of 150 produces 13 steps held. If a step 8 is recommended, 5 fewer steps are required. Referring to Table 2, the factor is 1.78. Divide the test exposure setting by the factor ($150 \div 1.78 = 84$). A setting of about 84 should result in 8 steps held.

AVAILABILITY

The DuPont 25-Step Density Tablet is available from your DuPont Electronics Technical Representative.

Stouffer Step Tablets or Sensitivity Guide can be obtained from Stouffer Graphic Arts Equipment Co. Inc., South Bend, IN 46617 USA.

ESTABLISHING EXPOSURE LEVELS FOR A PHOTORESIST

The first step in setting processing conditions for a new photoresist film type is to determine the functional exposure range for the film. Exposure range guidelines can be found in the data sheet or processing guide for the type of Riston® photopolymer film used. Prepare a series of test panels and expose the film with the step tablet using a broad range of times. Process the panels to determine which exposure level range produces satisfactory results.

Once the functional exposure step range has been determined, select a goal step value in the middle of the range to provide the widest latitude. In production, satisfactory results can be expected as long as the steps held are kept in the range defined by the functional exposure tests, assuming that other process conditions (prelamination cleaning, lamination, development, plating) are well controlled.

The recommended step ranges in the Riston® film data sheets are intended to serve as guidelines only. They represent a conservative judgment of the exposure range in which the film will perform best with respect to phototool reproduction, development, tenting, etching, and stripping. However, it is possible for a film to perform satisfactorily outside the range indicated in the data sheet. Specific parameters should be empirically established for all applications.

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