Thermal pinching of current in long silicon diodes having a single-valued current-voltage characteristic

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We observed experimentally thermal instability of the current in long silicon diodes with positive differential resistance. It is shown that this effect is due to the difference between the spatial dispersions of the intrinsic and the nonequilibrium conductivities in the weakly doped region of the diode.

In a recent article, (1) Kerner and Osipov predicted theoretically the possible onset of current instability in a system whose properties depend on two parameters having different spatial dispersions, even if the current-voltage characteristic is single-valued.

This phenomenon was observed by us experimentally in long \( p^+s n^+ (p^+s R^+ \) silicon diodes (\( p^+, n^+ \)—strongly doped regions, \( s \)—slightly doped region, \( R^+ \)—Ohmic junction of the recombination type).

Figure 1 shows the CVC of \( p^+ s n^+ \) structures plotted at the end of a rectangular pulse of 0.5 msec duration (the arrows show the instants when the diodes were damaged by local burning). We see that in the diodes with \( d/L \)

\[ = 1.4 \text{ and } d/L = 4.4 \text{ (} d \text{ is the thickness of the } s \text{ region and } L \text{ is the ambipolar diffusion length) the thermal breakdown set in on the CVC section with negative differential resistance (NDR), while in the diode with } d/L = 12 \text{ it occurred on the CVC section with positive differential resistance (PDR).}

To explain this fact, we turn to the model of a real \( p^+sn^+ \) structure, shown in Fig. 2. The solid curve in this figure shows the distribution of the concentration of the injected carriers (\( \Delta p = \Delta n \) ), while the dashed curve shows the distribution of the concentration of the intrinsic carriers (\( p_i=n_i \) ) in the \( s \)-region of the device. The forms of these distributions are governed respectively, by the presence of injection from the strongly doped \( p^+ \) and \( n^+ \) layers and by the heat dissipation in the tungsten thermal compensators \( W \). (1)

It is obvious that such a distribution of the concentrations of the intrinsic and injected electrons and holes leads to the formation of local NDR in the region of maximum heating of the base and to minimal modulation of its conductivity by the injected carriers, \( \sigma = q(\mu_n + \mu_p)p_i \exp(-1.16/2kT) \) (\( T \) is the temperature in °K). Connected in series with this region are sections of the
Neutral currents in neutrino experiment, and light neutral intermediate boson

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To explain the presence of neutral currents in the CERN experiment and their absence in the NAL experiment, it is suggested that the carrier of the neutral currents is a vector meson with mass $m < 2 \text{ GeV}$.

It was recently reported\textsuperscript{11} that an interaction of neutral currents was observed at CERN in the neutrino reactions

\begin{align}
\nu + N &\rightarrow \bar{\nu} + \text{hadrons} \quad (1) \\
\bar{\nu} + N &\rightarrow \nu + \text{hadrons} \quad (2)
\end{align}

The cross sections of reactions (1) and (2) amount to $\sim 20$ and $40\%$ of the corresponding cross sections with production of charged leptons. On the other hand, according to preliminary data obtained in Batavia, where neutral currents were also searched for, the effect is either nonexistent or small.

It is perfectly possible that the resultant contradiction will be eliminated with further refinement of the experiment of the experimental data, and the results of the two groups will agree. Nonetheless, we wish to call attention to the existence of a simple mechanism that is capable in fact of leading to the supression of the contribution of neutral currents at high energies.

Assume that the neutral intermediate boson ($C^0$) has a mass on the order of several GeV, and the mass of the intermediate charged boson is large. Then the relative contribution of the neutral currents will attenuate with increasing energy, owing to the cutoff action of the boson propagator $(q^2 + m^2)^{-1}$. Since the average neutrino energy at CERN is of the order of 2 GeV and in Batavia 15 GeV, the suppression effect can be appreciable.

Quantitative estimates can be obtained by using the parton model. These estimates are given in the table for several values of the $C^0$ mass. If we stipulate at least a twofold suppression of the neutral currents on

<table>
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<th>$s/m_C^2$</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>10</th>
<th>25</th>
<th>100</th>
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<tr>
<td>Suppression factor</td>
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<td>0.75</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
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