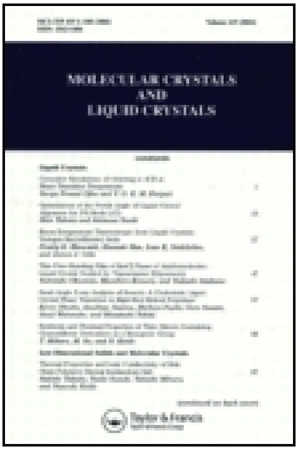

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl16

Electrical Properties in $(SN)_X$ and Doped $(SN)_X$ Crystal-Magnetoresistance at Low Temperature (0.2 - 4.2 K)

K. Kaneto [a] , S. Sasa [a] , K. Yoshino [a] & Y. Inuishi [a]
[a] Department of Electrical Engineering, Faculty of Engineering, Osaka University, Suita, Osaka, Japan
Version of record first published: 14 Oct 2011.

To cite this article: K. Kaneto , S. Sasa , K. Yoshino & Y. Inuishi (1982): Electrical Properties in $(SN)_X$ and Doped $(SN)_X$ Crystal-Magnetoresistance at Low Temperature (0.2 - 4.2 K), Molecular Crystals and Liquid Crystals, 86:1, 189-193

To link to this article: http://dx.doi.org/10.1080/00268948208073684

Mol. Cryst. Liq. Cryst., 1982, Vol. 86, pp. 189–193
0026-8941/82/8601-0189$06.50/0

(Proceedings of the International Conference on Low-Dimensional Conductors, Boulder, Colorado, August 1981)

ELECTRICAL PROPERTIES IN $(SN)_x$ AND DOPED $(SN)_x$ CRYSTAL-MAGNETORESISTANCE AT LOW TEMPERATURE (0.2 - 4.2 K)*

K. KANETO, S. SASA, K. YOSHINO and Y. INUISHI
Department of Electrical Engineering, Faculty of Engineering, Osaka University, Suita, Osaka, Japan

Received for publication August 31, 1981

The electrical resistivity of (SN)x along the b-axis increases by several times upon doping with sodium. Temperature dependence of resistivity does not change remarkably from that of pristine (SN)x. These experimental results are discussed comparing with the case of halogen doping. Transverse magnetoresistance ($\Delta\rho/\rho_0$) of pristine (SN)x crystal are measured in the temperature range of 0.2 - 4.2 K and magnetic field up to 90 kG. With the configuration of (magnetic field) $\perp$ (b-axis) // (current direction), $\Delta\rho/\rho_0$ at 0.2 K increases linearly with magnetic field ($<$ 40 kG), followed by saturation, contrary to the case at 4.2 K, at which temperature $\Delta\rho/\rho_0$ depends quadratically on the magnetic field.

I. SODIUM DOPING OF (SN)x CRYSTAL

Electrical properties,[1,2] superconductivity[3] and magnetic properties[4] in halogen (acceptor)doped (SN)x are studied intensively. However, donor doping in (SN)x has not been studied until now. In this paper, preliminary experimental results on electrical resistivity of sodium doped (SN)x will be reported and discussed, comparing with the case of bromine

*This work is partially supported by Grant in Aid for Scientific Reseach from the Ministry of Education, culture and Science of Japan.

doping.

Sodium doping of (SN)x is carried out by immersing the sample into the solution of Na^+ naphthalene$^{\cdot-}$ in THF. Electrical resistivity of Na ion solution is about several hundred Ω·cm, which is much greater than that of (SN)x crystal by several order of magnitudes. Four electrical probes were carefully contacted by pressing the sample onto Au lead wires with 30 μm diameter which were arranged on a ceramic holder.

Curve (a) in Fig.1 shows the typical time dependence of resistivity normalized to the original value of (SN)x after immersing the sample in Na^+ naphthalene$^{\cdot-}$ solution at ca. 20 C. The electrical resistivity of (SN)x along the b-axis increases by several times in Na^+ naphthalene$^{\cdot-}$ solution as shown in Fig.1 (a), contrary to the case of bromine doping of Fig.1 (b), in which resistivities are normalized to the original value at 290 K.

