1

The first magnetic recording device was invented and built by the Danish engineer Waldemar Poulsen. The device was called a telegraph and was intended for audio storage. The telegraph was patented in 1898, and this date is considered the year of birth of the magnetic record.

Типы магнитных лент для бытовых кассетных магнитофонов[3]

Тип магнитной ленты	Материал рабочего слоя	Типовая лента	Постоянная времени записи, мкс	
МЭК-1 (Type 1, extra 1, normal, Fe, Fe1, IEC1, EQ 120μS)	$\gamma{-}Fe_2O_3$	БАСФ/Р-723Д	120	3180
МЭК-2 (chromdioxid, chrom)	CrO_2	БАСФ/С-401	70	3180
МЭК-3 (Ferri chrom III, Ferrochrom)	$\gamma{-}Fe_2O_3 + CrO_2$	Сони/С-301 Сони/М-10655		
МЭК-4 (pure metal, metal)	Fe	не установлена		

Poulsen created several types of magnetic recording devices. In one of them, the wire (recording medium) is wound on a non-magnetic roller, which forms a magnetic working layer on it in the form of a cylindrical spiral. In the process of recording or playing the roller together with the wire rotated relative to the magnetic head, which moved parallel to its axis, sliding along the turns of the wire, like a screw thread. An electromagnet was used as the magnetic head, consisting of a rod core, which slid at one end on the carrier, and a coil of copper wire. The head with the core created a fairly strong and concentrated magnetic field, with which you could record sound frequencies.

2

and on this slide we can see the structure of the magnetic tape, that is, what it consists of,

3

The basis of the magnetic tape is made of synthetic materials, most often cellulose acetate (diacetate and triacetate), polyethylene terephthalate (mylar) and polyimides.

Powders of oxides of iron, chromium, cobalt and their mixtures, as well as powders of pure metals are used as a working layer. The main characteristics of the tape depend on the composition, thickness and homogeneity of the working layer, the size and shape of the magnetic powder particles.

4

Physically, the technology of recording on hard disks and films is the same: the data is recorded on a magnetized surface by narrow tracks on which the polarity is switched. The information is written in a sequence of bits.
Over the last decade, film has evolved no less than hard drives or transistors. The first digital storage film, the IBM Model 726, could hold 1.1 MB on a reel. Today, 1 coil can store 15 terabytes of data, and one robotic film storage - 278 petabytes.

To make this progress, engineers have adapted the read and write heads to move along extremely narrow paths on film - about 100 nanometers wide. In addition, we had to make the reading heads narrower - about 50 nanometers wide. When reading the signal level to noise also decreased, so we had to manipulate the size and position of the magnetized granules and the smoothness of the film surface, as well as improve the process of signal processing and reading errors.

5

As previously described, magnetic recording information is based on the fact that many materials in a magnetic field are magnetized along its lines and retain this magnetization even after the field is turned off. In magnetic media, such as floppy disks and HDDs, the role of bits is performed by the magnetization of small areas of the disk. As the size of these areas decreases, the amount of information that can be recorded on devices of the same size increases significantly. Today, one domain of commercially available hard drives has about a million atoms (several nanometers in diameter). Experiments show that cell size can be reduced to 3-12 atoms.

The authors of the new work have achieved stable recording and storage of information for several hours in single holmium atoms. Scientists explain the choice of metal as follows. Any orbital of an atom can carry one, one or two electrons. The magnetic properties of atoms are determined mainly by unpaired electrons, which are in their orbit in solitude. Holmium has a large number of unpaired electrons and, moreover, has the highest magnetic moment among the elements of the periodic table. In addition, the unpaired electrons of the atom are close to the nucleus, which provides some isolation from the environment. Therefore, the magnetic state of holmium can be maintained for a long time.

On the surface of magnesium oxide Holmium undergoes magnetic anisotropy - it leads to the fact that the atom has two stable magnetic states, determined by the orientation of its total spin. To move from one state to another atom must overcome the energy barrier. The lower the ambient temperature, the less likely this transition is. According to these two stable states, the values of "zero"and "one"are attributed.

In the experiment, scientists created a memory cell consisting of two holmium atoms on the surface of magnesium oxide, which was cooled to 1.2 Kelvin. To write and read, the scientists used a scanning tunneling microscope, which examines surfaces with an extremely sharp needle. The operation of recording was to add to the atom a certain voltage. For reading, the authors used the effect of tunneling magnetoresistance - the electrical resistance between the surface and the needle depends on the directions of magnetization of the tip of the needle and the holmium atom.

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