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Study of Microstructural and Electrical Properties of the (P)A-Si : H/(N)C-Si Heterojunction: Uncooled Microbolometer Application

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Introduction

Recently, outstanding achievements have been made in the development of a novel class of uncooled microbolometer infrared (IR) focal plane arrays (FPAs), the ones based on Si diodes as temperature sensors [1-2]. The previous achievements in this field [1-4], stimulates the search for simple complementary metal-oxide semiconductor (CMOS) compatible technologicalsolutions based on diode bolometers which would be suitable for mass production of IR FPAs with adequate performance for many civilian applications [4]. Indeed, to achieve high temperature resolution, the thermodiode must have a high temperature sensitivity and a linear dependence of the output over a wide temperature range. In this work, lightly hydrogenated a-Si:H(B) based heterojunction diodes are proposed as uncooled microbolometer IR FPA elements [5]. Our approach followed our previous study, in which we made a case that lightly hydrogenated a-Si:H(B) films prepared by DC magnetron sputtering promise high manufacturability, including the ease of incorporating its formation process into the CMOS production cycle, in combination with lowprocess cost. We study the interfacial electrical and bolometric properties of the (p)a-Si:H/(n)c-Si heterojunction for different boron concentrations in the a -Si:H layer.

Experimental Study

In this work, p-type a-Si:H was deposited by DC magnetron sputtering technique for different doping concentrations. Double side polished n-type float zone c- Si (100) wafers were used as substrates. The boron concentration on the a-Si:H(B) was estimated b y energydispersive X-ray (EDS). Ellipsometric measurements were carried out (p)a-Si:H/(n)c-Si structure using spectroscopic ellipsometer (Sopra, GES5). (I-V-T) measurements were performed at a temperature range between 290 K and 370 K. In our measurement, which is based on the variation of current with temperature at a fixed voltage, the sensitivity of the heterojunction diode isexpressed by the temperature coefficient of the detector current: TCS = d[ln S(T)]/dT, where S = I

Results and Discussion

Tauc–Lorentz (T–L) optical model is used to estimate the thickness, bandgap, structural properties of the films, whereas Bruggeman effective medium approximation (BEMA) is applied to find the thikness of the top rough layer. The thickness of the a-Si:H layers remains almost constant around a value of 700 nm, with the addition of boron. The band gap decreases with WB from 1.34 eV to 1.1 eV. The observations suggest an increase in structural disorder in the a-Si:H(B) layer deposited at higher boron concentrations. Varying the doping concentration of the (p) a-Si:H layer from 1.5% to 43% largely influences the properties of the (p)a-Si:H/(n)c-Si heterojunction. The samples prepared at the average boron

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concentration show the best rectification factor of about three orders at0.75 V, the smallest series resistance and the lowest ideality factor. On the other hand, the sample prepared at the highest doping concentration shows poor rectification quality and high ideality factor of about 5, which is related to the increase of structural disorder in the interface. I-V-T measurements show excellent linearity,with R^2 often greater than 0.9998, and a sensitivity always greater than 0.06 $°C^{-1}$. Indeed, the sensitivity obtained for this heterojunction is better than that reported in recent work on thermodiodes for bolometry applications [1-3].

Conclusion

The results obtained in this study indicate that (p)a- Si:H/(n)c-Si is a potential material for thermodiodes in uncooled microbolometers. Future efforts should be directed towards the fabrication of a-Si:H/(n)c-Si thermodiode in complete detector configurations.

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