Electrical resistivity of Na doped (SN)x decreases by exposing to the bromine vapour and recovers to the value of pristine (SN)x, indicating the fact that the charactor of donor of Na is compensated by the acceptor of bromine.

Curves (a), (b) and (c) in Fig. 2 show the typical temperature dependences of resistivities of pristine, Na doped and bromine doped (SN)x, respectively. Temperature dependence of resistivity in Na doped (SN)x does not change remarkably from that of pristine (SN)x, namely $\rho \propto T^2$, as shown in Fig. 2 (b). The increase of resistivity in Na doped (SN)x is not considered to be due to the decomposition of (SN)x by the Na ion and/or THF. The reasons are

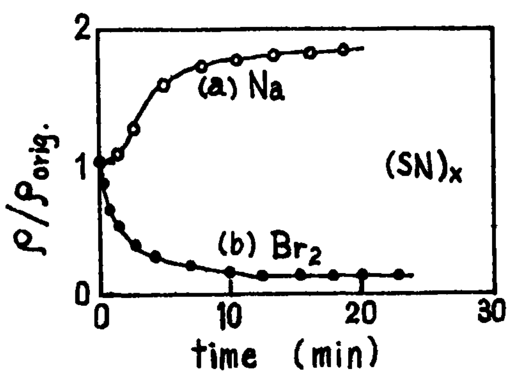

FIGURE 1 Time dependences of electrical resistivity in (a) sodium doping, (b) bromine doping of (SN)x, which are normalized to the original value.

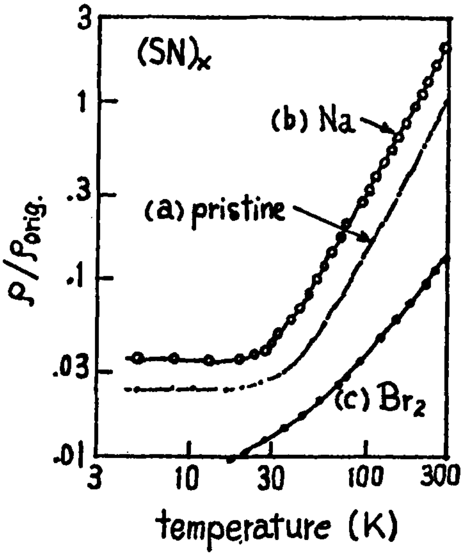

FIGURE 2 Temperature dependence of resistivities in (a) pristine, (b) Na doped and (c) Bromine doped (SN)x.

following. (i) The increased resistivity upon Na doping was recovered to the original value by the compensation with bromine. (ii) The increased residual resistivity observed below 20 K was very small and should be negligible above 100 K, since the decomposition (SN)x crystal by the mechanical stress or by heating above 60 C increased remarkably in residual resistance.[5] (iii) The decomposed (SN)x enhanced in the negative part of magnetoresistance.[6] The experimental fact that the magnetoresistance of Na doped (SN)x at 4.2 K did not enhance in negative part of magnetoresistance, indicating no decomposition of (SN)x crystal.

In the case of bromine doped (SN)x, the electrical resistivity decreases by about one order of magnitude as shown in Fig.1 (b) and the temperature dependence of resistivity becomes much less than the quadratic dependence as shown in Fig.2 (c). These facts of bromine doped (SN)x are explained with the idea of p-type conversion of (SN)x by bromine of acceptor nature and decrease of electron-hole Umklapp scattering probability.[7] The increased resistivity observed in sodium doped (SN)x should suggest the decrease of effective carrier density and/or decrease of carrier mobility which means that the probability of the electron-hole Umklapp scattering is not maximum at the intrinsic (SN)x and may becomes larger by donor doping.

At this stage of experiment, however, detailed mechanisms are not known and now under study.

