DEVELOPMENT OF HIGH-OPERATING-TEMPERATURE MERCURY CADMIUM TELLURIDE INFRARED DETECTORS AT DRS

H. D. Shih, M. A. Kinch, F. Aqariden, P. K. Liao, and H. F. Schaake
DRS Infrared Technologies, L.P.
13544 North Central Expressway
P.O. Box 740188
Dallas, TX 75374

ABSTRACT

An overview on DRS' approach towards realization of HgCdTe photonic infrared detectors based on DRS's proven HDVIP® technology is given. A summary of recent progress is described.

1. INTRODUCTION

In the early 1990s, DRS Infrared Technologies in Dallas, then a business unit of Texas Instruments Incorporated, developed a unique architecture for realization of large-area, reliable infrared focal plane arrays (IRFPAs). This architecture exists in two formats: the Vertically Integrated Photodiode (VIP) format for scanning IRFPAs and the High Density Vertically Integrated Photodiode (HDVIP®) format for staring IRFPAs. (Kinch, 2001) Both formats have been extensively validated for tactical applications. However, for low-background-flux and high-operating-temperature applications, further reduction of detector dark current is essential. In this paper, a summary of progress towards this goal is presented.

Both formats of the HDVIP® architecture rely on the formation of an $n^+/n^-/p$ $Hg_{1-x}Cd_xTe$ diode (shown in Fig. 1), in which the extrinsic p-type dopant is either copper or gold (Holander-Gleixner, 1997)

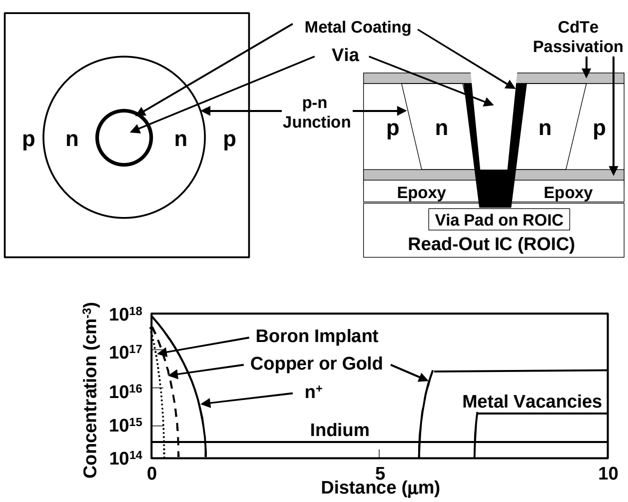

Fig.1. HDVIP® architecture. Top left: Top view. Top right: Side view. Bottom: Cross section through an HDVIP® diode.

Currently, copper at a concentration of ~ $4x10^{16}$ cm^{-3} is used in the standard HDVIP® in production. The disadvantage of copper as a p-type dopant is the requirement that metal (Cd and Hg) vacancies of ~ $1x10^{16}$ cm^{-3} be present to stabilize the copper profile in an HDVIP®, thereby degrading the minority carrier lifetime and limiting the detector performance. In this regard there is a need to replace copper by another extrinsic dopant that is thermally stable in the absence of vacancies in the material. Data obtained in this laboratory several years ago indicated that IRFPAs fabricated using gold-doped $Hg_{1-x}Cd_xTe$ material met this requirement. Because of this experimental data, gold-doped MWIR $Hg_{1-x}Cd_xTe$ was used to replace copper.

2. SUMMARY OF RESULTS

(1) State-of-the-art minority carrier lifetime from LWIR MBE (molecular beam epitaxy) gold-doped $Hg_{1-x}Cd_xTe$ (x ~ 0.227) was obtained (Fig.2). This is a very encouraging result, because it indicates that the material quality is as good as theoretically predicted.

