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# This Week's Citation Classic

**Archbold E & Ennos A E.** Displacement measurement **from double-exposure laser** photographs. *Optica Acta* **19**:253-71, 1972.
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Displacement of points on the surface of a structure when it deforms can be simply measured by recording a double exposure photograph under laser illumination and optically processing the resulting speckle pattern image. The limits within which the technique can be used are examined. [The *SCI*® indicates that this paper has been cited over 100 times since 1972.]

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"There is no doubt that optics received a tremendous boost in the early 1960s with the invention of the laser, to be followed closely by the development of laser holography for recording 3D images. In 1965, I was fortunate enough to join the group at the National Physical Laboratory led by Jim Burch, who had just demonstrated that holograms could be of real practical use in measuring, to very high accuracy, the deformation of a structure when it is stressed.[1] We set about investigating this exciting new measurement technique and, joined by Eddie Archbold, spent the next few years exploring its many possibilities and seeing where best it could be useful to the engineer. It soon became apparent that hologram interferometry, as this technique is called, gives an embarrassing wealth of data which is hard to unravel—not surprising when it is realised that each point on a two-dimensional surface can move in any of three coordinate directions! Some simpler way of measuring only the relative movement in the plane of the surface was called for, and one which was perhaps not so sensitive. After a conference on holography held in Besancon, France, in 1970, a number of strands of thought came together to make me realise that photographs taken in laser light with an ordinary camera could provide the solution, and furthermore there would be no need to keep apparatus so stationary as in holography. If two exposures are recorded on the same frame, with the object being deformed between whiles, the double image on the negative can be analysed with a laser beam to measure the vector displacement of the corresponding object point, to micrometer accuracy. Thus a complete displacement field of the surface movement can be built up.

"Although a preliminary account of the new method was published in 1970 as part of a paper on speckle interferometry,[2] during the following year Archbold and I carried out a detailed investigation of the technique in order to evaluate the limits within which it could be validly applied. In the course of this work we realised that other deformation parameters could also be measured by laser speckle photography, for example, tilting of the surface, and vibration. The sensitivity to tilt was discovered by accident when experiments were made with the camera defocused, for quite a different purpose, and unexpected fringe patterns were obtained!

"As in many fields of research, the work of diverse groups contributed ideas which led to the subject of this paper. Perhaps why it is cited so often is because the simplicity of the technique encouraged many workers to apply it to their measurement problems. In addition, our paper treats the new development comprehensively and assesses its soundness as a metrological tool, a fact that no doubt is associated with our working in a standards laboratory, where accuracy is all-important. It has been rewarding to see that laser speckle photography is now an established technique having application in a wide range of disciplines. A more recent review of the subject is given in *Progress in Optics.*"[3]

1. **Burch J M.** The application of lasers in production engineering. *Prod. Eng.* **44**:431-42, 1965.
2. **Archbold E, Burch J M & Ennos A E.** Recording of in-plane surface displacement by double-exposure speckle photography. *Optica Acta* **17**:883-98, 1970.
3. **Ennos A E.** Speckle interferometry. (Wolf E, ed.) *Progress in optics.* Amsterdam: North-Holland, 1978. Vol. XVI. p. 235-88.