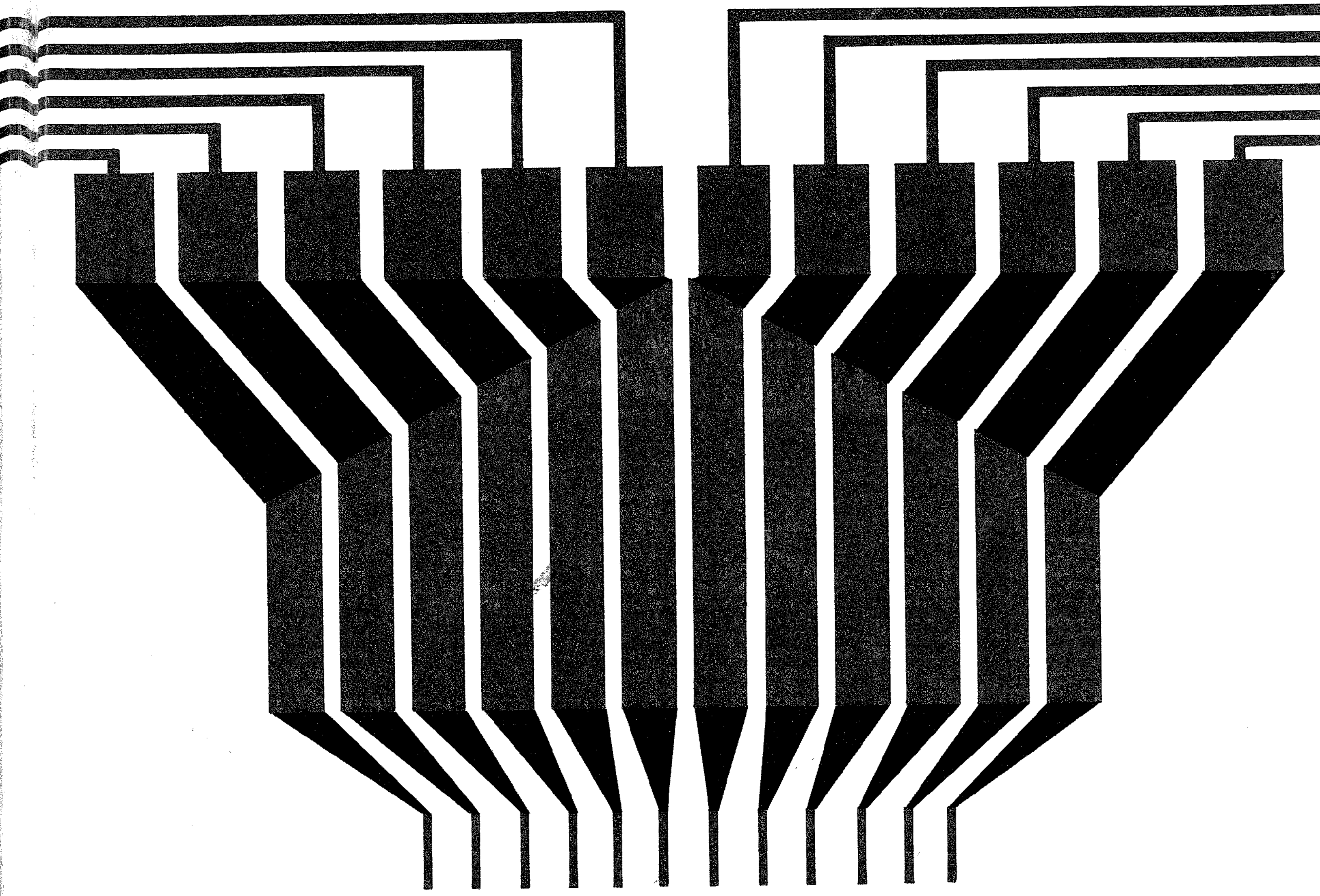

Electronic Materials Handbook™

Volume 1 Packaging

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ELECTRONIC MATERIALS HANDBOOK™

Volume 1

PACKAGING

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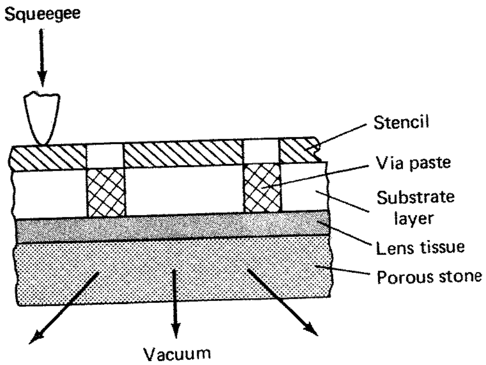

