



How to Select the Correct Indenter Tip

Support Note

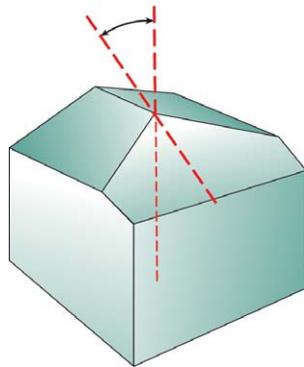


Figure 1. Berkovich indenter tip.

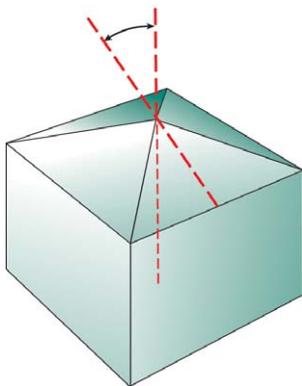


Figure 2. Vickers indenter tip.

It is important to select the correct tip for your application. Agilent Technologies offers high precision indenter tips that enable the finest quality data for your research. Our indenter tips are designed to meet all of your demanding applications. This document can be used as a guide in the selection process to determine the best tip for your needs.

There are five main types of indenter tips, each with a different geometry for a variety of applications:

- Berkovich
- Vickers
- Cube-Corner
- Cone
- Sphere

Berkovich

The Berkovich indenter tip is the most frequently used indenter tip for instrumented indentation testing (IIT) to measure mechanical properties on the nanoscale. The Berkovich indenter tip is a three-sided pyramid that can be ground to a point and thus maintains a self-similar geometry to very small scales. This geometry is often preferred to the Vickers indenter tip which is a four-sided pyramid.

The Berkovich indenter tip is ideal for most testing purposes. It is not easily damaged and can be readily manufactured. It induces plasticity at very small loads which produces a meaningful measure of

hardness. The Berkovich indenter tip has a large included angle of 142.3° which minimizes the influence of friction. The Berkovich indenter tip is available as a traceable standard.

Berkovich Recommended Applications:

There are many applications suitable for the Berkovich indenter tips. Some examples include:

- Bulk Materials
- Thin Films
- Polymers ($E' > 1\text{GPa}$)
- Scratch Testing
- Wear Testing
- Micro-electromechanical Systems (MEMS)
- *In-situ* Imaging

Vickers

The Vickers indenter tip is also used as an indenter tip for instrumented indentation testing (IIT) to measure mechanical properties on the nanoscale. The Vickers indenter tip is a four-sided pyramid. The Vickers indenter tip is available as a traceable standard.

Vickers Recommended Applications:

There are many applications suitable for the Vickers indenter tips. Some examples include:

- Bulk Materials
- Films and Foils
- Scratch Testing
- Wear Testing



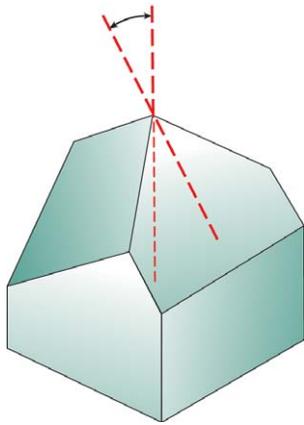


Figure 3. Cube-Corner indenter tip.

Cube-Corner

The Cube-Corner indenter tip is a three-sided pyramid with mutually perpendicular faces arranged in a geometry like the corner of a cube. The centerline-to-face angle for this indenter is 34.3° whereas for the Berkovich indenter it is 65.3° . The sharpness of the cube corner produces much higher stresses and strains in the area of the contact. This is useful in producing very small, well-defined cracks around hardness impressions in brittle materials. These cracks can be used to estimate fracture toughness at very small scales.

The Cube-Corner indenter tip is available as a traceable standard.

Cube-Corner Recommended Applications:

There are many applications suitable for the Cube-Corner indenter tips. Some examples include:

- Thin Films
- Scratch Testing
- Fracture Toughness
- Wear Testing
- MEMS
- *In-situ* Imaging

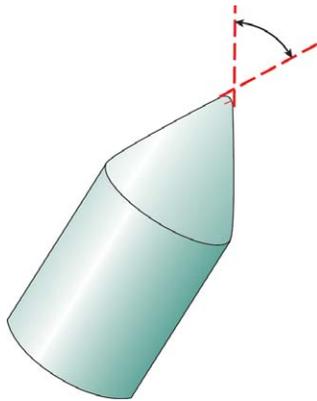


Figure 4. Cone indenter tip.

