Multi-Band Quantum Well Infrared Photodetectors

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The GaAs/AlGaAs based Quantum Well Infrared Photodetectors (QWIPs) afford greater flexibility than the usual extrinsically doped semiconductor IR detectors because the wavelength of the peak response and cutoff can be continuously tailored over any wavelength between 6-20 μm. The spectral band width of these detectors can be tuned from narrow ($\Delta\lambda/\lambda \sim 10$ %) to wide ($\Delta\lambda/\lambda \sim 50$ %) allowing various applications. Thus, QWIP offers multi-color infrared focal plane arrays (FPAs) by stacking different multi quantum well layers which are capable of acquiring images in different infrared bands. In this presentation, we will discuss the recent results of large format specially separated four band QWIP FPA based on a GaAs/AlGaAs materials system and its performance. In this application, instead of quarter wevelength groove depth grating reflectors, three-quarter wavelength groove depth reflectors were used to couple radiation to each QWIP layer. This technique allow us to optimize the light coupling to each QWIP stacks at corresponding pixels while keeping the pixel (or mesa) height at the same level which will be essential for indium bump-bonding with the multiplexer. In addition to light coupling, these gratings serve as a contact to the active stack while shorting the unwanted stacks.

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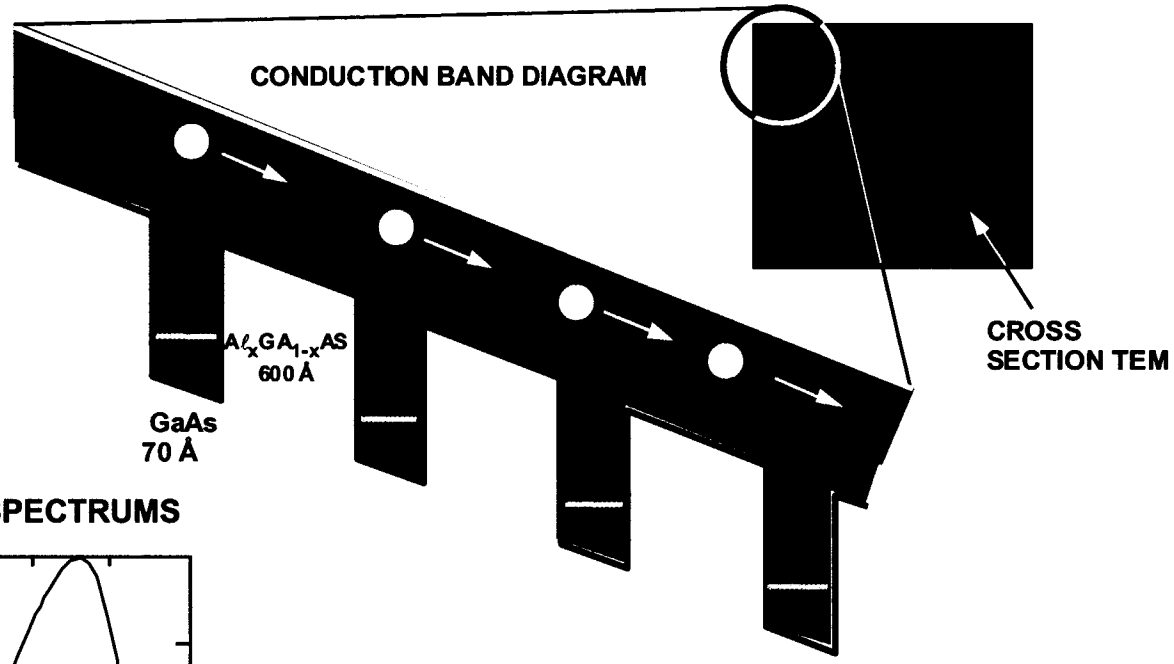
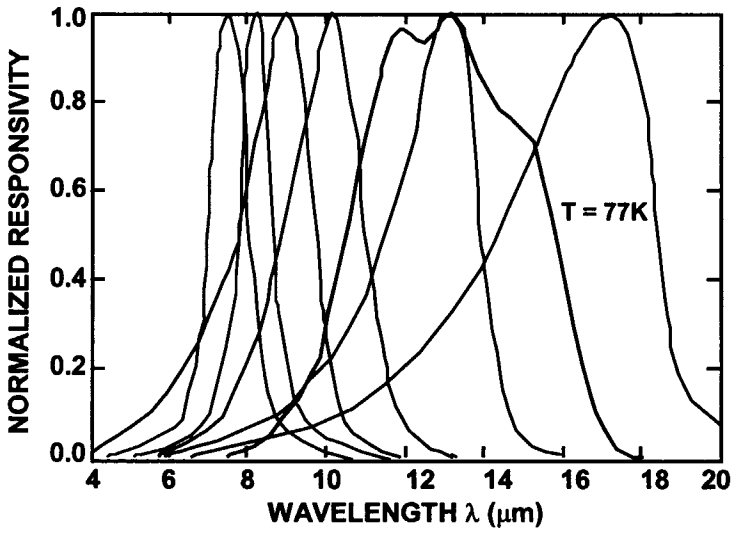
QUANTUM WELL INFRARED PHOTODETECTORS (QWIPs)



