〈論　文〉

Major New Materials in Electrical and Telecommunications Engineerings Field and its Development in Korea

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Abstract

Whenever we see the development of technology of the past, the respective ages always produced the development of new materials.

The appearance of the new materials have been making technologies progress. In this way, we may say new materials and new technology are insparably related to each other. The technology of today has emerged between a valley of new technology of today and it is regarded as contributing to various technologies expected to be executed in the 21 century. Presently, so called new materials mean fine cermic, high performance organic polymer, new metal materials, compound materials etc.

This paper presents several new materials which are chiefly concerned with the electrical and telecommunications engineerings field and its development in Korea.

1. Piezoelectric Materials

A piezoelectric effect occurs when certain materials are subjected to mechamical stress. An electrical polarization is set up in the crystal and the faces of the crystal become electrically charged. The polarity of the charges reverses if the compression is changed to tension. Conversely an electric field applied across the material causes it to contract or expand according to the sign of the electric field.

The piezoelectric effect is reversible with an approximatey linear relation between deformation and electric field strength. The piezoelectric strain constant, d, is defined as

$$d_{ik}=\partial c_k/\partial E_i$$

where ∂c_i is the incremental stress and ∂E_i the change in electric field strength along defined axes in the crystal ($i\equiv x, y, z$ and $k\equiv xx, yy, zz, yz, zx, xy$).

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The piezoalectric crystallization indicating piezoelectric effect is crystallized quartz, Rochelle salt, titan balium etc.

The piezoelectric effect is important because it couples electrical energy and thus has many applications for electromechanical tranducers, extremely stablee frquency oscillators, piezo igniting element (electronic lighters) and so on in Korea as well as other industrialized countries.

2. Amorphous Metal, Alloy

The amorphous metal alleys possess the intensity not weaker than super strength steel. It has corrosion resistance and wear/tear resistance and also has magnetic characteristics as well. World's leading electric or telecommunications manufacturers, making the best of electromagnetic mechanical characteristics of amorphous alloys, are successful in commercializing high performance magnetic heads for tape recorders. However, at present commercializing is restricted to small parts for electronic apparatus.

If amorphous alloys were used as a changing materials for electric transmission and distribution transformers, it is said annually about 1.2 million kilowatts of electric power could be saved. Though a morphous metal alloy has excellent characteristics, it also has a problem that it is weaker at high temperatures.

Of the amorphous alloys, some are about twice as strong as a piano wire in tension, and they are promising as magnetic body. Furthemore amorphous silicon is expected as low cost solar battery and already used in hand calculators.

Among amorphous magnetic materials there are rare earth transit metal system alloys, transit alloys-metalloid system alloys, the materials with large mechanical strength and high permeability. For this reason, it is being noticed as a new material replacing the former silicon steel or permalloy.

The amorphous magnetic material of oxidization is also being studied and the manufactures for trial are both anti-ferromagnetic substance and paramagnetic substance.

The amorphous containing P_2O_2 is capable to pass light. With the development of new materials, such as stronger magnetism materials, excellent material having lightmagnetic characteri stics, new applications of amorphous ferrite such as an expansion to light-magnetic devices, magnetic head, microwave device and so on are expected.

3. Materials for Large Scale Integration (LSI)

For LSI, metals. semiconductors. insulators etc are used by making the best use of the respective characteristics and functions. Metals used for LIS are mainly wiring materials・electrode materials. For this, Au (gold) and Al(Aluminium) are mainly used. Besides, Mo(morbfuden) W(tungsten), Ti(titanium) etc which are high melting point metal are attracting attention as very large scale integration materials(VLSI). On the other hand, as insulators SiO_2 (silicon dioxide) thin film and Si_3N_4 (nitrification dioxide) thin film are used for gate insulation film, wiring inbetween insulation film and surface protection film.

