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 РЕФЕРАТ

##  Тема: ***Fiber******Optics***

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 Введение.

# Что такое Волоконная оптика , где используются оптоволоконные световоды, из чего они сделаны и как работают?

 На все эти вопросы вы найдёте ответы в этом материале. А ещё для вас станет понятно, что человечество никогда не остановится на достигнутом, то есть не все “паровые двигатели” ещё изобретены, а компьютер сможет сделать намного больше, если не будет ограничен в информационных возможностях.

 Мы сможем сэкономить большое количество цветного металла, из которого изготавливаются провода. Почему? Да потомку что, сейчас появилась реальная возможность и необходимость использования оптоволоконных световодов.

 Ведь оптоволоконные световоды - это просто-напросто очень чистое стекло, а стекло - это песок. А чего больше на земле: меди или песка? К тому же на оптоволоконные световоды не действуют ни электрические, ни магнитные поля, а температура, при которой они плавятся, равна 2000°С, а эта температура, близкая к околосолнечной.

 Волоконная оптика интересна и тем, что носителем информации является не электромагнитный импульс, а закодированный пучок света.

 Если же сравнивать пропускную способность, то оптоволоконный световод толщиной с человеческий волос равноценен пучку медной проволоки толщиной с руку человека.

 И, наконец, ответьте на вопрос: что это такое, если оно быстрее, точнее, дешевле? Конечно же, это волоконная оптика!

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 **1**

 **What is Fiber Optics?**

 In 1880, four years after he invented the telephone, Alexander Graham Bell tested another talking device. He called it the photophone.

"Photo" and "phone" come from the Greek words for "light" and "sound." Bell's telephone used pulses of electricity traveling over copper wires to carry sound. But the photophone used a beam of sunlight traveling through air to carry the human voice from one place to another.

Bell was very enthusiastic about the photophone. He wrote to his father, "I have heard a ray of sun laugh and cough and sing!"

However, the new invention did not prove to be very practical. Sunlight was only available during the daytime. And even then, bad weather such as fog, rain, or snow blocked the beam of light.

In spite of these problems, throughout his life, Alex­ander Graham Bell thought the photophone was his most promising idea. He felt certain that someday people would use beams of light to talk to each other.

For nearly one hundred years, scientists like Bell dreamed of using light to communicate. They knew that light and electricity traveled as vibrations or waves. And they knew that many more light waves could he trans­mitted in one second than electrical waves. For this reason, light could carry more information than electricity flowing in copper wires.

Not until the 1960s and 1970s did two inventions make the dream possible. During this time, scientists invented *lasers.* Lasers are powerful sources of a special kind of light. Other researchers developed *optical fibers.*

An optical fiber is a flexible thread of very clear glass—thinner than a cat's whisker and up to six miles long. Laser light can pass through the length of an optical fiber and still stay bright. Because optical fibers can serve as pipelines for light, they also are called *lightguides.*

In the mid-1970s, these inventions were teamed to­gether. Now pulses of light flash through optical fibers carrying information and messages over great distances. This important new technology is called *fiber optics.*

Glass fibers are replacing copper wires for many reasons. The fibers are not as expensive for telephone companies to buy and install. They weigh a lot less than copper wires — making them easier for workers to handle. A single four-and-one-half-pound spool of optical fiber can carry the same number of messages as two hundred reels of copper wire that weigh over sixteen thousand pounds!

Optical fibers also take much less space than copper wires. This is very important in crowded cities where bulging, overloaded telephone cables have little room for additional lines. Optical fibers can help unsnarl this telephone traffic jam.

The fibers are better, too, because light is nut affected by nearby electrical generators, motors, power lines, or lightning storms. These often are the cause of noisy static on telephones or information errors in computer systems connected by copper wires.

As electrical signals pass through copper wires, they become weakened. Devices called *repeaters* are used to strengthen the electrical signals about every mile along each line. In a fiber optic system, repeaters are needed only every six miles or so to boost the light signals. And experiments have shown that this distance can be stretched many more miles. This means that installation costs for a fiber optic system are less now and can be cut further in the future.

