Abstract—The realization of low resistivity and stable contacts on p-type CdTe is still challenging, especially if high annealing temperatures must be avoided. In this paper, the electrical characteristics of Sb$_2$Te$_3$ contacts on p-type CdTe single crystals are studied. It is found that the resistivity of the contacts is low and constant with time.

I. INTRODUCTION

The achievement of linear, stable and low-resistance contacts on p-type CdTe is still demanding, although the first report on this subject dates to about 50 years ago [1]. This in spite of the fact that high quality ohmic contacts are extremely important both in the solar cells technology [2] and in the x-ray detectors technology, in particular whenever p-i-n structures are to be used [3]. The use of both large work-functions metal like Au, P and Ni [4, 5], or p-type conduction oxide layers like CuO or CuO$_2$ [6] is not satisfactory due to the high solid state diffusivity of the metals in CdTe that results in a poor stability of the contact [4].

On the other side, when contacts must be prepared on p-type single crystals, it is important that the process does not require a high temperature stage. In fact it is known that CdTe and CdZnTe are not stable when annealed at temperature higher than 200° C. Otherwise, dramatic changes in the resistivity of the samples are registered in particular in the case of the high resistivity samples. This makes some procedures for the preparation of ohmic contacts, which involve high annealing temperatures, not suitable for device manufacturing [7]. This is one of the reasons why in the last years the use of laser pulses has been proposed to anneal the contact region preventing the heating of the whole sample [8].

In this report, we show the excellent features of Sb$_2$Te$_3$ ohmic contacts on p-type CdTe single crystals. Solar cells exploiting Sb$_2$Te$_3$ as a back contact proved to be very efficient [9], however a direct characterization of the contact resistivity and the formation temperature of the contact is still missing.

II. EXPERIMENTAL

The contacts are obtained by depositing in a sputtering chamber a thin film of Sb$_2$Te$_3$. The samples are CdTe undoped Bridgman grown samples, with a resistivity ranging from 10 to 1x10$^5$ Ωcm. The samples are cut from single CdTe crystals, with a very low background impurity content [10]. Care was taken in order to avoid heating of the sample during the deposition by sputtering. A subsequent thermal annealing at a temperature of 150°C was carried out in order to improve the quality of the contact. This temperature is well below the temperature of 200°C above which CdTe is no more stable. In Fig. 1 are reported the I/V characteristics of the contacts after subsequent annealing treatments. The contacts as deposited present a almost linear I/V characteristic, but the resistance is high. The resistance decreases down to a minimum value for an annealing time of about 130 min. Subsequent annealing at 150°C were also tested, but with no results on the contact quality.

The contact resistivity was determined by the usual transmission line tap resistor (TLTR) geometry [11]. The experimental configuration is sketched in Fig. 2. The total resistance $R_n$ measured for each contact can be written as

$$R_n = 2R_f + R_c l_i / w$$  

where $R_f$ is the so called “front” resistance and $R_c$ is the sheet resistance. $R_f$ is linked to the contact resistivity $\rho_c$ by the equations

$$R_f = z \coth \frac{d}{l_i}$$  

$$z = \frac{(R_c \rho_c)^{1/2}}{w}$$  

$$l_i = \frac{\rho_c}{R_f}$$

where $z$ is the characteristic line resistance and $l_i$ is the transfer length of the line.

In Fig. 3 the total resistance $R_n$ is plotted against the intercontacts distance $l_i$. Using eq. 1) we can determine $2R_f$ (intercept of the line and the ordinate axis) and $R_c$ (from the angular coefficient of the line). Then, from eq. 2 we can calculate the quantity...
\[ \rho_c = 1.5 \times 10^{-1} \Omega \text{cm}^2. \] This value is comparable to the best values found in the case of contacts based on metals [5], but with the advantage to be stable with time.

Indeed we observed that the contacts are stable since more than one year. Moreover by thermal cycling the structure at 150°C no appreciable change of the contact resistivity was found. This is in agreement with a previous study of the chemical stability of the Sb$_2$Te$_3$ contact on CdTe [12].

### III. CONCLUSIONS

The electrical properties of the Sb$_2$Te$_3$ contacts on p-type CdTe samples have been studied. The contact resistivity is 0.15 \( \Omega \text{cm}^2 \). The contacts resulted to be stable over more than one year and many annealing cycles at a temperature of 150°C.

### IV. REFERENCES


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**Fig. 1.** Current/Voltage characteristics for the Sb$_2$Te$_3$ contacts after subsequent annealing treatments; 1) red dots: as deposited contacts 2) blue squares: after 10 min annealing at 150°C 3) green diamonds: after 40 min at 150°C 4) black triangles: after 130 min at 150°C.

**Fig. 2.** Transmission line tap resistor (TLTR) geometry [11]

**Fig. 3.** Total resistance \( R_t \) as a function of the contact distance \( l \). The result of the fitting procedure is also shown.