	IC type	Product
①	Memory IC	1M DRAM, 256K SRAM, 256K DRAM, 64K SRAM, 64K EEPROM, 64K DRAM, 16K EEPROM
②	Linear IC	Audio IC, Video IC, Telecommunication IC, VTR IC, IC for electronic switching systems, Industrial IC, AD/DA Converter
③	Custom IC	Gate array, Linear array, Standard Cell, PLD, Full custom IC
④	Logic IC	AHCT/HCT LS Families, HC, AHC
⑤	MOS IC	Watch chip, Melody IC, Calculator IC, Speech synthesizer IC
⑥	MICOM	4 bit/8 bit MICOMs
⑦	Transistor	P/W TR, S/S TR, Power MOS FET, Digital TR, High Frequency TR

A semiconductor for LIS is silicon and mainly single crystal materials are used whilepartly sometimes a multi crystal Si is used for electrodes of LSI or wiring materials. And for VLSI use, the development research of III-V group compound semiconductor, centering around Ga As (gallium arsenide), is being conducted.

Korea turns out semiconductor products at several factories. Semiconductor products range from advanced memory chips to high-efficiency transistors. They manufacture the most sophistic ated memory chips such as DRAMs, SRAMs, EEPROMs and EPROMs, while some produces logics ICs, MICOMs, ICs for consumer goods, telecomunication ICs and high-efficiency transistors, numbering about a thousand items in all.

4. Engineering Plastics

This means industrial plastics used for engines of automobiles or parts of electronic apparatus, commonly called enpla. For application purposes the property of heat-resistance, high degree of strength, light weight, electrical insulation and so on are required and various kinds of plastics are being used according to applications: nylon, polycarbonate, polyacetal, polybutyleneterephthalate and methylated polyphenylene oxide are representative enplas.

As an enpla of high degree of strength light weight, for example, Kevlar fiber has strength twice as much as piano wires in tension and its weight is about one fifth. Korean chemistry manufacturers are also moving ahead with applications development of engineering plastics as part of high added value strategy and the major companies of Korea are also activeely embarking on marketing in expectation of increased demand in the future.

5. Glass Fiber

A glass fiber is a fiber state glass which has a thickness of several thousands of a mm by having glass melted with high temparature blow off with centrifugal force, high pressure gas, vapor etc. Compared with normal plate glass, it is in a state of having alkali components reduced and exceeds in heat resistance proof·corrosion resistance proof·dampproof. It is used for heat insulating material, sound absorbing material, filtering material etc. Besides, it is used for intensifying material with plastic and concreted.

Glass fiber intensified plastic has applications for the body of airplanes·automobiles, fishing rods, and sports articles. Besides, the glass made in a wool state is called glass wool and it is used for heat insulation·electricity insulation etc.

A fiber scope is used for stomach camera both for medical application and fiber communication. Diversified applications of fiber optic technology have made ISDN possible. This embraces such sophisticated hightech systems as optical video teleconferencing, optical LAN systems and data-computer networking. ISDN is hailed as a communication medium for the future.

Korea produces the optic fiber cables at four factories. The total production capacity amounts to 150,000km (length of fiber), operating at a 30 percent capacity.

6. Superconductivity Materials

There are a number of substances which show superconductivity. If the greater part of elements to which metals and compounds are added it amounts to several hundreds of kinds. Since super low temperature state and the substance of special structures have become possible, the list of superconductors is furthermore increasing. The figure below shows the elements and its transition temperature which are confirmed superconductivity.