However, the most important reason for using glass fibers is that they can carry much more information than copper wires. A single pair of threadlike glass fibers can transmit thousands of telephone calls at once. A cable as thick as your arm and containing 256 pairs of copper wires would be needed to handle the same number of conversations.

Pairs of fibers (or wires) are used for two-way com­munication. One fiber carries your voice to the listener at the other end of the line. The other member of the pair transmits the other person's reply to you.

Optical fibers are less expensive, easier to install, and more dependable than copper wires. With tight from a laser, they can transmit thousands of times more infor­mation than electricity in copper wires. The new tech­nology of fiber optics is a better and faster way to communicate.

  **2**

 **Where Are Optical Fibers Used?**

All over the world, the copper wires of telephone trunk lines are being replaced by modern glass optical fibers.

One of the first attempts to use an optical fiber system in the United States was in 1977 in Chicago. There, two offices of the Bell Telephone Company and a third building for customers were connected successfully by twenty-four light-carrying glass fibers. The fibers were threaded through telephone cables already under the city streets. The total length of the fibers was about 1.5 miles.

In 1978, Vista-United Telecommunications at Walt Disney World near Orlando, Florida was first to use fiber optics commercially in the United States. Tele­phones throughout the 28,000-acre park are linked by fiber optic trunk lines. Video transmissions by glass fibers are made to many individual hotel rooms on the property from one location. Lighting and alarm systems also use optical fibers.

In EPCOT Center (Experimental Prototype Com­munity of Tomorrow), there are information booths equipped with television-tike, two-way video screens and speakers. The screens and speakers are connected by optical fibers to a central office. A visitor can activate the screen by touching it and select the information needed. Or the guest can talk to an operator who appears on the screen if requested.

American Telephone and Telegraph has in service a fiber optic trunk line that connects Boston, New York City, Washington, D.C., and Richmond, Virginia. The trunk line is part of a project 780 miles long. The light cable used is only about the thickness of a garden hose. Nevertheless, it can carry eighty thousand calls at once.

By July 1988, American Telephone and Telegraph will have laid a fiber optic cable beneath the ocean between North America and Europe. The cable is called TAT-8 because it is AT&T's eighth /transatlantic tele­phone cable. TAT-1, a copper cable, was completed in 1956 and could carry fifty-one calls at a rime. TAT-7, the last copper cable, was laid in 1983. It can handle about eight thousand calls at once. ТЛТ-8 will transmit forty thousand calls at one time. Even with TAT-8, a second fiber optic transatlantic cable, TAT-9, probably will be needed by 1991. Another undersea cable, between California and Hawaii, is planned.

The Japanese telephone company, Nippon Telephone and Telegraph, has placed glass fiber cables from one end of the country to the other. By 1990, similar lines will join Japan to Hong Kong, Australia, and New Zealand.

A fiber optic system in Munich and other cities of West Germany is called Bigfon. It transmits a video picture along with voice. In addition, Bigfon sends and receives copies of documents and other important papers.

Over fifteen hundred customers in Biarritz, France, use videophones and television channels made possible by fiber optics.

In the remote countryside of Manitoba, Canada, two towns are part of an experiment. Elie and St. Eustache have become "glass-wired" communities. Optical fibers connect keyboards and television sets in homes in these towns to distant computers. People who live there use the keyboards to get television shows, radio broadcasts, weather forecasts, news, farm and stock market reports. In addition, over three hundred items for sale at a large, well-known department store, Hudson Bay Company, can be viewed on television. To make a purchase, a customer types an item code, number of items wanted, size, color, and credit card number on the keyboard. Hudson Bay Company receives the order and ships the goods directly to the customer.

Near Tokyo, in Japan, there is an optical fiber com­munications network known as HI-OVIS (Highly Interactive Optical Visual Information System). With this two-way system people can take an active part in edu­cational classes such as piano lessons. They also can learn about schedules for airlines, trains, and concerts, and get up-to-the-minute news and weather reports.

