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Lawn B & Wilshaw R. Indentation fracture: principles and applications.
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The principles and applications of indentation fracture are reviewed. A methodology for analyzing the evolution of indentation-induced crack systems in terms of classical elastic contact solutions is established. This methodology forms the basis for evaluating a wide variety of micromechanical properties of brittle materials. [The *SCI*® indicates that this paper has been cited in over 205 publications.]

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This paper was compiled while I was on leave with Rod Wilshaw at the University of Sussex in 1975. At that time I held a lecturing position at the University of New South Wales. Wilshaw and I had just finished writing a book on the *Fracture of Brittle Solids*,[1] and we were directing our attention back to our major research interest, the fracture of materials in well-defined contact fields. This problem had been around since 1881, when Heinrich R. Hertz examined the beautiful cone-shaped fracture that develops in glass lenses under load with a hard sphere, the so-called Hertzian cone crack. Subsequently, in 1891, F. Auerbach showed empirically that the critical force needed to generate a cone crack was in direct proportion to the radius of the sphere. The fascinating thing about "Auerbach's law" was that it appeared to contradict all the well-established theories of strength. I had become interested in the mechanics of Hertzian fracture while working as a postdoctoral fellow with F.C. Frank at Bristol University in 1966 and, using the modern methods of fracture mechanics, had succeeded in deriving Auerbach's law from first principles. Interestingly, the coefficient in this law contained the surface energy of the fractured material as a proportionality factor. Thus, not only did our derivation resolve a long-standing paradox, it opened up the prospect of using indentation as a tool for characterizing fracture behavior in terms of fundamental cohesive properties.

Wilshaw and I had been exploring such possibilities, somewhat independently, since those early days. It was the joint venture on our book, however, that ultimately motivated us to review this field during that sabbatical in 1975. As we became more and more aware of the limitations of conventional fracture-testing methodologies, we began to realize that the time was right to present "indentation fracture mechanics" to the materials community at large, particularly to ceramics scientists.

Looking back, it is not too much to suggest that our review article signaled a new era in the scientific understanding of fracture and deformation processes in brittle solids. This was a time of surging interest in the development of ceramics as the potential "supermaterials" of the future. One major drawback stood in the way of this development: brittleness. Consequently, researchers working in the last decade have witnessed an intense effort to characterize the way that cracks behave in ceramic specimens. Indentation fracture has emerged as the most versatile of all the available crack-testing techniques.[2,3] It is now used routinely as a means of quantifying the "toughness" and "fatigue" properties of brittle materials. It forms the underlying basis of all current theories of wear, erosion, and machining properties of ceramics, and it is used to evaluate residual stress states in strengthened surfaces. Perhaps most importantly, indentation remains the single most powerful route to the investigation of intrinsic mechanical properties at the fundamental level; the use of "subthreshold" indentation flaws to elucidate the critical role of precursor shear deformation in crack initiation[4-6] is just one illustrative example of the unique capacity of this methodology to shed light on the material variables that control brittleness.

1. **Lawn B R & Wilshaw T R.** *Fracture of brittle solids.* New York: Cambridge University Press, 1975. 204 p. (Cited 195 times.)
2. **Cook R F & Lawn B R.** Controlled indentation flaws for construction of toughness and fatigue master maps. (Freiman S W & Hudson C M, eds.) *Methods for assessing the structural reliability of brittle materials.* Philadelphia: American Society for Testing and Materials, 1984. p. 22-42. Special Technical Publication 844.
3. **Lawn B R.** Indentation: deformation and fracture processes. (Kurkjian C R, ed.) *Strength of inorganic glass.* New York: Plenum, 1986. p. 67-86.
4. **Hagan J T & Swain M V.** The origin of median and lateral cracks around plastic indents in brittle materials. *J. Phys.—D—Appl. Phys.* 11:2091-102, 1978.
5. **Lawn B R.** Physics of fracture. *J. Amer. Ceram. Soc.* 66:83-91, 1983.
6. **Lawn B R, Dabbs T P & Fairbanks C J.** Kinetics of shear-activated indentation crack initiation in soda-lime glass. *J. Mater. Sci.* 18:2785-97, 1983.

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