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al 1.18	Si	P	S	Cl	Ar
K	Ca	Sc	Ti 0.39	V* 5.03	Cr	Mn	Fe	Co	Ni	Cu	Zn 0.86	Ga 1.09	Ga	As	Se	Br	Kr
Rb	Sr	Y	Zr 0.55	Nb* 9.23	Mo 0.92	Tc 8.22	Ru 0.49	Rh	Pd	Ag	Cd 0.52	In 3.41	Sn 3.72	Sb	Te	I	Xe
Cs	Ba	La α-4.9 β 6.3	Hf 0.17	Ta 4.48	W 0.003	Re 1.7	Os 0.66	Ir 0.14	Pt	Au	Hg α4.15 β3.95	Tl 2.35	Pb 7.19	Bi	Po	At	Rn
Fr	Ra	Ac	Th 1.37	Pa 1.4	U 0.7	*The second catergory supper conductors											

The elements showing superconductivity and its transition temperature. Note that some elements do not show superconductivity while showing superconductivity when they become metals or compounds

Looking from the supercondutivity application technology of today, both the transition temperature and critical magnetic fields are too low to be used for practical purposes.

In this sense, superconducting substances are not superconducting materials if we leave things as they are. At present, the things, which are used for practical purposes with the form of superconducting lines, are alloys system i.e. Nb-Ti three element systems based on it, and Nb_3 Sn, V_3Ga of metal inbetween compounds.

This transition temperature(critical temperature) and critical magnetic field are shown in the following table.

Representative superconducting materials

		T_c(K)	H_0(kOe)		T_c(K)	H_0(kOe)
(a) Critical temperatuer (T_c) of superconductors, critical magnetic field (H_0)	Nb	9.5	2.8	Sn	3.7	306
	Pb	7.2		In	3.4	283
	V	5.3		Al	1.2	100
	Ta	4.8	830	Ga	1.1	51
	α-Hg	4.2	410	Zr	0.75	43
	β-Hg	4.0	340	Ti	0.40	100
		T_c(K)	H_0(kOe)		T_c(K)	H_0(kOe)
(b) Critical temperature (T_c) of practical uses superconductors, critical magnetic field(H_0)				Nb_3Sn	18	215
	Nb-Zr	11	105	V_3Ga	15.1	220
	Nb-Ti	10	110	Nb_3Ge	23.2	370

7. Magnetic Bubble Memory

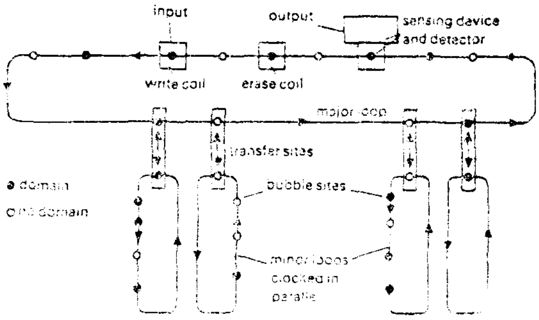
A serial magnetic memory that is fabricated as a solid-state device and in which information is stored as microscopic domains of magnetic polarization. The memory consists of a nonmagnetic garnet substrate—G^3—on which an epitaxial layer of magnetic garnet (usually calcium-germanium YIG) is grown. In the presence of a sufficiently large steady magnetic flux density applied perpendicular to the surface, the direction of magnetic polarization tends to be all in one direction. Any small domains of opposite polarization, which can be produced (or destroyed) by local variation of the magnetic flux density, are stable and may be moved through the surface using suitable weaker magnetic flux densities applied parallel to the surface.

The small domains are known as *magnetic bubbles* and are formed by electromagnetic induction using a single coil on the surface. They are caused to move through the surface by means of a periodic structure of suitably shaped magnetic electrodes formed from a different material, such as permalloy. A rotating magnetic flux density parallel to the surface causes the electrodes alternately to attract and repel the bubbles.

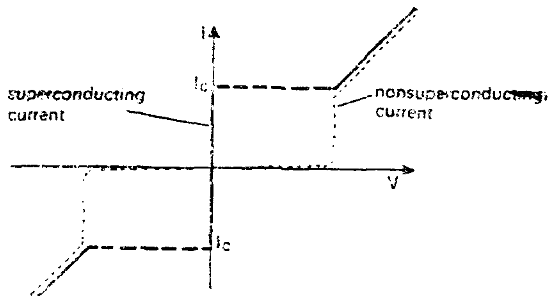
The bubble memory is a digital device in which the main direction of polarization is usually vertically downwards; the presence of a domain polarized vertically upwards represents a logical; the absence of a domain represents a logical 0. The information may be sensed at the end of the electrode structure either by electromagnetic induction or magnetoresistance.

