SOME RECENT SOVIET WORK ON CRYSTAL PHYSICS

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DURING recent years, the volume of published Soviet work in physics has increased considerably. The established journals have tended to become larger, and several new journals have appeared. An appreciable fraction of this output has been devoted to various aspects of crystal physics, and this article summarizes some of the work. X-ray and electron diffraction investigations are excluded, as is also much of the work on barium titanate and allied piezoceramics; a review of early investigations on the latter subject was given by Hausner,[1] and more recent work has been dealt with by Smolenskiĭ,[2] who has correlated the Russian results with those of workers in other countries.

The majority of references given at the end are to work published after 1952-53; a review of earlier Soviet work on crystallography, including crystal physics, has been given by Mackay.[3]

ELECTICAL AND MAGNETIC PROPERTIES

Zheludev[4] has dealt with the fundamentals of the dielectric properties of crystals, including their representation by ellipsoids, together with the associated radius normal property. Electric strength has also been considered[5] experimentally in relation to crystallographic orientation, and theoretically in relation to mechanical and thermal stability and the lattice energy. Experimental results have also been given for the temperature dependence of dielectric constant in NaCl[6]; for dielectric losses in alkali halides as affected by frequency and temperature,[7] and for the dependence of electrical conductivity in quartz on temperature and on the electric and magnetic fields.[8] Work on magnetism has included the theory of magnetic symmetry[9]; magnetostriction in nickel[10]; and the anisotropy of magnetic properties in zinc single crystals.[11]

PIEZOELECTRIC AND FERROELECTIC PHENOMENA

In 1955, a conference on piezoelectricity was held in Moscow, and the papers presented, numbering 15 altogether, were published early in 1956.[12] The papers dealt with: barium titanate and other piezoceramics; new piezoelectric crystals; piezoelectric properties of wood and cellulose materials; physical properties and domain structure of Rochelle salt, including the effect of impurities and exposure to gamma radiation; the theory of piezoelectric resonators and the use of defective crystals for the production of oscillator plates.[13] Methods have been investigated[14] for growing crystals of ethylene diamine tartrate, lithium sulphate and potassium tartrate; and instruments described[15] utilising piezoelectric crystals for measuring the pressure of explosions in gaseous mixtures and the stresses in intermittently acting mechanisms. In addition to the work on wood mentioned above, studies have been made of the piezoelectric effect in rocks.[16] Electrets in carnauba wax, and photoelectrets in sulphur single crystal have also been investigated.[17]

The properties of Rochelle salt and other ferroelectric materials have received much attention. In strong 50 c/s. fields it appears[18] that ferroelectric properties in Rochelle salt persist above 24° C., normally taken as the upper Curie point. The index of refraction shows no discontinuity at the upper Curie point,[19] and on exposure to gamma rays from Co 60, the ferroelectric behaviour becomes less marked and ultimately disappears.[20] The effect of impurities on dielectric constant, piezoelectric modulus, crystal habit and domain structure have been studied.[21] Zheludev and Shuvalov[22] list the crystal symmetries of possible ferroelectric phases corresponding with a given symmetry and direction in the initial phase. The domain structure of Rochelle salt has been examined optically, and by a technique involving micro-cinematography.[24] The latter technique has also been used to follow phase transitions and domain structure in barium titanate[25] and the behaviour of spiral centres and dislocations during crystal growth.[26]

ELASTIC AND ALLIED PROPERTIES

Values of the elastic constants of α- and β-quartz, NaCl, AgCl and ammonium dihydrogen phosphate (ADP) have been published, and, except for ADP, the variation with temperature is also given.[27] Three different techniques were involved: a composite oscillator was used for NaCl and AgCl; the Schaefer-Bergmann method for α- and β-quartz; and for ADP, the method involved comparing the transmission velocity through the material with that through a known liquid.

Zubov and Firsova[28] have reported measurements on quartz at 20° C., obtained by the Schaefer-Bergmann method. They observed some inconsistencies in the results which they

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interpret as supporting the theory of Laval and Raman-Viswanathan, according to which the number of independent elastic constants needed to specify the behaviour of a completely asymmetric material is 45, instead of the 21 required according to the classical theory of Voigt; in quartz, the corresponding numbers are 10 and 6.

Aleksandrov[29] has dealt theoretically and experimentally with the analogy between the propagation of ultrasonic waves and light in crystals; various aspects of this analogy had previously been brought out by other workers. For an arbitrary direction of wave propagation in an anisotropic material, there are three independent waves, the displacement directions in each being mutually perpendicular. In general, these directions are neither coincident with, nor perpendicular to the direction of propagation, and the vibrations are therefore *quasi*-longitudinal or *quasi*-transverse. In certain special directions, however, the waves are purely longitudinal and purely transverse, and, following Borgnis, Aleksandrov has worked out the special directions for a material of orthorhombic symmetry, and from these results has deduced the special directions in tetragonal, hexagonal, and cubic materials. Aleksandrov has demonstrated experimentally the existence of polarisation effects with ultrasonic waves, and has discussed the possibility of double refraction and internal conical refraction. All these effects have, in fact, been observed previously, but another effect mentioned by Aleksandrov, the possibility of using a quarter wave plate of quartz to produce circularly polarised vibrations, has not.