New installations for communications at Kennedy Space Center in Florida use fiber optics. These include the Space Shuttle control center and operations building for Launch Complex 39. In addition, the Space Center's fiber optic system is used to check out experiments, such as those on board *Skylab,* before launch. Eventually, all of the facilities for the Shuttle at Kennedy Space Center will use fiber optic systems.

There arc many other uses for fiber optics. A medical instrument known as an *endoscope* is made from bundles of optical fibers packed inside a long, slim, bendable tube. A doctor slips this medical "spyglass" into a patient's throat, stomach, lungs, or intestines to look for anything abnormal. One bundle of fibers carries light to the tip of the probe. Another bundle of fibers transmits pictures back to an eyepiece. This allows a doctor to see inside the human body without surgery. And sometimes it locates early stages of serious diseases, such as cancers, that X-rays may miss. Miniature tools within a separate channel in the endoscope tube can remove samples of tissue for a closer look.

Veterinarians examine horses, cats, clogs, and other animals with similar fiber optic scopes. Pets sometimes choke on foreign objects. With the probe of the scope, the animal doctor can locate the object, snare it, and quickly remove it.

People peer into dangerous or hard-to-see places with industrial fiber optic scopes too. Workers can look inside and check radioactive reactors in nuclear power plants, the jet engines of airplanes, turbines, boilers, pipelines, gear boxes, and many other types of machinery.

*Image conduits* are large pipelines for light. They are formed from thousands of optical fibers that have been bundled and fused together into one unit. They can directly transmit images or pictures from one place to another. If the conduit is tapered on one end, it can be used to make an image larger or smaller. And if the fibers in the conduit are twisted, the picture can be turned upside down.

Wafer-thin plates sliced from *fused* bundles of optical fibers are used to make night-vision goggles or scopes. The plates are treated with chemicals that enable them to magnify moonlight, starlight, or any other available light thousands of times. With the goggles, U.S. Forest Service helicopter crews can spot even small embers on the ground that could start a fire.

Individual optical fibers guide light from one source to many switches and displays on the dashboard of a late model automobile or the instrument panel of a recently built jet fighter. The fibers are small and lightweight. And they are not bothered by other electrical equipment fitted closely behind the dash or panel. In some cars, optical fibers monitor parts of the car. They signal the driver if a light burns out or if a door is ajar.

Many kinds of sensors are made with optical fibers. These devices can detect changes in temperature, pres­sure, or the presence or absence of something. Different sensors can check for a wide range of things at factories—from missing caps on soda bottles to toxic fumes. They help guide robots or other automatic machinery to manufacture items as intricate as electronic circuits or as large as automobiles.

Glass fibers are ideal for military defense. In addition to their other advantages, the fibers are easy to hide from an enemy. Metal detectors cannot locate them, for example. Also, the fibers are almost impossible to secretly tap or jam. Thus, vital messages are more likely to get through. Light-carrying fibers usually are not affected by radiation. And they can be used safely near ammu­nition storage areas or fuel tanks because they do not create sparks as electricity can in copper wires.

The North American Air Defense Command is located deep inside Cheyenne Mountain in Colorado. Its com­puters, linked by optical fibers, process radar information from around the globe. Army field communications systems also depend on optical fibers.

Optical fibers are being used by the University of Pittsburgh to connect school computers. A college stu­dent or teacher will be able to get information from any connected computer, library, or classroom on campus. Other schools are installing similar networks.

The new technology of fiber optics has grown quickly in the past decade. In the next ten to fifteen years, the copper wire telephone trunk lines in most of the world will be replaced with glass "wires." These slender strands will harness pulses of light to transmit the human voice and vast amounts of information in a twinkling. More and more, people will use beams of light to communicate with each other.

Imagine how excited Alexander Graham Bell would be to know that his dream has come true.

**3**

**How Are Optical Fibers Made?**

The glass used to make optical fibers must be very pure. Light must be able to pass through the length of the fiber without being scattered, or losing brightness.

Though the glass in an eyeglass lens looks perfect, a three-foot-thick piece of this kind of glass would stop a beam of ordinary light. Tiny particles of iron, chromium, copper, and cobalt absorb or scatter the light.