Magnetic bubble memories are nonvolatile, i.e. the information is retained if the power supply is interrupted provided that the steady magnetic flux density is maintained, usually by using a permanent magnet. Very little power is consumed and, using suitably shaped electrodes and organization of storage cells, very large functional packing density can be achieved. Chips containing 100 kilobits have been produced using a major-minor loop arrangement (see diagram), which is the analogus of the serial parallel serial arrangement used for CCD memory.

Magnetic bubble memory is the magnetic analogue of CCD memory, which it predates. Compared to CCD memory it is nonvolatile, requires fewer processing steps, and consumes less



Major-minor loop organizanization of magnetic bubble memory



I-V Characteristic of Josephsonjunction

power. CCD memory however is faster, the silicon chips are considerably cheaper than the garnet chips, and sensing and control circuits can be formed on the same chip as the memory array. The magnetic bubble memory requires external control circuits and also requires extra circuits to generate the rotating magnetic fields.

8. Josephson Element

An effect that occurs when a sufficiently thin layer of insulating material is introduced into a superconducting material (see superconductuvity). A superconducting current can flow across the junction, known as a Josephson Junction, in the absence of an applied voltage. This is the direct-current Josephson effect. If the value of the current exceeds a critical value, Ic, determined by the properties of the insulating barrier, current can only flow when a finite voltage is applied. The current-voltage characteristic is shown in the diagram, in which the dashed curve is the current-voltage characteristic in the non superconducting state.

The alternating-current Josephson effect occurs when a small direct voltage, V is applied across a Josephson junction. The superconduction becomes an alternating current given by

$$I_2 = I_c \sin\omega t$$

where

$$\omega = 2\pi v = 2e/h\nu$$

h is the Planck constant, v the frequency, and e the electron charge.

The direct-current Josephson effect is utilized in several devices, particularly the Josephson memory. The alternating-current Josephson effect is utilized for radiofreqency detection, the determination of h/e, for accurate measurement of frequency, and as a monitor of voltage changes in standard cells or for the comparison of cells at different Standards Laboratories.

The representative superconducting materials of Josephson element are lead compounds, niobium, niobium compound etc. The characteristics of Josephson element are high speed of switching and very little amount of electrical consumption, so it is noticed in the field of supercomputer etc requiring extra-high speed.

Summary

As symbolized with "Iron Cold", namely, the sinking of the existing material industry, is difficult to deny. The influences owing to the oil shock and trade friction are big. The age of selling visible goods has passed a long time ago and the presentday is the age of selling "added value".

For assembly industry pursuing high added value the superiority and/or infetriority of materials becoming the base are(is) directly connected to the relative merits of manufactured goods.

For any industries such as metal, chemistry, electricity, the development of new materials is a "State of War". Referring to electronic materials, topics become more extreme. At the present time a computer occupying the most of the building space will become the size of one volume of a dictionary and yet it performs 500 times as many functions. The European countries and the United States have so far been a center of the creative ideas of these technologies and Korea is also striving for R & D and enterprices of these technologies.

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위의 論文은 東亞엔지니어링株式會社(東亞그룹)의 技術常任顧問 曺圭心博士가 大韓電氣工學會 및 大韓電子工學會共同主催 半導體·材料 및 CAD (computer aided design) 硏究部門學術會議(19895. 20)에서 發表한 世界 및 우리나라 電氣 및 電氣通信分野의 尖端新素材中 8種類에 關해 發表한 것을 移載(記)한 것이다.