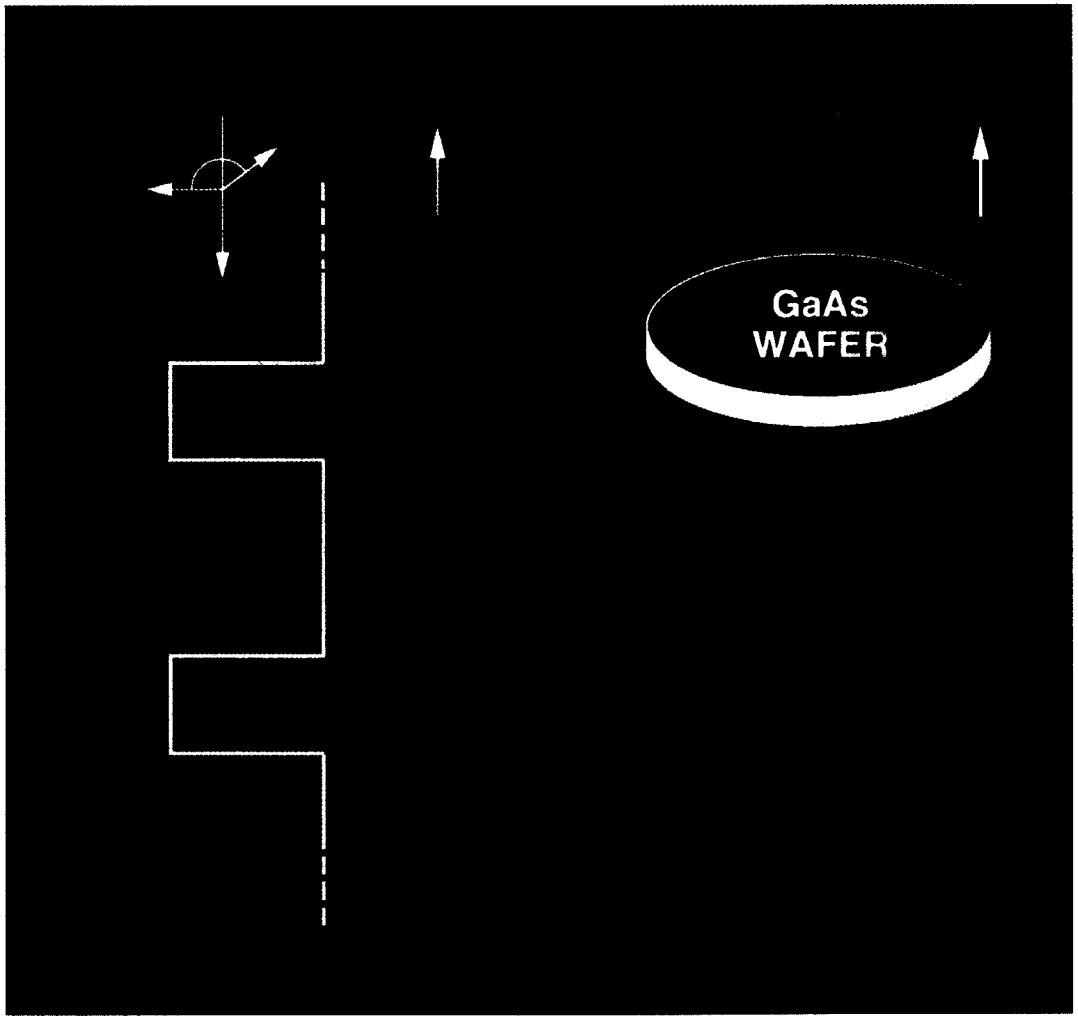
GaAs/AlGaAs BASED QWIP SPECTRUMS



GaAs/AlGaAs BASED QWIP CAN COVER A VERY BROAD INFRARED (3-25 μm) REGION

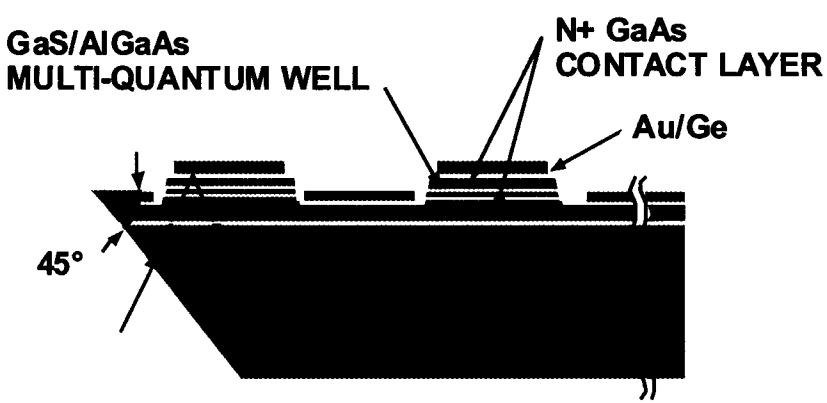
QWIPs COVER 4-20 μm WAVELENGTH REGION WITH BROAD-BAND, NARROW-BAND AND DUAL-BAND LARGE FORMAT FOCAL PLANE ARRAYS

WHY QWIPs DO NOT WORK WITH NORMAL INCIDENT LIGHT?

