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Comparison of the Schaake and Benson Etches to Delineate Dislocations in HgCdTe Layers

S. FARRELL,[1,5] MULPURI V. RAO,[1] G. BRILL,[2] Y. CHEN,[2] P. WIJEWARNASURIYA,[2] N. DHAR,[2] J. D. BENSON,[3] and K. HARRIS[4]

1.—Department of Electrical and Computer Engineering, George Mason University, Fairfax, VA 22030-4444, USA. 2.—U.S. Army Research Laboratory, Sensors and Electron Devices Directorate, 2800 Powder Mill Road, Adelphi, MD 20783, USA. 3.—U.S. Army RDECOM CERDEC Night Vision and Electronic Sensors Directorate, Ft. Belvoir, VA, USA. 4.—Penn State Electro-Optics Center, 222 Northpointe Blvd., Freeport, PA 16229, USA. 5.—e-mail: farrell_stu@yahoo.com

The morphology and classification of etch pits in molecular beam epitaxy-grown (211) HgCdTe/CdTe/Si layers were investigated using the Schaake and Benson etch pit density (EPD) etches. The two EPD etches were compared and shown to have a 1:1 correlation in the etch pits that were produced. Close examination of the shape of the etch pits via scanning electron microscopy shows that several distinguishable classifications of etch pits are revealed using both etches. Samples subjected to thermal cycle annealing (TCA) treatment show a nonuniform reduction in etch pit populations according to the classification defined in this study. In particular, a class of etch pits called "fish shaped" are completely absent after TCA and can account for up to one-third of the total reduction in EPD.

Key words: HgCdTe, EPD, MBE, thermal cycle annealing, dislocations, Schaake etch, Benson etch, SEM

INTRODUCTION

HgCdTe/Si technologies have been shown to be a viable structure for producing short- and mid-wavelength infrared focal-plane arrays.[1–3] However, their use in long-wavelength focal-plane arrays is limited by large dislocation densities, which are two orders of magnitude greater than in HgCdTe grown on lattice-matched CdZnTe substrates.[4,5] This increased dislocation density leads to higher dark currents in devices and poor performance/uniformity in focal-plane arrays.

The foremost method for determining dislocation densities in HgCdTe is by means of a wet chemical etching process that reveals the locations of dislocations on the surface as small pits. The etch pit density (EPD) has been shown to have a 1:1 correlation with dislocations found via transmission electron microscopy (TEM) and other analysis methods. EPD etches are often not isotropic, meaning that they have a high etch rate along some crystal planes. In particular, the etch is slower along the close-packed planes. Thus, an EPD etch produces pits with facets along {111} planes.

The standard EPD etches that are used for HgCdTe and CdTe are the Schaake etch[6] and Everson etch,[7] respectively. In 2008, Benson et al.[8,9] developed a new EPD etch designed to be effective for etching both CdTe and HgCdTe. When used on CdTe the Benson etch leaves a smoother surface and thus reveals more etch pits than the Everson etch when viewed via optical microscopy, though the number of pits is comparable when analyzed via atomic force microscopy.[8,9] However, a comparison of EPD results based on the Benson etch versus the standard Schaake etch on HgCdTe layers has not been reported to date. In this work we examine and compare the characteristics of the Schaake and Benson etches and show that they have a 1:1 correlation for use in etch pit density determination. In an effort to further show a 1:1 correlation between

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