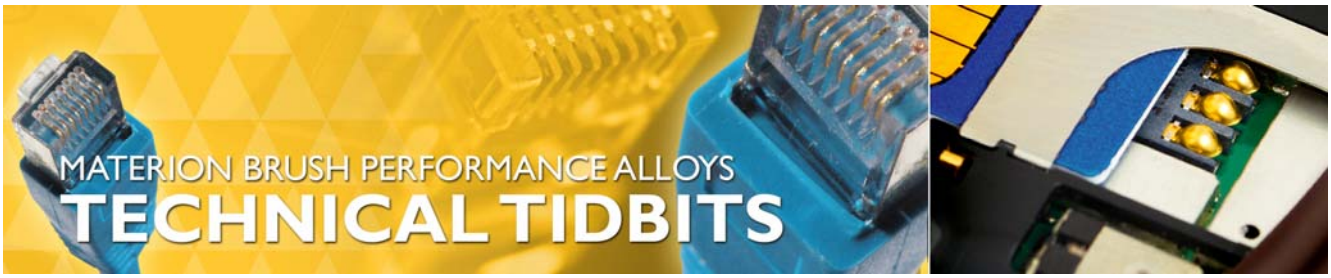

Issue No. 25 – January 2011 **Updated from Original July 2001 Publication**

Harder than it looks! – An examination of the various hardness testing techniques that one would encounter in electronic strip applications.

- **Macro-indentation hardness**
- **Micro-indentation hardness**
- **Superficial**
- **Brinell**
- **Rockwell**
- **Knoop**
- **Vickers**

The next issue of Technical Tidbits will discuss some of the potential pitfalls of hardness testing.

Hardness Testing

Hardness is the measure of how resistant a material is to deformation of the surface under a specified load. Stronger materials will have greater resistance to deformation than weaker materials, so hardness testing is often used as an approximate means of gauging the relative strength of materials. It can also be used to estimate whether or not the mechanical properties of a particular piece of metal or stamped part fall within the desired range. This is especially true in areas where it is impossible or impractical to perform a tensile test to precisely measure the strength of the metal.

Every hardness test uses an indenter, which is pressed into the surface to be tested by a specified force load for a specified amount of time. When the indenter is removed, the size of the indentation left behind gives a measure of the hardness of the material. Soft materials will show large indentations; hard materials will show small indentations. Since the amount of force used to make the indentation will also affect its size, it is important to specify the amount of force used.

The various hardness scales (tests) available differ in the force load that is applied, and in the type of indenter used. Indentation hardness tests fall into two categories. **Macroindentation hardness** (or macrohardness) scales are those that use an indentation load greater than 1000 grams. The Brinell and Rockwell scales fall into this range. **Microindentation hardness** (or microhardness) scales use a load between 1 and 1000 grams. Knoop and Vickers fall into this category. Rockwell tests are further subdivided into standard and **superficial** scales. The standard tests use loads of 60 kg or greater, and the superficial tests use 15, 30, or 45 kg loads.

The scales are further differentiated by the type of indenter used. **Brinell** tests use spherical indenters made from hardened steel or tungsten carbide. **Rockwell** tests use either a diamond cone or a hardened steel sphere. The **Vickers** test uses a square based diamond pyramid. The **Knoop** test uses an elongated diamond pyramid, where the major diagonal is seven times longer than the minor diameter. The tip of each type of indenter is shown in figure 1.

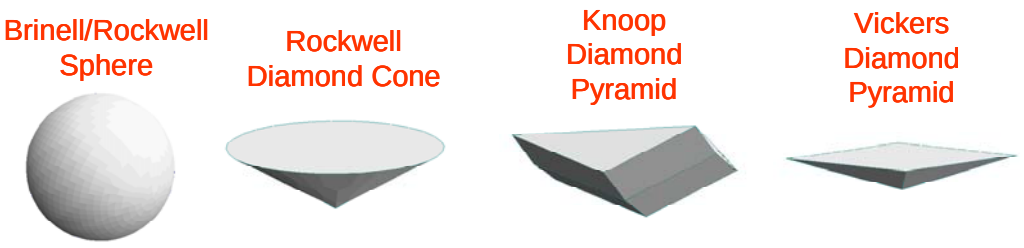

Figure 1. Various Indenters Used in Hardness Testing

ASTM has established specifications to ensure consistent and proper testing. ASTM E10 covers the Brinell scale, and ASTM E18 covers the Rockwell scales. The Knoop and Vickers microhardness tests are covered by ASTM E384 and ASTM E92, respectively.