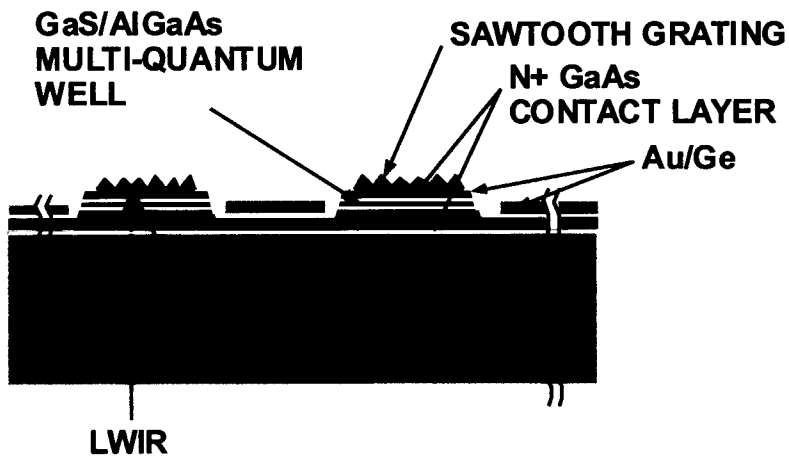


VARIOUS LIGHT COUPLING METHODS

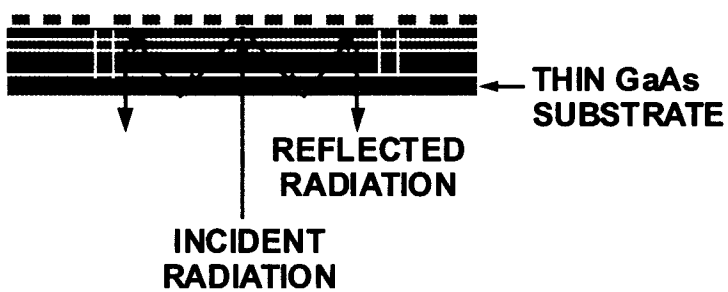
45° COUPLING



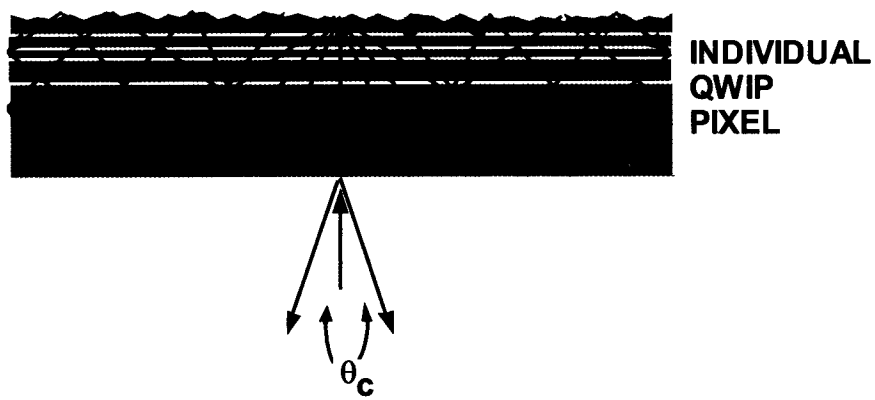
LINEAR GRATING



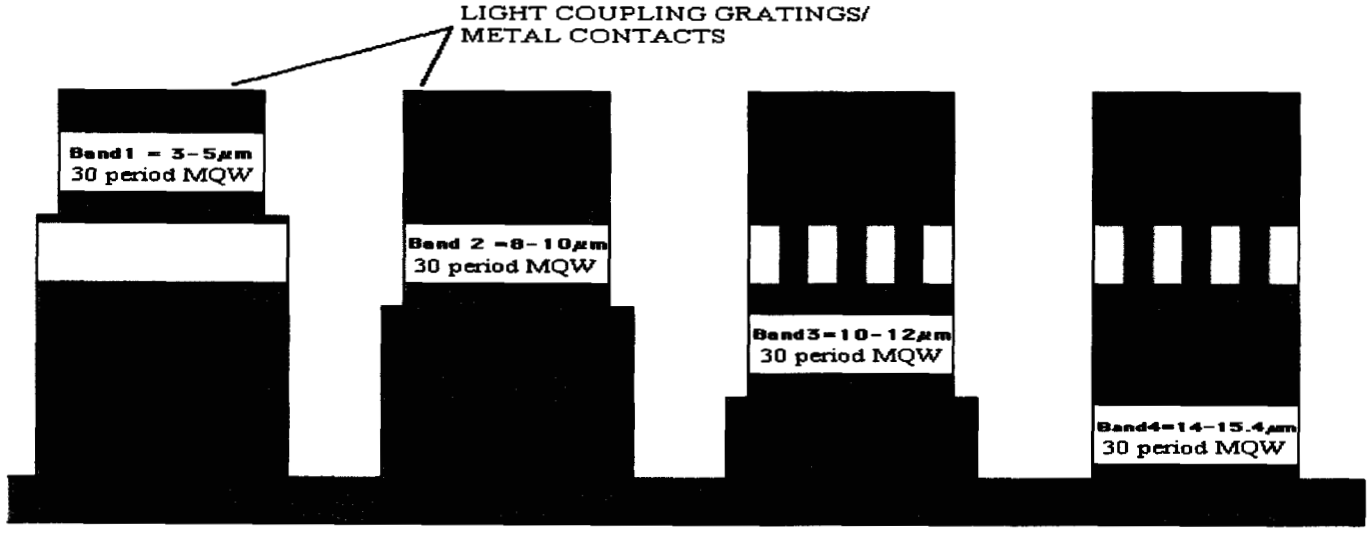
GRATING AND CAVITY

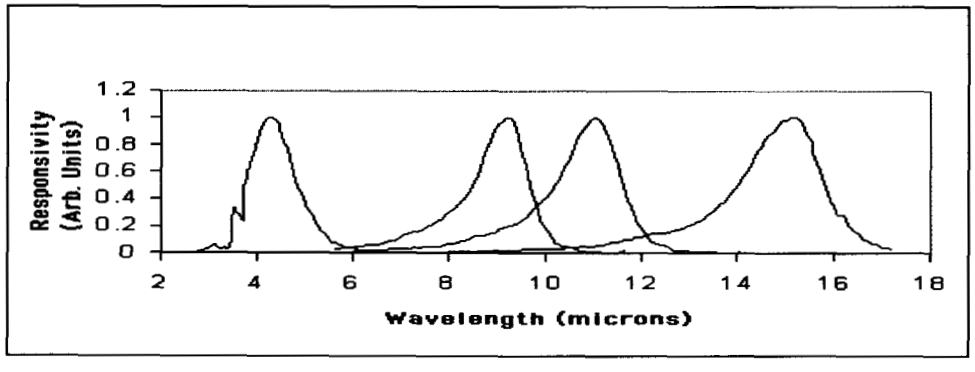


RANDOM REFLECTOR

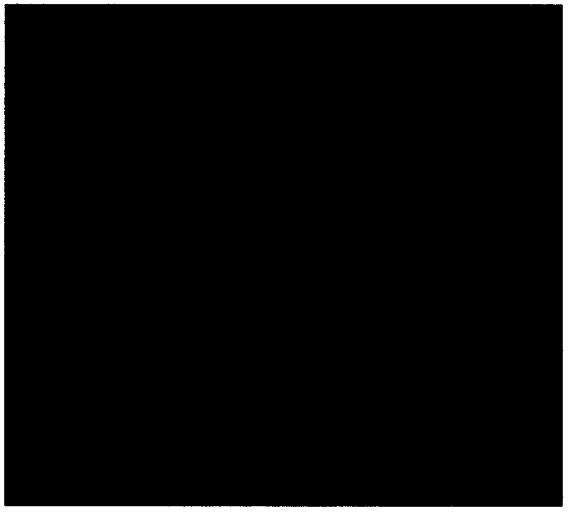


640X512 FOUR BAND QWIP FPA





Deep Groove Etch Gratings for QWIPs



Destructive interference