The glass in an optical fiber is nearly free of impurities and so flawless that light travels through it for many miles. If ocean water were as pure, we would be able to see the bottom of the Mariana Trench, over thirty-two thousand feet down, from the surface of the Pacific.

An optical fiber has a glass inner *core.* Light travels through this highly transparent part of the fiber.

The core of an optical fiber is surrounded by an outer covering called the *cladding.* The cladding is made of a different type of glass from the core of the fiber. For this reason, the cladding acts like a mirror. Light traveling through the core of the fiber is reflected back into the core by the cladding—much like a ball bouncing off the inside wall of a long pipe. In this way, light entering one end of an optical fiber is trapped inside the core until it comes to the other end.

How do people make these gossamer threads of glass that can carry light around curves and corners and over long distances?

Optical fibers are manufactured in "clean rooms." The air in these rooms is filtered to keep out the tiniest particles of dust. Even the smallest specks of dirt could ruin the fiber as it is made. Workers in these areas usually wear jump suits or lab coats and caps made from lint-free fabric.

An optical fiber starts out as a hollow glass tube. The tube is mounted on a machine that rotates it. A special gas is fed into the tube. A naming torch moves back and forth along the tube, heating it to nearly 1,600° С. With each pass of the torch, some of the hot gas inside forms a fine layer of glass on the inner wall of the tube. A series of different gases can be fed into the tube. With this method, layers of several different kinds of glass are added to the inside wall. When the addition of glass is complete, gas still inside the tube is gently sucked out.

Now, the heat from the torch is increased to 200U° C-The hollow tube collapses into a solid glass rod called a *preform.* The preform is the size of a broomstick—about as big around as a fifty-cent piece and a yard long.

The preform is cooled and carefully inspected. Light from a laser is used to make sure the core and cladding of the glass preform are perfect.

Next, the preform is placed in a special furnace where it is heated to 2,200° *С.* At this temperature, the tip of the preform can be drawn or pulled like taffy into a wisp of an optical fiber—thinner than a human hair.

Usually, as soon as it is drawn, the fiber passes through a tiny funnel where it is coated with fast-drying plastic. The coating protects the fiber from being scratched or damaged.

The fiber from a draw may be up to six miles long. It is wound onto a spool for ease of handling and storage.

Glass is usually thought to be brittle, unbendable, and easily broken. Amazingly, optical fibers arc flexible and strong as threads of steel. The fibers can be tied into loose knots without breaking and light still passes through from end to end.

**4**

 **How Do Optical Fibers Work?**

Whenever you talk to someone else the sound of your voice travels to their ears as a pattern of vibrations or *waves* in the air. Light and electricity also move in

 waves.

To get an idea what waves look like, tie one end of a long rope to a post or tree. Hold the other end of the rope and walk away until the rope is stretched out, but still slightly slack. Now yank the free end of the rope up and down repeatedly. A series of bumps or waves travels down the rope.

You can change the pattern of the waves. You can make small waves by giving weak, up-and-down yanks on the rope. Or you can make big waves by giving strong, up-and-down yanks on the rope. The height or tallness of the waves depends on the strength you use to yank the rope up and down.

The distance between the top of one wave and the top of the next wave is called the *wavelength.*

Another way to vary the waves is to change their speed. You can yank the rope up and down only once in a second or many times in a second. The number of waves reaching the tree or post each second is the *frequency* of the waves.

Why do pulses or waves of light streaking through an optical fiber go farther, better, and faster than electricity pulsing through copper wires?

Lasers used in fiber optic systems are made from tiny crystals of a material called gallium arsenide. These lasers are as small as a single grain of salt and easily could fit through the eye of a needle. Nevertheless, they can produce some of the world's most powerful pinpoints of light.

Light from a laser is unlike ordinary light. Laser light is all of the same frequency and wavelength. And all of it is traveling together in the same direction—like bullets aimed from the barrel of a gun at one target. The result is a brilliant source of very pure light. Laser light can shine through miles of optical fiber without being boosted as often as an electrical signal.

The laser light used in fiber optic telephone or com­munications systems is *infrared.* The frequency of infrared light is just below what people can see with their eyes unaided. Infrared light is used in communications sys­tems because it can travel long distances through optical fibers with less loss of power.

