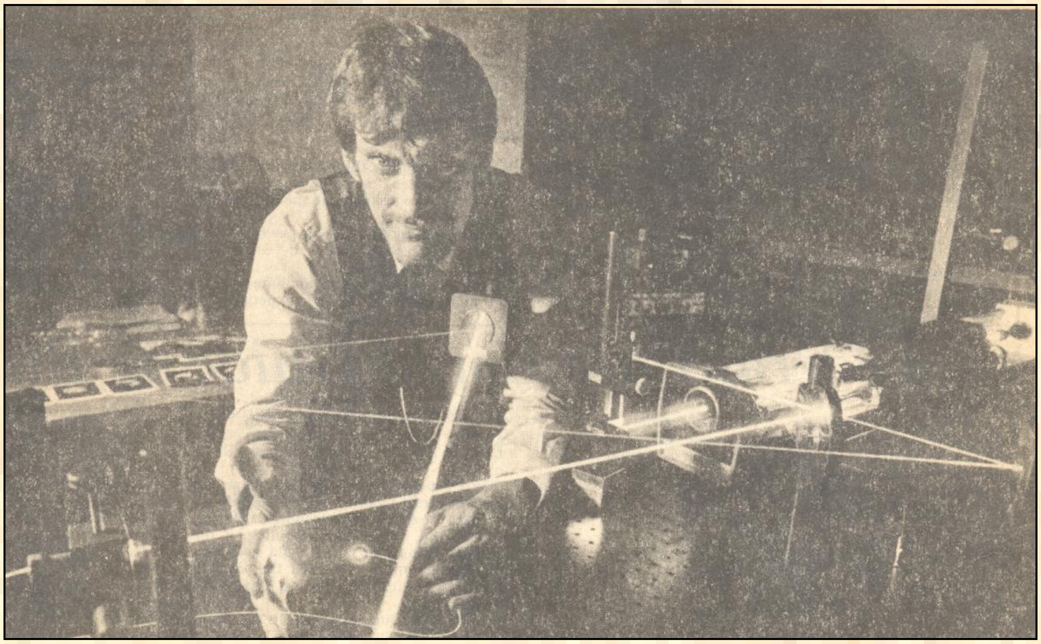
The Huntsville Times

Huntsville, Alabama, Sunday, July 27, 1986



(Times Photo by Glenn Baeske)

DR. GILBERT HOLDS PINPOINT OF LIGHT AS LASER ARCS THROUGH LABORATORY

Laser Researcher Tests Stress On Parts With Space-Age Optics

By MARTIN BURKEY
Times Science Writer

Dr. John Gilbert experiences a lot of stress in his job at University of Alabama in Huntsville — not physical tension, but the kind that Gilbert in his research can measure with laser beams.

From microcircuits to human arteries, from mine shafts to spacecraft, the name of the game is measurement.

Gilbert, a one-time rock musician from New York City, came to UAH from the University of Wisconsin at Milwaukee. He brought with him the lasers and other equipment of a $500,000-plus laboratory and several graduate students.

One of his techniques is holographic interferometry — the science of three-dimensional photography without cameras or lenses. The tools are lasers and bundles of optical fibers — strands of glass finer than a human hair.

One of his most promising photographic research areas is microcircuitry. His objective is to study the mechanics of thermal deformation that affects solder posts when power is applied to leadless ceramic chip carriers on a printed wiring board.

Using two lasers on a table surface that floats on air to damp all vibration, Gilbert basically takes two pictures — one before the circuit board was turned on and one after — and superimposes one over the other.

The result looks like a modern art version of the ripples of a pebble dropped in a pond, the growth rings in a tree trunk, or a magnified fingerprint.

"We're looking for surface movement. The fringes develop because of the changes in shape between the loaded and unloaded shape," he said. "There are more fringes as the surface distorts more."

A better comparison, Gilbert explains, would be a surveyor's topographic map with lines denoting hills and valleys. In the field of stress analysis, they indicate small (in the neighborhood of 1—100,000th of an inch) but significant amounts of bending and warping due to heat.

The purpose, as with any type of stress analysis, is to understand how the materials in a prototype or production sample react during operation and make them more reliable, Gilbert said.

Stress analysis relies now largely on brittle coatings or strain gauges attached directly to the part to be tested, a method that requires ready access and can accidentally affect the stress characteristics of the test subject, Gilbert said.

> *"I don't have to bring a part to the point of failure. I can tell by subtle changes where weakness is developing. I can tell where the flaw is in a week instead of five years down the road."*

"We are trying to access remote areas of structures through fiber optics, to use them as environmentally insensitive light guides to channel laser light from the source to a test object," he said. "One of the major advantages of using laser-based fiber optic techniques over more conventional methods is that they are non-contact, non-destructive, and extremely sensitive.

"Since fiber optics are small and flexible, one can use them to gain access to remote areas of structures or to illuminate objects which are underground or submerged. They can be applied to problems which up to now have been difficult or impossible to detect."

The technique might be used to study crack initiation and growth in composite materials or study stress inside an airplane wing or an underground pipeline.

"I believe we are the first to record holograms through a fully fiber-based system, to illuminate a target and bring back the image through fiber optics," Gilbert said.

An alternate approach for measuring surface changes is speckle metrology. Laser light hitting the surface of an object creates spots or speckles that move when forces are applied to the object. A computer digitizes the pictures of the unstressed and stressed objects and compares the two patterns to measure displacement.

The two techniques have a large number of research applications, but production testing is difficult because of the stability required. One solution would be pulsed lasers that would photograph the subject in such a negligible fraction of a second that small vibrations would not affect the picture, Gilbert said.

Gilbert's research now is supported by the Army Research Office in North Carolina and Bell Telephone Laboratories in New Jersey.

One or both techniques can apply to circuit boards which may warp a few hundred thousandths of an inch or to 20-foot beams under loads of several thousand pounds. That might be thermal or mechanical deformations in an orbiting spacecraft or the flow of underground pollutants.

"These small measurements are proportional to what it would be if we put large loads on," Gilbert said. "I don't have to bring a part to the point of failure. I can tell by subtle changes where weakness is developing. I can tell where the flaw is in a week instead of five years down the road."