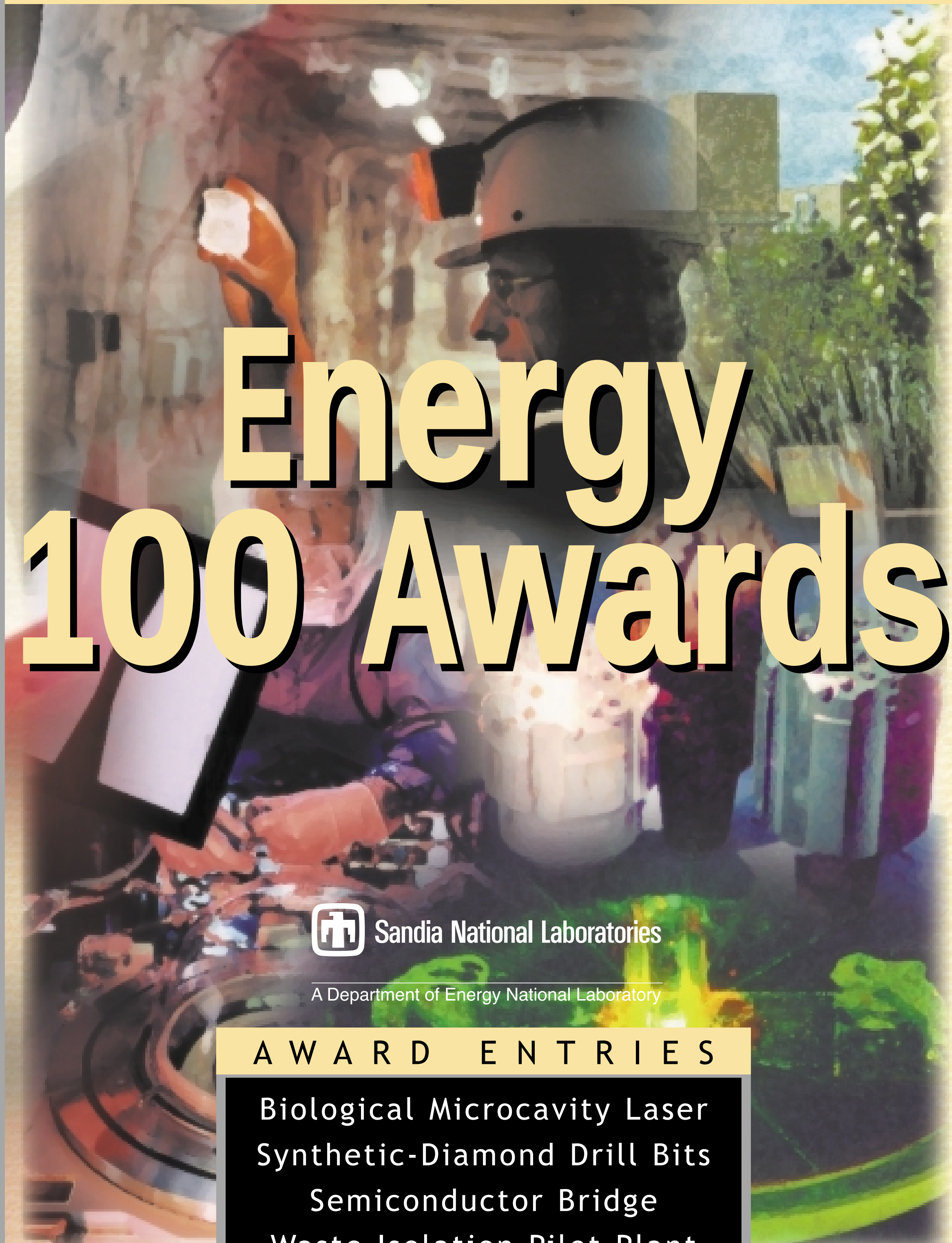
SANDIA NATIONAL LABORATORIES



Energy 100 Awards

Sandia National Laboratories

A Department of Energy National Laboratory

AWARD ENTRIES

Biological Microcavity Laser
Synthetic-Diamond Drill Bits
Semiconductor Bridge
Waste Isolation Pilot Plant
Energy Storage System
Strained-Layer Semiconductor