II. MAGNETORESISTANCE OF $(SN)_x$ CRYSTAL AT LOW TEMPERATURE (0.2 - 4.2 K).

(SN)x polymer is known as a highly anisotropic semimetal, and several models of Fermi surface are proposed theoretically.[7] The purpose of this experiment has been to investigate experimentally the Fermi surface of intrinsic (SN)x and whether (SN)x is semimetal or not.

Curves in Fig. 3 (a), (b) and (c) show the magnetoresistance $\Delta\rho/\rho_0$ vs magnetic field in (SN)x crystal for the various temperatures of 0.2, 1.0 and 4.2 K, respectively, with the configuration of (magnetic field) $\perp$ (current direction) // (b-axis). At 0.2 K, although (SN)x crystal is superconductive, ρ_0 is regarded as the resistivity of normal state in a low magnetic field.

$\Delta\rho/\rho_0$ at 0.2 K increases linearly with increasing the magnetic field up to 40 kG, followed by saturation without showing negative part of magnetoresistance as shown in Fig. 3 (a), contrary to the case at 4.2 K, in that temperature $\Delta\rho/\rho_0$ depends quadratically on the magnetic field shown in Fig. 3 (c).

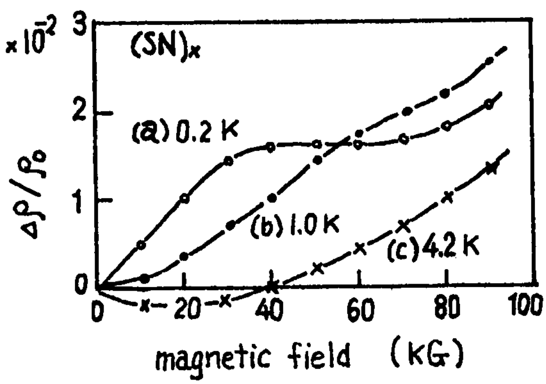

FIGURE 3 Magnetoresistance of pure (SN)x at low temperature of (a) 0.2 K, (b) 1.0 K and (c) 4.2 K

These linear dependence and saturation of magnetoresistance are also observed slightly at 1.0 K as shown in Fig. 3 (b)

The quadratic dependence of magnetoresistance at higher temperature ($>$ 4.2 K) are well known.[8] These linear dependence of magnetoresistance observed below 1.0 K has not been observed, however, which may be due to break down of supercondution by the application of magnetic field and/or intrinsic behavior of (SN)x itself.

At this preliminary stage of experiment, we can not give conclusive remarks about the results on magnetoresistance below the temperature of 1.0 K. Detailed experiment on the angular dependence of magnetoresistance and analysis are now under progress.

REFERENCES

1. C.K. Chiang, M.J. Cohen, D.L. Peebles, A.J. Heeger, M. Akhtar, J. Keppinger, A.G. MacDiarmid, J. Milliken and M.J. Moran, Solid State Communication 23 (1977) 607.
2. K. Kaneto,,S. Sasa, K. Yoshino and Y. Inuishi, J. Phys. Soc. Jpn. 49 (1980) 1902.
3. J.F. Kwak, R.L. Greene and W.W. Fuller, Phys. Rev. B 20 (1979) 2658.
4. R.H. Dee, J.F. Carolan, B.G. Turrell and R.L. Greene, Phys. Rev. B 22 (1980) 174.
5. K. Kaneto, K. Tanimura, K. Yoshino and Y. Inuishi, Solid State Communication, 22 (1977) 38.
6. M. Yamamoto, K. Kaneto, K. Yoshino and Y. Inuishi, Solid State Communication, 29 (1979) 541.
7. A. Oshiyama, Thesis, University of Tokyo , (1981). R.L. Greene and G.B. Street, Proc. of Chem. and Phys. of One dimentional Metal (Plenum press. 1977).
8. K. Kaneto, M. Yamamoto, K. Yoshino and Y. Inuishi, J. Phys. Soc. Jpn, 47 (1979) 167.