$2h\cos\theta = n\,\lambda'/2, \quad n = 1,3,5..$

To minimize normal reflection

i.e., $\theta = 0$

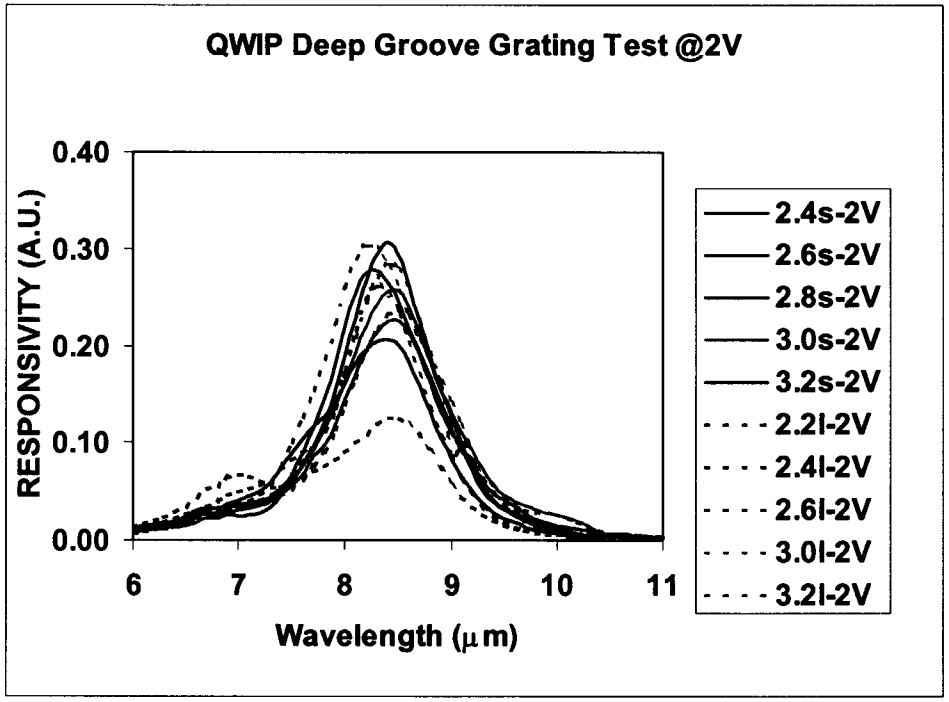
$h = \lambda'/4,\ 3\lambda'/4,\ 5\lambda'/4,\ \ldots$

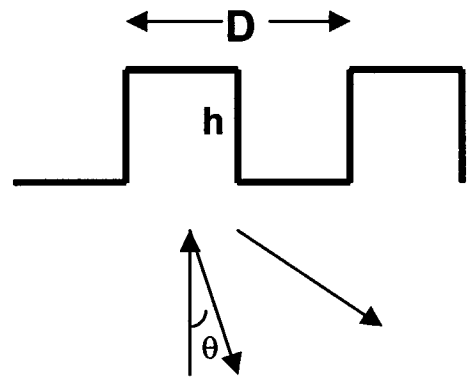
$\lambda = 15\ \mu m\ (\lambda' = \lambda/n_{ref})$

$h = 1.25\ \mu m,\ 3.75\ \mu m,..$

In spatially integrated 4-color QWIPs, at least $3\lambda'/4$ deep groves are required to isolate the each color response band

