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# VARIATION OF ELECTRON RANGE IN DEFECT INDUCED POTASSIUM IODIDE CRYSTAL

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Potassium iodide crystal heat treated at various elevated temperatures is irradiated with an electron beam of energy 50 keV. The range of electron decreases with the temperature of heat treatment up to 645 K, and on further enhancement of temperature of heat treatment the electron range is found to increase. An explanation for such anomally in electron range is put forward.

## *1. Introduction*

Channeled particles experience a low rate of energy loss $\left(-\frac{\mathrm{d}E}{\mathrm{d}x}\right)$ with subsequent increase of range in a crystalline medium. The classical description of channeling is that the interactions of channeled particles with rows or planes of atoms is determined by many small angle scatterings and the particle do not feel the individual atoms[1]. Lindhard[2] theoretically demonstrated channeling phenomenon by classical methods, with the assumption that the potential due to a row of atoms is uniformly smeared out along the row (continuum stirring approximation). But in case of channeling in the low energy region quantum corrections to the classical description is necessary. The channeling of electrons has been studied by a number of workers[3-7]. Anderson et al.[8] have studied channeling of 700 keV electrons, and the obtained results were discussed in terms of dynamical theory of electron diffraction with assumption of many Bloch waves.

Mukherjee et al.[9] have reported a range energy relation of the electron penetration in KCl crystal along various channel directions and found that the electron energy loss is low along the low index direction. It is known that the transverse energy is conserved in the channel. Defects, lattice vibrations, point defects, dislocation etc. are detrimental to the transverse energy conservation, and as a result the penetrating particles are dechanneled. In order to have an idea of the degree of the dechanneling, Morgan et al.[1] defined the term »dechanneling probability«, $P = \frac{n_{ch} - n'_{ch}}{n_0}$, where, $n_{ch}$ and $n'_{ch}$ are the channeled fluxes in the perfect and imperfect crystals, and $n_0$ is the total flux. Looking into the channeling process it becomes evident that $P$ is a sensitive function of the position of a defect in the channel. Lattice vacancies also have some significant contributions to dechanneling phenomenon. The influence of thermally created lattice-vacancies (Schottky type) on channeling of electrons in NaCl crystal has been observed[10]. The results indicate that negative ion vacancies induced by heat treatment up to a limited range of temperature cause a reduction in the range of channeled electrons.

In the present paper attempts have been made to report some results obtained from the study of the electron range when the defect concentration is comparatively of higher orders in the crystals of potassium iodide.

## 2. *Experimental and results*

A flake of KI ⟨100⟩ was cleaved from a single crystal block. Surface polishing was done for electron bombardment and optical measurements. The specimen was irradiated with an electron beam of energy 40 KeV at R. T. for 5 minutes, the beam current 1$\mu$A. The depth of electron penetration (x) was estimated[9]. The crystal was heated to a temperature of 373 K for one hour and quenched to R. T. The heat treated crystal was irradiated with 50 keV electrons with the same dose and the depth of electron penetration was estimated. The measurements were carried out for the crystal heat treated at various elevated temperatures. Depth of penetration $(x)$ is converted to range value $(R)$. A graph of range of electrons against temperature of heat treatment is plotted and is shown in Fig. 1.

## 3. *Discussion*

When a crystal is cooled suddenly from a high temperature, a concentration of vacancies well above the equilibrium concentration at the ambient temperatures may be frozen in. In fact for an ideal quench (e. g. in metal) almost all the vacancies formed at high temperature were retained. In the case of an ionic crystal, quenching is definitely slow, and a fraction of the vacancies created at high temperature is lost. However, an activation energy is necessary for the formation of defects, and as the thermal energy for surmounting the activation barrier is large at high temperature the equilibrium concentration of vacancies increase with temperature of heat treatment. The vacancies so formed play the role of scattering centres with the incident charged particles and consequently increase the dechannelling

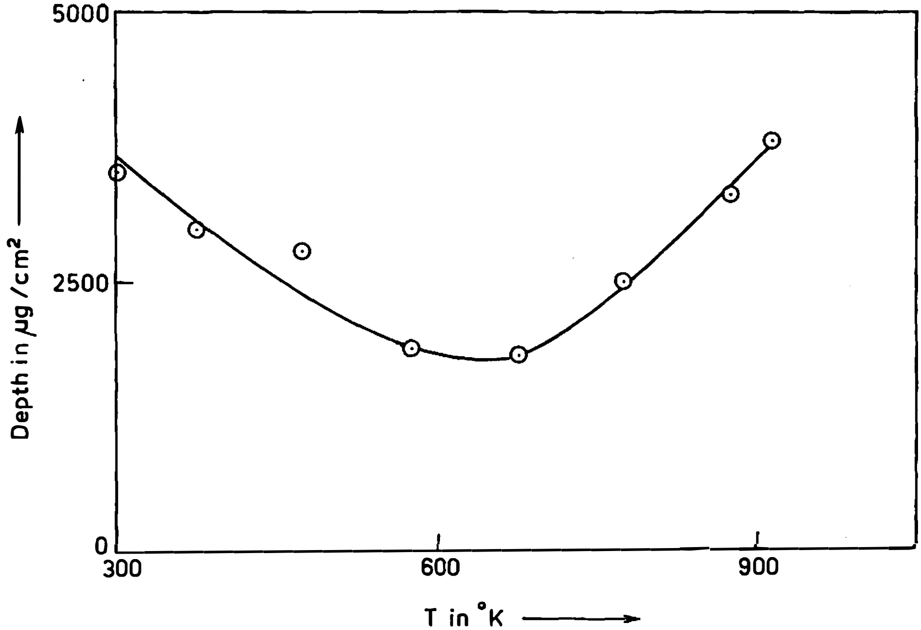


Fig. 1. Range values for the heat treated KI <100> crystal irradiated with 50 keV electrons; beam current of 1 $\mu$A for a period of 5 minutes.

probability. These defects produce localized strains[11] and perturb the channel potential[2] in such a fashion that the energy loss of the incident particles increases resulting in the diminution of range values. This is evident from the left part of the figure. The range of electrons in the crystals decreases continuously up to a certain temperature of heat treatment (675 K).

The large number of single vacancies favourably combine into clusters (di-. tri-. or higher order vacancies). The cluster concentration ($C_n$) is significantly large when the concentration of single vacancies ($C_1$) is high and is given by equation

$$C_n = A_n \cdot C_1^n \exp (B_n/kT)$$

where $A_n$ is a geometrical factor and $B_n$ is the binding energy of the vacancy complex[12]. When there is a large number of vacancies forming clusters in the specimen, they arrange themselves in such a way that the anisotropy in the strain-field due to one of the vacancy is balanced by that of the other and the crystal becomes strain free[13]. In this way the distortion in the chanel potential caused by some fewer number of monovacancies is removed. This view of van Bueren corroborates the present observation which shows an increase of electron range at a higher temperature of heat-treatment. This is indicated in the right part of Fig. 1.

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# MIJENJANJE ELEKTRONSKOG DOSEGA U KRISTALU KALIJEVOG JODIDA SA INDUCIRANIM DEFEKTIMA

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Kalijev jodid dobiven toplinskom obradom na visokim temperaturama bio je izložen elektronskom snopu energije 50 keV. Doseg elektrona u kristalu smanjuje se sa temperaturom toplinske obrade do 645 K, a daljnjim povećanjem temperature toplinske obrade doseg raste. U članku je predloženo i objašnjenje ove anomalije.