Another source of light that also is used with optical fibers for communication is a *light emitting diode* or *LED.* LEDs are less costly than gallium arsenide lasers. How­ever, lasers can transmit more information at higher speeds than LEDs.

Copper wires can carry a few million electrical pulses each second. But the number of light pulses an optical fiber can carry is much greater. It is limited by how many pulses of light each second today's best lasers can produce. Recent experiments done at AT&T Bell Laboratories combined the output of several lasers to achieve as many as 20 billion pulses per second! This far outshines the number transmitted by copper wires.

How do telephones connected by optical fibers work?

In the mouthpiece of a telephone, the pattern of sound waves of your voice is first changed into a pattern of waves of electricity moving through copper wire. In a fiber optic system, a special electronic device called an *encoder* measures samples of the waves of electricity eight thousand times each second. Then, each measurement of the waves is changed into a series of eight ON-OFF pulses of light.

The pulses of light are a code that stands for the strength or height of the waves of electricity. This is called a *binary code* because it uses only two signals or digits; zero for when the light is OFF and one for when the light is ON. The word "binary" means two. Each zero or one is called a *binary digit* or *bit.* And each pulse of ON-OFF light stands for one piece or bit of infor­mation. Fight bits grouped together are a *byte.*

The specks of ON-OFF light flash like tiny comets through optical fiber carrying your message in binary code.

At the other end of the line is another device called a *decoder.* The decoder changes the pulses of light back into electrical waves. The receiver of the telephone then changes the electrical waves back into the sound waves of your voice.

The coded pulses of light in a fiber optic system can carry so much information so rapidly that many telephone conversations can be stacked in an optical fiber. They are then unscrambled at the other end of the line.

Because a fiber optic system uses coded pulses of ON-OFF light, it is ideal to link together computers. Com­puters "speak" this binary language. They not only count in binary, computers also store and handle huge amounts of information as a code of zeros and ones. The entire 2,700 pages of *Webster's Unabridged Dictionary* can be transmitted from one computer to another over optical fibers in six seconds'

Morse Code is a binary code you may already know. Instead of zeros and ones, Samuel Morse used dots and dashes to send any message by telegraph. The dots and dashes can stand for any letter of the alphabet or any decimal number.

Here are two binary codes. One is international Morse Code and the other is a computer code known as the American Standard Code for Information Interchange or ASCII-8.

Character Morse Code ASCII-8

0 ----- 01010000

1 .---- 01010001

2 .. --- 01010010

3 …-- 01010011

4 ….- 01010100

5 ….. 01010101

6 -…. 01010110

7 --… 01010111

8 ---.. 01011000

9 ----. 01011001

 Can you figure out what the following message says? First it is given in International Morse Code; then in ASCII-8. Alexander Graham Bell said these words in the first telephone message to his assistant, Watson, on March 10, 1876.

 .-- .- - … --- -. --..--

-.-. --- -- . …. . .-. . .-.-.-

.. .-- .- -. - -.-- --- ..- ---.

10110111 11100001 11110100 1111001I 11101111

11101110 01001100 11100011 11101111 11101101

 11100101 11101000 11100101 11110010 11100101

 01001110 10101001 11110111 11100001 11101110

 11110100 11111001 11101111 11110101 01000001

ANSWER: Watson, come here. I want you!

Morse code and ASCI1-8 may seem awkward. But Morse code made possible sending messages quickly by telegraph over long distances as early as 1845. Today, computers linked by optical fibers can send vast amounts of any kind of information, including pictures. And they can do it faster than the human mind can think.

 **5**

 **Fiber Optics in the Future**

Many scientists think that the technology of fiber optics wilt lead to an enrichment of life like that following the invention of the steam engine, light bulb, and computer.

Only a small number of homes, businesses, school, hospitals, and libraries in the world are connected by optical fibers now. But as fiber optic technology develops there will be an enormous expansion of use. In the future, fiber optics wilt make affordable a wide range of services that may be too expensive for most people or businesses now.