The size and hardness of the piece to be tested dictates which combination of indenter and load is to be used. Most of the Rockwell scales (A, B, C, D, etc.) make large indentations and are intended only for testing large or thick pieces, and should not be used on anything less than one millimeter (0.040 inches) thick. (Consult ASTM E18 for the proper choice of indenter and load.) Brinell tests require no less than 3.2 mm (0.125 in) thickness.

Hardness Testing (continued)

Superficial Rockwell scales with 30 gram loads (30N, 30T) can be used on material greater than 0.6 mm (0.025 in) thick, and 15 gram load superficial scales (15N, 15T) can be used on thicknesses down to 0.4 mm (0.015 in). Anything thinner (like most connector materials) should be tested only with Knoop or Vickers microhardness scales.

Hardness tests are most accurate on smooth, flat surfaces. Any curvature of the surface will affect the shape and size of the indentation, making it difficult to get an accurate hardness reading. Microindentation hardness testing works best on a metallographically mounted and smoothly polished cross section. Readings should be taken near the center of the cross section, far from the edges where plating or any surface features can affect the test results. Strip material should be mounted on its side, so hardness indentations taken into the cross section have the full width of the strip underneath them. Small diameter rod or wire should be mounted on end for the same reason.

Indentations from the Brinell and common Rockwell hardness tests cover a large portion of the microstructure of the material, and do not show much sensitivity to local variation in the microstructure. Any such variation will be averaged out over the large area involved. It is still good practice to take the average of several readings. Conversely, microindentation hardness tests are extremely sensitive to local hardness variations. It is therefore important to take several readings and average the results. Figure 2 shows a typical indentation from a standard Vickers test, using a 15 second, 300 gram load on a copper alloy. Note that the size of the indentation is less than 50 micrometers across.

It is extremely important to ensure that all hardness testing equipment is properly calibrated every year. Test block pieces should be used daily to verify the calibration of the equipment before the first measurement of production material is made.

Hardness testing is quick and easy way of verifying material properties. Of course, nothing can replace a tensile test for accurately determining the material properties and whether or not they fall within specifications. However, when properly administered, the hardness test can be a good approximation of the material's suitability.

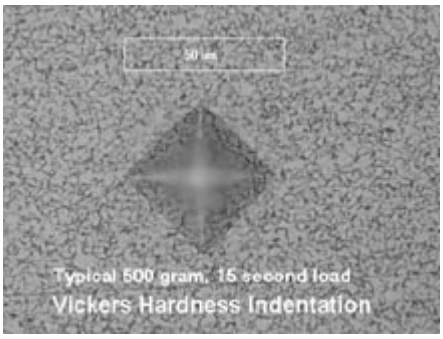

Figure 2. SEM Image of a Typical Vickers Microhardness Indentation

Written by Mike Gedeon of Brush Performance Alloys Customer Technical Service Department. Mr. Gedeon's primary focus is on electronic strip for the telecommunications and computer markets with emphasis on Finite Element Analysis (FEA) and material selection.

References:

Fee, Segabache & Tobolski
"Hardness Testing"
ASM Handbook V. 8
pp 69-113 ©1985
ASM International

ASTM E10
ASTM E18
ASTM E92
ASTME E384
ASTM E140

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Brush Performance Alloys
6070 Parkland Blvd.
Mayfield Heights, OH 44124
(216) 486-4200
(216) 383-4005 Fax
(800) 375-4205 Technical Service

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