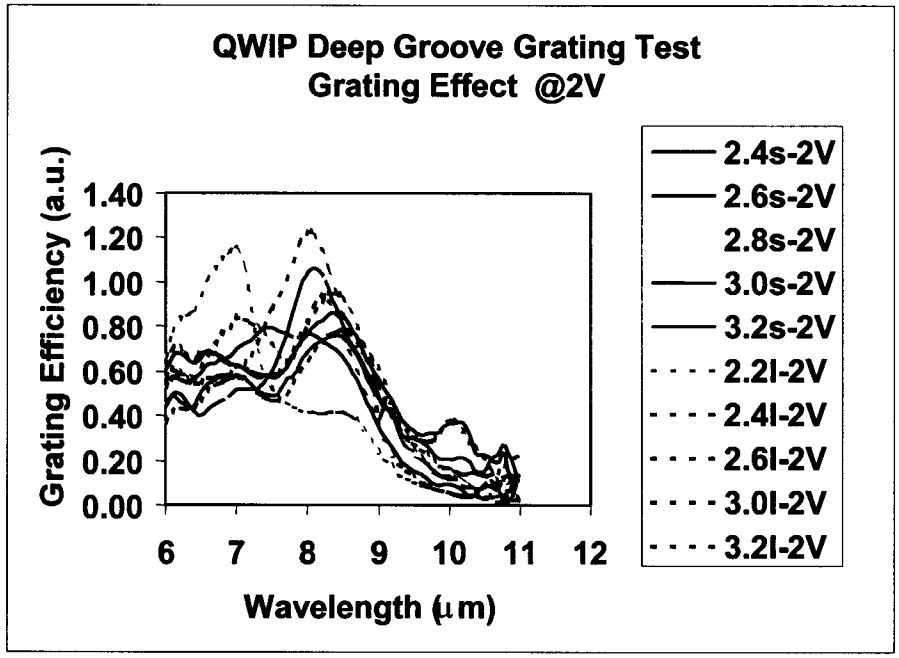
DEEP GROOVE GRATING TEST

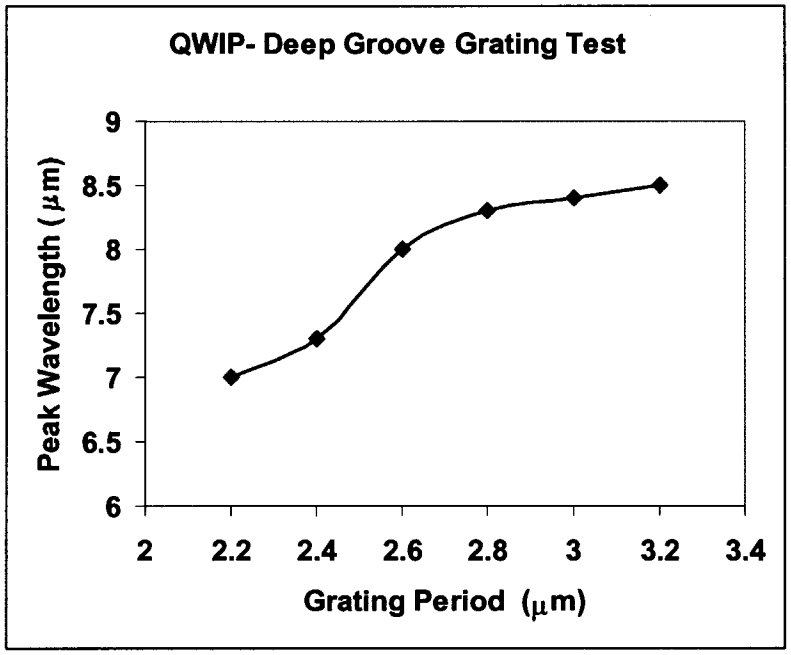




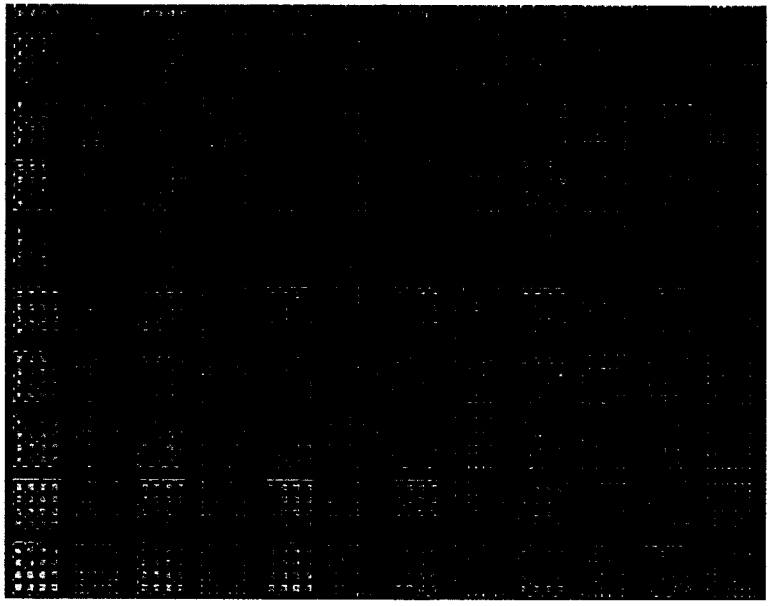
- Keep h = 2.0 μm~ 3λ/4
- Change D from 2.2 μm to 3.2 μm

