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# Strain Determination in Quasi-Lattice-Matched LWIR HgCdTe/CdZnTe Layers

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We take advantage of the zinc distribution of (211)B CdZnTe substrates to probe the lattice-mismatch-induced stress in long-wave infrared HgCdTe layers grown by molecular beam epitaxy. High-resolution x-ray diffraction is used to accurately determine the strain-free lattice parameters of both CdZnTe and HgCdTe, together with the in-plane components of the stress tensor. By using several wafers, the stress evolution is derived over a broad range of lattice mismatch. In particular, stress relaxation is evidenced for mismatch greater than 0.02% and 0.04% for tensile and compressively strained HgCdTe, respectively. In-plane strain anisotropy, expected for the (211) orientation, is only evidenced for the compressive configuration. Strain relaxation is correlated with substrate curvature and rocking-curve peak broadening, providing indirect evidence for plastic relaxation.

**Key words:** Strain, HRXRD, HgCdTe, MBE

## INTRODUCTION

The performance of HgCdTe-based devices is closely related to the crystalline perfection of the HgCdTe thin film.[1–3] Lattice matching is therefore essential, and can be achieved, in principle, by growing HgCdTe on CdZnTe substrates with an appropriate zinc fraction.[4] Practically, the zinc content varies both between CdZnTe substrates and within a single wafer. This is particularly true for (211) substrates since vertical gradient freeze ingots are usually (111) oriented leading to a 20° offset in the cutting of the (211) wafers.[5] The typical zinc dispersion is found to be about 0.5% to 0.8% over the surface of the 4 cm × 4 cm wafers used in the present work. The variation of the CdZnTe composition over larger wafers is therefore expected to be strongly enhanced. As a result, the lattice-matching condition cannot be guaranteed systematically, and significant deviation may cause strain build-up and sometimes strain relaxation through the generation of misfit dislocations, which are highly detrimental to device performance.[3,6–8]

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In this work, we take advantage of the zinc distribution to probe different strain states over a single HgCdTe/CdZnTe epitaxial layer, thus avoiding any process nonreproducibility effects. We also take advantage of the substrate-to-substrate zinc fraction variation to measure the in-plane stress of the HgCdTe layer over a wide range of lattice mismatch. We chose to focus on long-wave infrared (LWIR) material because it is well known that devices designed to photodetect in the LWIR spectral band are much more sensitive to extended defects such as misfit dislocations because of the reduced bandgap of HgCdTe.[6–9]

Our approach relies on high-resolution x-ray diffraction (HRXRD) to measure the stress tensor of HgCdTe. The accuracy of this technique is such that very small variations in lattice spacing can be easily detected. This is of prime importance for this study since HgTe/CdTe is a quasi–lattice-matched system. As a consequence, a very important material requirement is the substrate quality to avoid any diffraction peak broadening caused by crystalline imperfections. For this study, CdZnTe wafers with rocking-curve full-width at half-maximum (FWHM) lower than 30 arcsec over the entire wafer area have been selected.