Cone

The cone indenter tip has a sharp, self-similar geometry, but the simplicity of its cylindrical symmetry makes it attractive from a modeling standpoint. Many models used to support IIT are based on conical indentation contact. The cone is also attractive because the complications associated with the stress concentrations at the sharp edges of the indenter are absent. However, very little IIT testing has been conducted with cones. The primary reason is that it is difficult to manufacture conical diamonds with sharp tips, making them of little use in the small-scale work around which most of IIT has developed. This problem does not apply at larger scales, where much could be learned by using conical indenters in IIT experimentation.

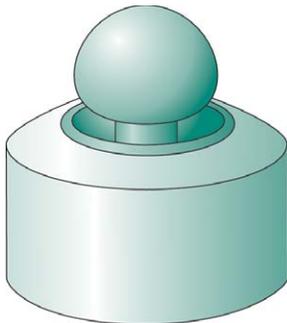


Figure 5. Sphere indenter tip.

Cone Recommended Applications:

There are many applications suitable for the Cone indenter tips. Some examples include:

- Scratch Testing
- Wear Testing
- *In-situ* Imaging
- MEMS

Sphere

Stresses develop differently during indentation when using a spherical indenter tip compared to either a Berkovich or Vickers tip. For spherical indenters, the contact stresses are initially small and produce only elastic deformation. As the spherical indenter is driven into the surface, a transition from elastic to plastic deformation occurs, which can theoretically be used to examine yielding and work hardening, and to recreate the entire uniaxial stress-strain curve from data obtained in a single test. IIT with spheres has been most successfully employed with larger-diameter indenters. At the micron scale, the use of spherical indenters has been impeded by difficulties in obtaining high-quality spheres made from hard, rigid materials. This is one reason the Berkovich indenter has been the indenter of choice for most small-scale testing, even though it cannot be used to investigate the elastic-plastic transition.

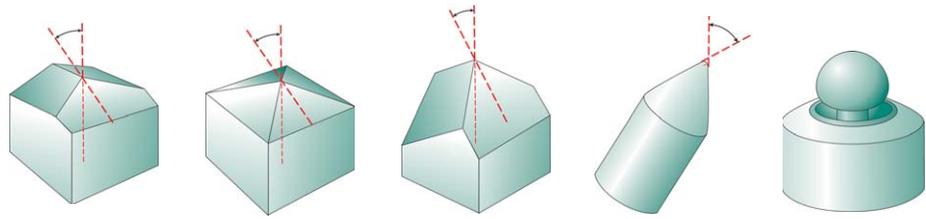
Sphere Recommended Applications:

The Sphere indenter tip is typically used for MEMS applications.

Custom Shape

At times, standard geometry indenters will not achieve the desired results. Applications Engineers for Agilent Technologies work with the customer to choose a custom-designed indenter geometry to best suit their application.

Indenting Tips Summary



	Berkovich	Vickers	Cube-Corner	Cone (angle ψ)	Sphere (radius R)
Features					
Shape	3-sided pyramid	4-sided pyramid	3-sided pyramid w/ perpendicular faces	Conical	Spherical
Applications	Bulk Materials, Thin Films, Polymers, Scratch Testing, Wear Testing, MEMS, Imaging	Bulk Materials, Films and Foils, Scratch Testing, Wear Testing	Thin Films, Scratch Testing, Fracture Toughness, Wear Testing, MEMS, Imaging	Modeling, Scratch Testing, Wear Testing, Imaging, MEMS	MEMS
Available as Traceable Standard	Yes	Yes	Yes	No	No
Parameter					
Centerline-to-face angle, α	65.3°	68°	35.2644°	—	—
Area (projected), A(d)	24.56d ²	24.504d ²	2.5981d ²	πa^2	πa^2
Volume-depth relation, V(d)	8.1873d ³	8.1681d ³	0.8657d ³	—	—
Projected area/face area, A/A _f	0.908	0.927	0.5774	—	—
Equivalent cone angle, ψ	70.32°	70.2996°	42.28°	ψ	—
Contact radius, a	—	—	—	d tan ψ	$(2Rd-d^2)^{1/2}$

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