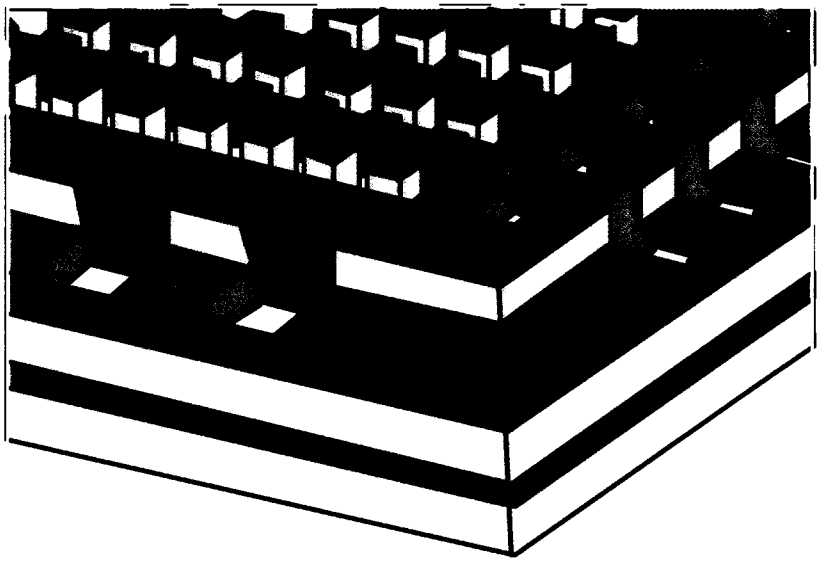
DEEP GROOVE GRATING TEST



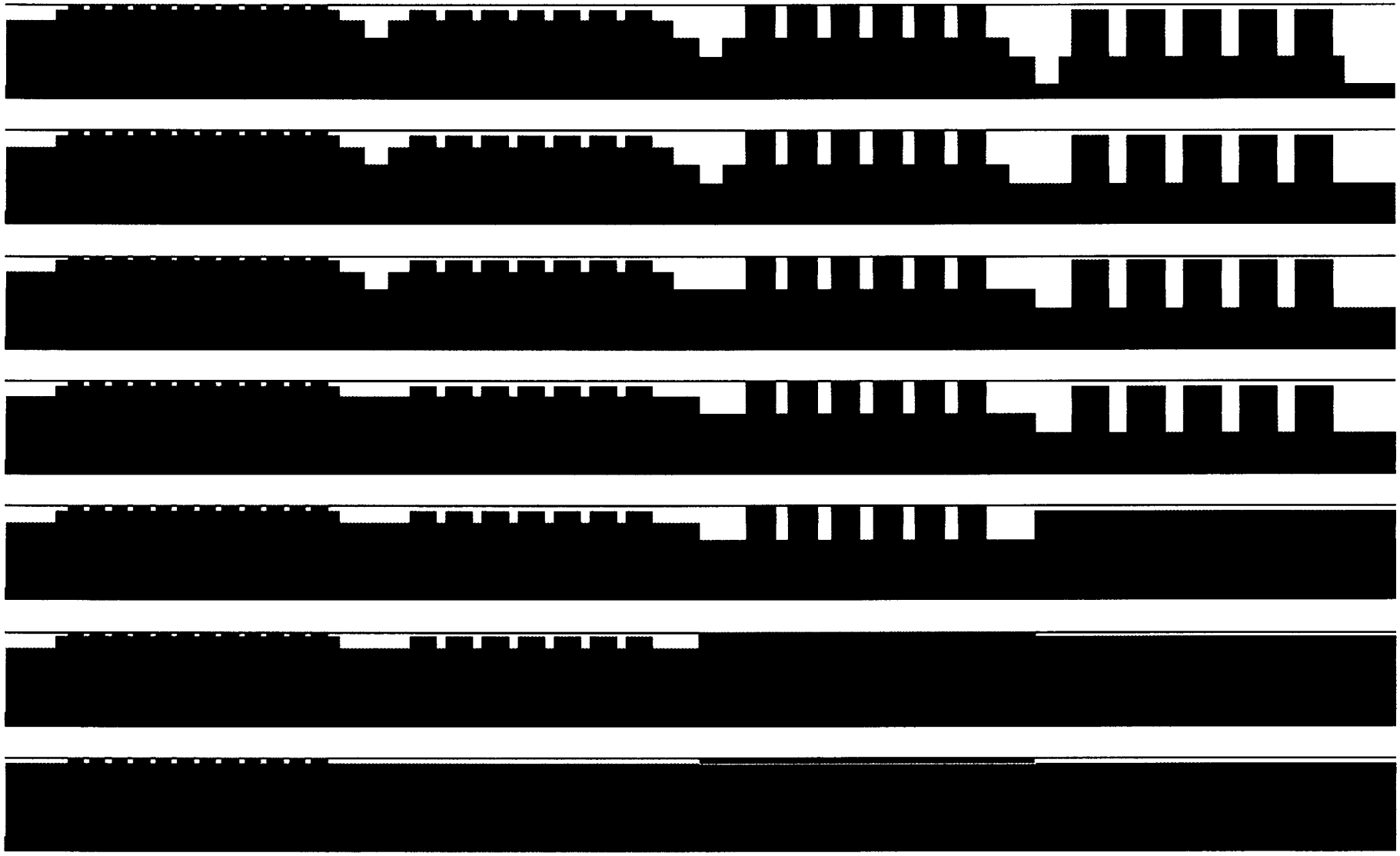


8-9 μm AND 14-15 μm TWO COLOR QWIP FOCAL PLANE ARRAY