An example of this is teleconferencing. Rather than travel far from their companies and homes, business people will more commonly meet by teleconference. They will send live television pictures of themselves to each other and talk as though they were in the same room. AT&T, Western Union, and some hotels already have teleconferencing rooms for rent in many major cities. However, in 1984, the cost was over $2,000 an hour. But soon it may cost as little as $30 an hour. Further in the future, fiber optics may be used with a method called holography for teleconferences. Holography uses lasers to project three-dimensional images of people or things into thin air—no viewing screen is needed. Laser images transmitted by glass fibers will be so lifelike they will be hard to tell from the real person or object.

Some researchers dream of building an optical com­puter. The "brains" of today's computers are microchips. These tiny electronic devices are only as thick as a thumbnail and one-quarter inch on a side. Within, they are a maze of miniature metal circuits and thousands of special switches known as *transistors.* Pulses of electricity passing through the microchip's circuits and switches process all of the computer's information.

An optical computer will operate using pulses of light passing through optical switches. The transistors in a microchip are fast— they can switch ON or OFF millions of times each second. But scientists have built experi­mental optical switches that are ten thousand times faster. They can switch ON or OFF an incredible one *trillion* times each second!

Supercomputers of the future operating at faster speeds would make possible automatic translation of foreign language telephone calls (such as English to Japanese). Optical computers also would be the best way to transmit or process highly detailed visual information such as photographs or maps.

In an optical computer, switches will be able to process many bits of information at the same time—something electronic computers usually do not do. Because of this and their faster speed, optical computers would be far more powerful than the computers we have now.

With fiber optics, individual homes and businesses will have new, improved services available. The future will bring routine use of videophones that allow callers to see and hear each other. Telephone consoles may also be computer terminals. And there will be two-way television reception.

Fiber optic sensors will send information to automatic controls for lights, heat, air conditioners, appliances, or industrial machinery. Police and fire fighters will give better security to homes and businesses that have sensors connected directly by optical fibers to monitors at head­quarters.

Someday you may work in an "intelligent" office building. The building itself may look much like other offices. But inside will be a world of difference.

The first of these office buildings is City Place in Hartford, Connecticut. Others that already have been built include Tower Forty-Nine in New York, LTV Center and Lincoln Plaza in Dallas, Texas, and Citicorp Center in San Francisco. By 1990, over 300 million square feet of "high I.Q." office space is expected to be in use.

An "intelligent" office building has fiber optic detectors that "see" if people are in a room before turning lights on or off. The detectors are connected to a main computer that regulates heat, ventilation, air conditioning, and lighting in each office of the building. Such automatic controls in large buildings can save as much as one-half on energy usage.

Just as important is that businesses in an "intelligent" office building share the benefits and costs of the most modern computer information networks, electronic mail, word processing, and telephone service. These services have been designed into the building's fiber optic system.

Security in "intelligent" office buildings also is im­proved. If, for example, a sensor detects a fire, its signals automatically ring alarms, call the fire department, ac­tivate sprinklers, exhaust smoke to the outside, and broadcast emergency instructions.

Fiber optics is lighting the way to an astonishing information age. Home computers will be "wired" to the world. Information from libraries and other sources will be available to us instantly. Banking and shopping will be done from home as well- Electronic newspapers, magazines, and mail will become commonplace. Tele­phones will be fitted with sockets to plug in computers, printers, television screens, and other information trans­mitting or receiving devices.

Away from Earth, new uses for fiber optics also will be found. In the 1990s, the National Aeronautics and Space Administration will build a permanent space station. It will be in orbit about three hundred miles up. The space station will use on-board fiber optic systems for communications, computer processing, monitoring, and controls. The station also will establish factories in the near-zero gravity of space. Some of these factories will manufacture glass more flawless and free of impur­ities than can be made on Earth. This ultrapure glass will be brought back to Earth by the Space Shuttle to be made into even better optical fibers and other products.

Sometime in the next century, people will live in space colonies. They will process information and communicate using optical fibers and light. And they probably will find uses for fiber optics that hasn’t yet been imagined.

Alexander Graham Bell's brightest idea will have become a reality reaching far beyond his most fantastic dreams.