Some of the recent work has dealt theoretically with thermal stresses in anisotropic bodies belonging to different crystal classes,[30] and with the fundamentals of the strength of anisotropic materials.[31] The formation and structure of "kink-bands", and their relationship to crystal orientation and state of stress in ionic crystals have been investigated[32]; the application of photoelastic methods to the study of stress distribution in anisotropic systems has also been suggested.[33]

Thermal Properties

Values of the thermal expansion coefficients as measured by X-ray methods have been rereported[34]; theoretical analyses have been made of problems in thermal expansion and conduction[35]; and relationships between the expansion and conduction coefficients have been examined.[36] Shubnikov[37] has discussed some fundamental points connected with the thermal expansion of crystals; he has emphasised the importance of the thermal shear deformation which occurs in many crystal classes and has illustrated diagrammatically the thermal deformation surfaces corresponding with different relative values of the principal thermal expansion coefficients of single crystals.

References

The references below are believed to include the majority of important papers published in the last few years, but the coverage is not exhaustive. The journals most frequently referred to are denoted by single letter abbreviations. Complete translations of *D.*, *E.*, *I.* and *T.* are available from 1956 onwards; translated titles are given in "Translated Contents Lists of Russian Periodicals", prepared by the Department of Scientific and Industrial Research, and published by Her Majesty's Stationery Office, London. The following list gives: (1) Name of Journal, (2) Single letter abbreviation, (3) Title of translation, (4) Translating authority.

(1) *Dokl. Akad. Nauk SSSR.* (2) D. (3) Soviet Physics-Doklady. (4) American Institute of Physics.

(1) *Zh. éksper. teor. Fiz.* (2) E. (3) Soviet Physics-JETP. (4) American Institute of Physics.

(1) *Izv. Akad. Nauk SSSR. Ser. Fiz.* (2) I. (3) Bulletin of the Academy of Sciences, USSR, Physics Series. (4) Columbia Technical Translations.

(1) *Kristallografiya.* (2) K. (3) and (4) Not translated.

(1) *Zh. tekh. Fiz.* (2) T. (3) Soviet Physics-Technical Physics. (4) American Institute of Physics.

The American Institute of Physics also issues a translation of "Akusticheskiĭ Zhurnal" as "Soviet Physics-Acoustics".

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LIGHTNING SHOCK

A DIRECT HIT by a lightning flash or a high-voltage electric current is almost invariably fatal. Massive holes and tears are found in the body, especially in the brain and blood vessels. But most people apparently struck by lightning seem to suffer no more than freakish damage to parts of their clothes and body. This is because the current tends to take the pathway of lowest resistance; it leaps from one low resistance conductor to another, so that down this pathway all the energy is dissipated, leaving organs a few centimetres away unharmed. The main resistance offered by the body is in the dry skin, and that is why household electric currents are so much more dangerous to the wet body. Surprisingly, the pathways followed by such currents as do traverse the body are not yet finally settled. It is thought that the energy goes mainly along blood vessels or nerves and it is considered that the whole body is a low resistance, structureless gel, so that there is a steady potential drop along the shortest line between the points of entry and exit of the current, with uniform potential fields around. When the current passes from one hand to the other it traverses the lower cervical spinal cord, which may explain why the results of this accident often took like transverse myelitis or even disseminated sclerosis. Whatever the pathways taken, it is the nervous system that always seems to bear the brunt of the current, though experimentally large currents can make the heart stop or fibrillate. A condition of profound "shock" with apparent suppression of all nervous activity may last one or two hours after a heavy electrical shock, yet the persons still recover without apparent sequelæ.

The changes seen in the body after an electric shock depend in the first place and most importantly on the physical characteristics of the current applied, especially on voltage. Of secondary importance is the pathway of the current—its points of entry and exit—and how great a potential gradient is produced inside the body once the high resistance of the skin has been broken down. The brain seems to be the most sensitive organ, but its functions are more often temporarily suspended than destroyed or permanently modified. For this reason it has always been recommended that prolonged artificial respiration be given to those apparently dead from electric shock or lightning. However, a careful physical examination is also necessary, since other potentially fatal lesions such as skull fractures may result from the patient being hurled on to the ground or on to other hard objects by the force of the current. (*B.M.J.*, Nov. 16, 1957.)