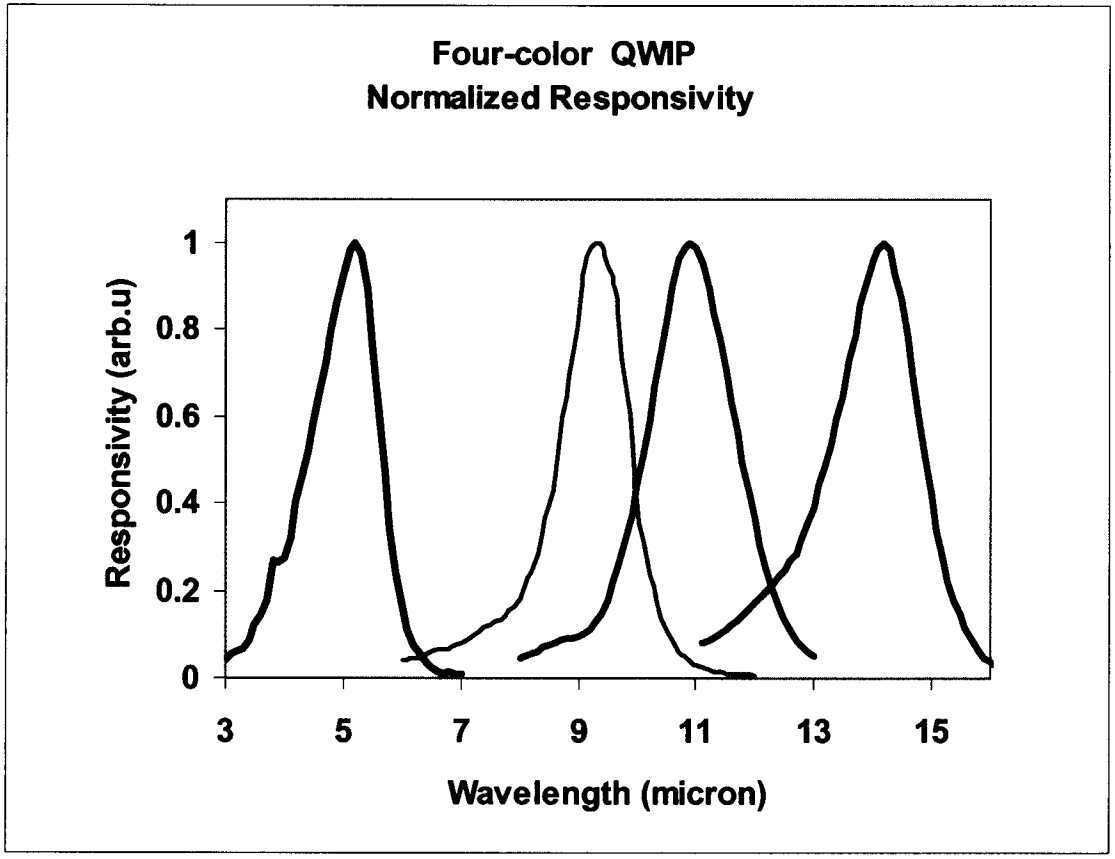




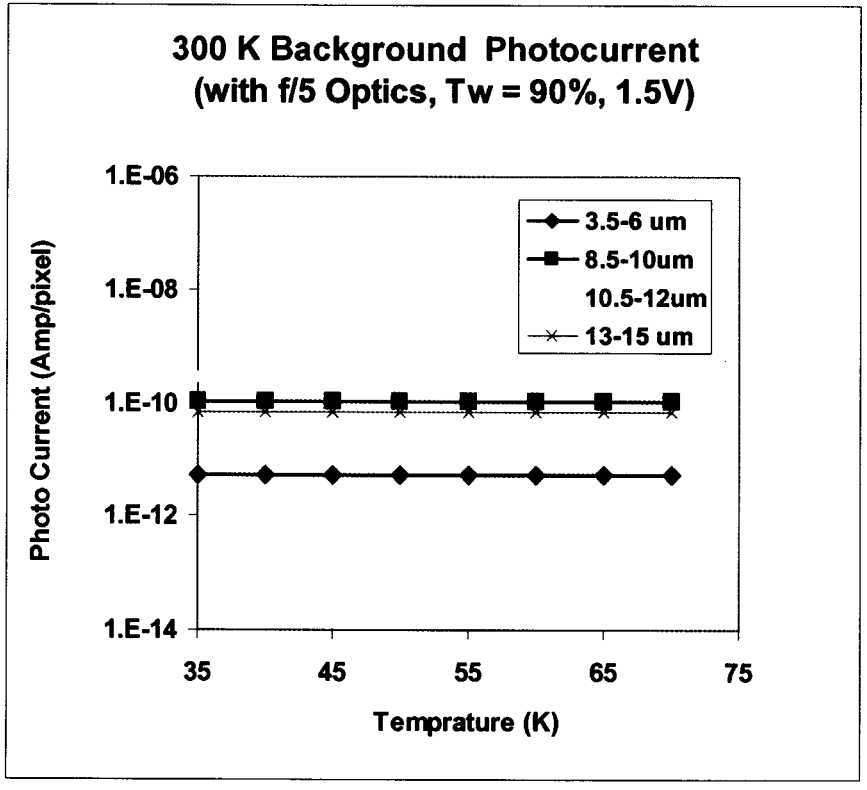
7- Step Etch for Four Color FPA

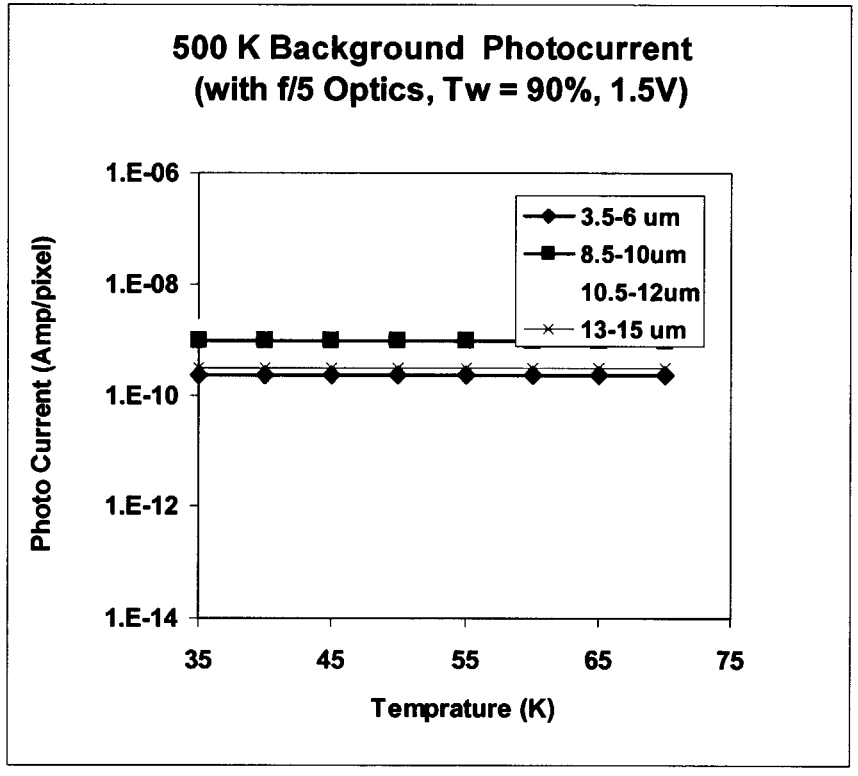