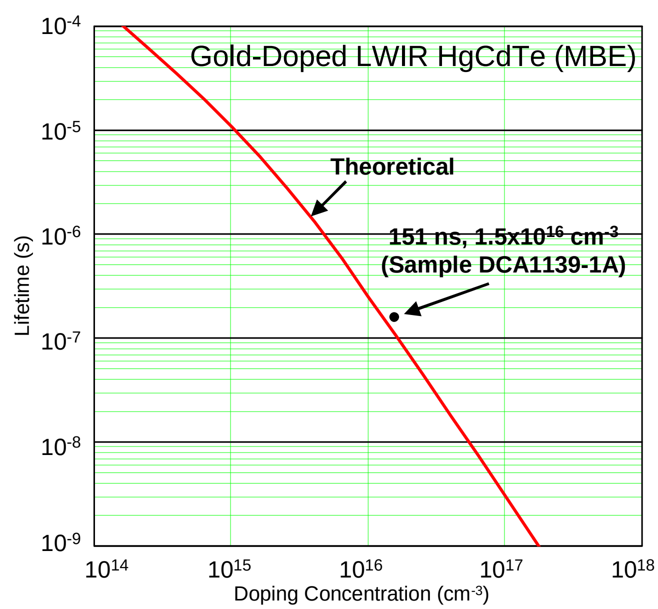

Fig.2. Theoretical data of minority carrier lifetime versus carrier concentration for LWIR $Hg_{1-x}Cd_xTe$ (x ~ 0.227). The experimental data is also shown. (Supported by ARL CTA)

(2) Excellent dark current versus temperature data from MWIR LPE (liquid phase epitaxy) gold-doped $Hg_{1-x}Cd_xTe$ (x ~ 0.3)

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diodes was obtained (Fig.3). Even though the dark current is about a factor of 2 higher than the modeled value, the result still is very encouraging. It appears that the device passivation process needs to be optimized at that stage of the development.

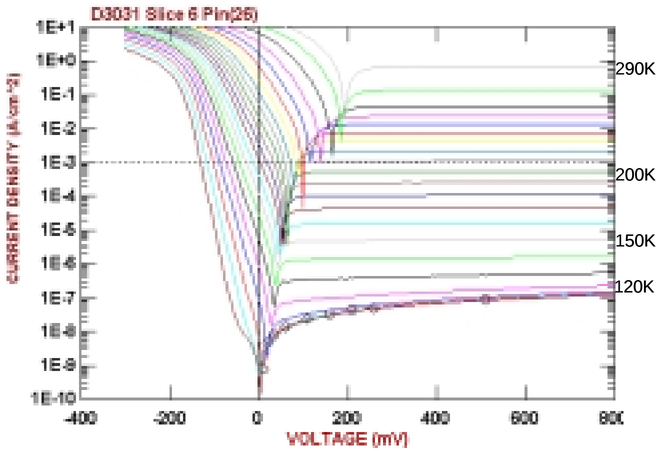

Fig.3. Excellent dark current versus temperature data from MWIR LPE gold-doped $Hg_{1-x}Cd_xTe$ (x ~ 0.3) diodes. (Supported by AFRL, Kirtland)

(3) State-of-the-art 77K dark current data from LWIR LPE gold-doped $Hg_{1-x}Cd_xTe$ (x ~ 0.3) diodes was obtained (Fig.3). This is a very important result because it indicates that the device passivation process employed in this lot works quite well.

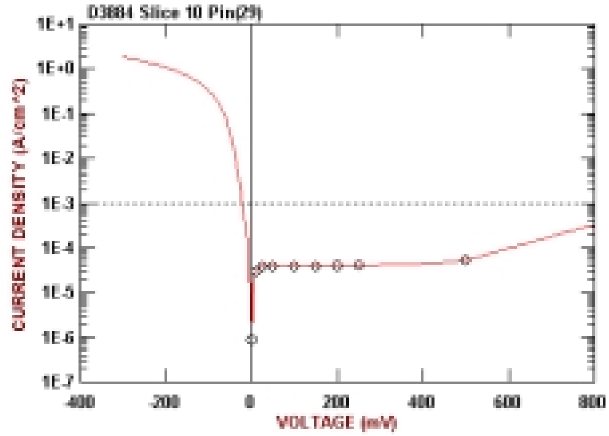

Fig.3. Excellent 77K dark current data from LWIR LPE gold-doped $Hg_{1-x}Cd_xTe$ (x ~ 0.22) diodes. (Supported by ARL CTA and by NRL)

3. FUTURE DIRECTIONS

Investigation of low-dark-current LWIR FPAs is in progress. Working with the University of Illinois at Chicago group, DRS also is exploring arsenic-doped HgCdTe.

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Kinch, Michael A., 2001: HDVIP™ FPA technology at DRS in *Proc. SPIE Meeting*, Vol. 4369, pp.566-78 (Orlando, April 2001).