Fig. 8 Filling vias in prepunched tape

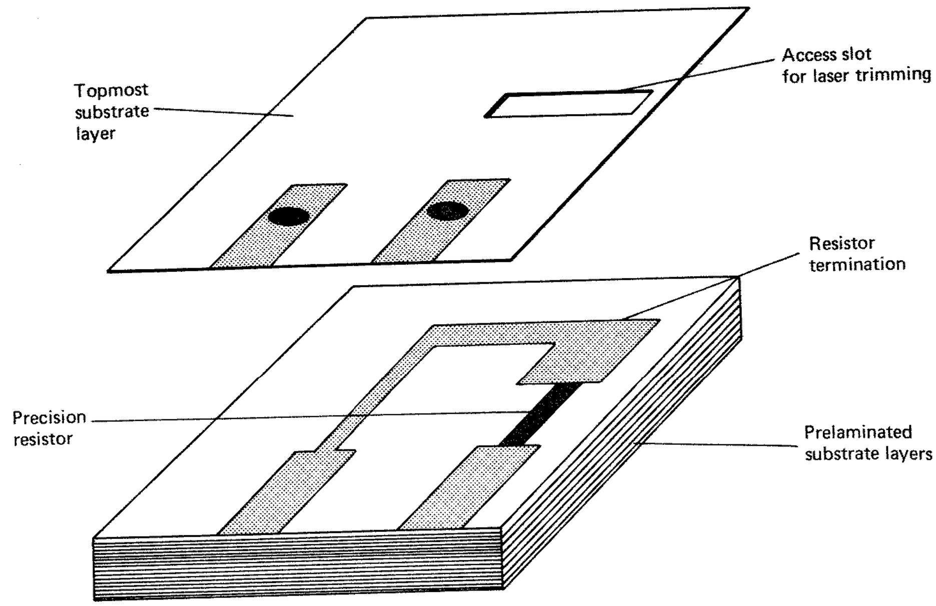

Fig. 9 Two-step lamination process for laser-trimmable buried resistors

modified printing stage. Complete filling of the vias in a single printing pass is accomplished by using on-contact printing through a stencil made of brass foil on a polyester film carrier.

Via fill compositions are designed to match the shrinkage rate of the dielectric. Ideally, the via should appear slightly underfilled. Grossly overfilled or underfilled vias are undesirable. The overfilled vias create problems when conductors are subsequently printed over them because paste spreading may cause shorts between closely spaced vias. Underfilled vias can occasionally "open up," forming a coated hole. After via filling, the tape layers are dried in a convection oven. If defects are observed, the pattern can be corrected or the layer discarded prior to lamination.

A special printing stage is required for filling vias or printing conductors. A porous stone plate through which a vacuum is drawn is used to hold down the tape and provide a flat, distortion-free substrate for printing (Fig. 8). The machine setup for conductor printing is similar to that for via filling, but the conventional off-contact printing mode is used (as on an alumina substrate). The substrate layer with the conductor print pattern is then dried.

In the low-temperature cofired process, thick-film resistors can also be printed on the substrate layer. If the resistor formulations are appropriately adjusted, they can be cofired in buried configurations (Ref 23). Resistors can be printed on any substrate layer and terminated with appropriate metallization. Resistors buried within the laminate cannot be laser trimmed to precise values; consequently, such formulations are designed to have resistance tolerances of less than ±25%. Resistors requiring precise resistance values need to be laser trimmed. These resistors can be printed either on the topmost substrate layer or one layer below it. In the latter configuration, a slot (250 μm, or 10 mils, wide and 2.5 mm, or 0.1 in., long) in the top layer provides access for laser trimming the resistor printed below it. Figure 9 illustrates a two-step process for laser-trimmable buried resistors. The two-step process involves prelaminating a stack of substrate layers (on which laser-trimmable resistors are printed) and subsequently laminating the topmost layer over the stack.

Inspection, Collation, and Registration. After drying, layers are inspected for line continuity and via registration. Registration of the substrate layers must be held to less than ±0.1 mm (±0.004 in.) tolerance through via forming, conductor printing, and lamination steps. After inspection, tape layers are collated and aligned so that the corner registration holes are concentric, for placement of the registration pins in the lamination die, as shown in Fig. 10.

Substrate Fabrication

Lamination. Sets of collated, registered layers are placed in a pressing die having cavity dimensions identical to those of the blanked sheet. The (confined) die walls prevent lateral distortion of the sheets during lamination, and the registration pins ensure mechanical registration and circuitry alignment. Because the extent of metallization also influences the absolute value of shrinkage, local laminating conditions can be used to establish final dimensions in actual designs.

Although the green microstructures of the substrate layer contain a spatial distribution of porosity (see the section "Substrate Layers" in this article) that varies with the formulation and the processing parameters used, the distribution of porosity can be changed during the lamination process. The amount of pore removal is often a function of the lamination pressure used. Figure 11 shows decreasing mercury (Hg) intrusion volumes (in Hg porosimetry tests) associated with a decreasing volume of porosity (in tapes laminated at increasing pressures). The removal of this porosity directly affects the amount of shrinkage that occurs during firing.

The relationship between lamination pressure and shrinkage in the *x*-*y* plane of a laminate is shown in Fig. 12. Once the shrinkage for a specific tape lot is determined and lamination conditions are main-

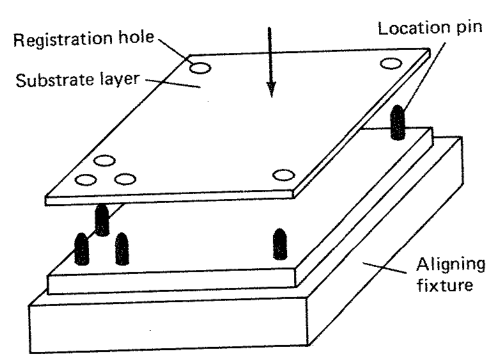

Fig. 10 Alignment fixture for substrate layer registration

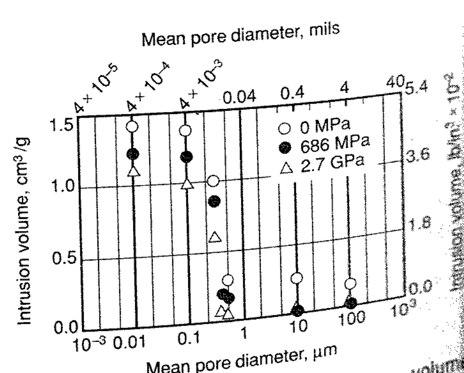

Fig. 11 Decreasing mercury porosimetry volume with increasing lamination pressure