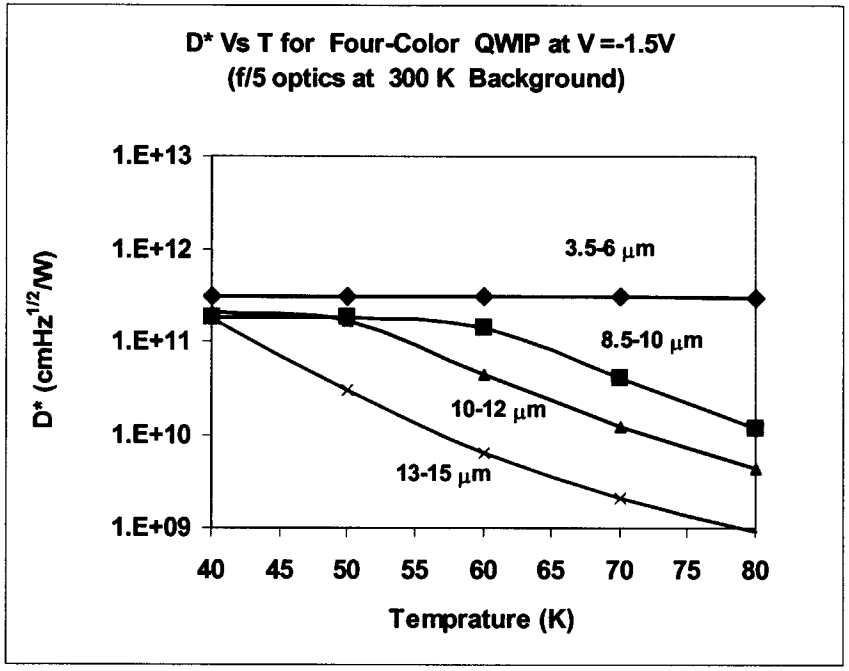
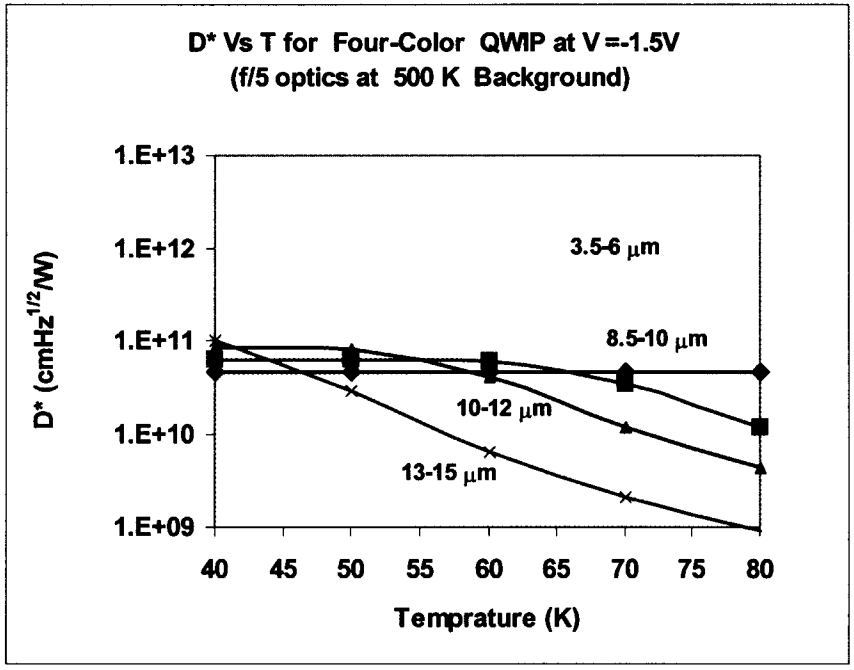


Four Color QWIP Responsivity



Four Color QWIP Photocurrent





Four Color QWIP Detectivity