Strained-Layer Semiconductor

Energy 100 Award Nomination
Technology: Strained Layer Superlattices
Title: Strained Layer Semiconductor

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ABSTRACT

In 1982, Sandia physicist Gordon Osbourn opened the door for almost two decades of scientific advances concerning semiconductors. These advances have changed the multibillion dollar communications and entertainment industries and improved the quality of life of any American owning a telephone, television, or disc player. While leading scientists of that time believed that for semiconductors to work, their lattice structures must be perfectly aligned, Osbourn realized that if materials with slightly different lattice sizes remained together, they would have many useful and novel properties. He predicted they would generate a broader range of laser wavelengths and faster transistors for communications and electronics. His research set off the large-scale, worldwide R&D effort on strained-layer devices that continues unabated to this day.

1. Program Description

One of the more dramatic moments in the history of late 20th Century American science occurred in 1982 when a young physicist at the Department of Energy's Sandia National Laboratories decided to go against the established wisdom by asking a simple question: why not sandwich together very, very thin layers of crystals of slightly different atomic lattice sizes? The effect would be like putting one sweater over another with slightly different-sized checks and trying to line up the checks . It would be difficult, it would be a strain, but the benefits in crystal, if it worked, would be huge: one would have a kind of superlattice, under strain of course, but if made correctly, stable, and of materials that had never been joined for such purposes before. Success would make it possible for materials to generate far more tiny lasers from the same cross-sectional area, a boon to the huge communications industry, and at an unheard-of variety of frequencies (band gaps) that would improve communications and electronic entertainment, each multibillion dollar industries.

The only problem was that the established wisdom held that such a concatenation of materials would not work. It was believed that for semiconductors to be useful, they must be almost perfect crystals. If the strained layers –- imperfect crystals by intent -- by some miracle did work, it would only be temporarily before the forces generated by slightly misaligned atoms blew such structures apart.

The Sandia physicist's idea was rejected in strong terms by the most prominent materials scientists of that day – not an easy reception for a young man just starting out – but he kept at it. Today, the world agrees he was right and the wise men of that time, mistaken. The strained superlattices devised by the young physicist, Gordon Osbourn, earned him the Ernest O. Lawrence Award in Materials Science (1985) of the U.S. Department of Energy, and then the International New Materials Prize (1993) of the American Physical Society.

2. Improving Quality of Life

Today, most state-of-the-art optoelectronic devices employ strained-layer structures. Microwave transistors of this type now offer the highest frequencies and lowest noise performance available, and are used in almost all broadcast satellite systems. Strained-layer semiconductors form the backbone of fiber optic communications and of compact disc players. They improve the efficiency, performance and lifetime of semiconductor lasers, a market of more than $1.3 billion a year. They have become the lasers of choice in undersea fiber optic cables. They have led to the development of lasers at formerly unachievable frequencies, like violet. This will enable manufacturers to place about 7 hours of movies on a disk. (Red lasers, achieved by conventional means, can place only about 2.5 hours on a disk.)

Other Noteworthy Benefits: Osbourn's invention has impacted the whole field of optoelectronics and the more than $80 billion-dollar-a-year industries that it enables, and has raised the standard of living of every American with a disc player, TV set, or telephone.

3. Cost Savings

The benefit of this discovery is not in the cost savings for exiting products or services, but rather in the entirely new applications it has enable.

SUPPORTING MATERIALS

To further illustrate the importance of the strained-layer semiconductor, below are copies of key correspondence.

Gossard, Arthur C., University of California, Santa Barbara, Personal Communication, May 29, 1998.

Peercy, Paul S., SEMI/SEMATECH, Personal Communication, April 28, 1998.

Vook, Frederick L., Sandia National Laboratories (retired), Personal Communication, April 27, 1998.