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6. AUTHORS
David J. Smith

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES
Arizona State University
PO Box 876011

Tempe, AZ 85287 -6011

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14. ABSTRACT
The prime objective of this research is to contribute towards the development of improved HgCdTe (MCT) detectors and devices. Advanced electron microscopy methods, including high-resolution imaging, nanoprobe spectroscopy, and nanoscale elemental mapping, were used to address key issues relating to MCT material growth and processing. These collaborative studies have included: a) Si-based substrates for defect reduction in HgCdTe; b) GaAs-based substrates for growth of HgCdTe; c) Investigation of HgCdSe grown by molecular beam epitaxy; and d) Critical thickness for ZnTe on GaSb(100) and GaSb(211) substrates. These investigations involved leading

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Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received		Paper
09/08/2011	1.00	W. F. ZHAO, R. N. JACOBS, M. JAIME-VASQUEZ, L. O. BUBULAC, DAVID J. SMITH. Microstructural Characterization of CdTe(211)B/ZnTe/Si(211) Heterostructures Grown by Molecular Beam Epitaxy, Journal of Electronic Materials, (6 2011): 0. doi: 10.1007/s11664-011-1673-2
09/24/2012	3.00	C. Nozaki, L.A. Almeida, M. Jaime-Vasquez, C. Lennon, J.K. Markunas, D. Benson, P. Smith, W.F. Zhao, D.J. Smith, C. Billman, R.N. Jacobs, J. Arias, J. Pellegrino. Development of MBE II–VI Epilayers on GaAs (211)B, Journal of Electronic Materials, (10 2012): 2707. doi: 10.1007/s11664-012-2218-z
09/24/2012	6.00	G. Brill, Y. Chen, David J. Smith, W. F. Zhao. Microstructural Characterization of HgCdSe Grown by Molecular Beam Epitaxy on ZnTe/Si(112) and GaSb(112) Substrates, Journal of Electronic Materials, (10 2012): 2852. doi: 10.1007/s11664-012-2069-7
11/02/2013	7.00	Yuanping Chen, Sina Simingalam, Gregory Brill, Priyalal Wijewarnasuriya, Nibir Dhar, Jae Jin Kim, David J. Smith. MBE-Grown ZnTe/Si, a Low-Cost Composite Substrate, Journal of Electronic Materials, (3 2012): 0. doi: 10.1007/s11664-012-2032-7
11/02/2013	8.00	Jae Jin Kim, R. N. Jacobs, L. A. Almeida, M. Jaime-Vasquez, C. Nozaki, David J. Smith. TEM Characterization of HgCdTe/CdTe Grown on GaAs(211)B Substrates, Journal of Electronic Materials, (08 2013): 0. doi: 10.1007/s11664-013-2688-7
11/02/2013	10.00	David J. Smith. Atomic-Scale Characterization of II–VI Compound Semiconductors, Journal of Electronic Materials, (08 2013): 0. doi: 10.1007/s11664-013-2701-1
11/02/2013	11.00	J. Chai, O. C. Noriega, A. Dedigama, J. J. Kim, A. A. Savage, K. Doyle, C. Smith, N. Chau, J. Pena, J. H. Dinan, D. J. Smith, T. H. Myers. Determination of Critical Thickness for Epitaxial ZnTe Layers Grown by Molecular Beam Epitaxy on (211)B and (100) GaSb Substrates, Journal of Electronic Materials, (6 2013): 0. doi: 10.1007/s11664-013-2650-8

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Number of Papers published in peer-reviewed journals: 3

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

1) "TEM characterization of CdTe/HgCdTe surface passivation layers", by W.F. Zhao, et al., at 2009 II-VI Workshop, Chicago, 6-8 October, 2009.

2) 2) "TEM characterization of CdTe(211)B/ZnTe/Si(211) grown by MBE, by W.,F. Zhao, R.N. Jacobs, M. jaime-Vasquez, L.O. Bubulac, and D.J. Smith, presented at 2010 U.S. Workshop on Physics and Chemistry of II-VI Materials, New Orleans, October 26-28, 2010.

3) "TEM Investigation of HgCdSe Grown by Molecular Beam Epitaxy", by W.,F. Zhao, D.J. Smith, G. Brill, and Y. Chen, presented at 2011 U.S. Workshop on Physics and Chemistry of II-VI Materials, Chicago, Oct. 4-6, 2011.

4) "MBE-Grown ZnTe/Si: A New Low-Cost Composite Substrate for 6.1A? III-V and II-VI Compound Semiconductors", by Y.Chen, G. Brill, P. Wijewarnasuriya, N. Dhar, X. Liu, J. Furdyna, J. Fan, Y.-H. Zhang, and D.J. Smith, presented at 2011 U.S. Workshop on Physics and Chemistry of II-VI Materials, Chicago, Oct. 4-6, 2011.

5) "Characterization of Zinc Telluride Grown on Silicon by MBE", by J.J. Kim, Y. Chen, G. Brill, and D.J. Smith, presented at Microscopy and Microanalysis 2012, Phoenix, July 29-August 2, 2012.

6) "Critical thickness for ZnTe on GaSb(211)B and GaSb(100) substrates for MBE", by J. Chai, O.C. Noriega, J.H. Dinan, J.J. Kim, D.J. Smith, and T.H. Myers, presented at 2012 U.S. Workshop on Physics and Chemistry of II-VI Materials, Seattle, Nov. 27-29, 2012.

7) (invited paper) "Atomic-Scale characterization of II-VI compound semiconductors", by D.J. Smith, J.J. Kim, M.R. McCartney and T. Aoki, presented at 2012 U.S. Workshop on Physics and Chemistry of II-VI Materials, Seattle, Nov. 27-29, 2012.

8) "TEM characterization of HgCdTe/CdTe grown on GaAs(211)B substrates", by J.J. Kim, R.N. Jacobs, L.A. Almeida, M. Jaime-Vasquez, C. Nozaki, J.K. Markunas, J.D. Benson, and D.J. Smith, presented at 2012 U.S. Workshop on Physics and Chemistry of II-VI Materials, Seattle, Nov. 27-29, 2012.

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Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

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(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received	Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

2010 - D.J. Smith elected Fellow, Materials Research Society

2013 - D.J. Smith elected Fellow, Microscopy Society of America

Graduate Students

NAME	PERCENT_SUPPORTED	Discipline
Wenfeng Zhao	0.33	
Jae Jin Kim	0.67	
FTE Equivalent:	**1.00**	
Total Number:	**2**	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
David J. Smith	0.00	
FTE Equivalent:	**0.00**	
Total Number:	**1**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:...... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):...... 0.00

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The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:...... 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME
Wenfeng Zhao
Jae Jin Kim

Total Number: **2**

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

Inventions (DD882)

The prime objective of this research program was to contribute towards the development of improved HgCdTe (MCT) detectors and devices. Advanced electron microscopy methods, including high-resolution imaging, nanoprobe spectroscopy, and nanoscale elemental mapping, were used to address key issues relating to MCT material growth and processing. These collaborative studies involved leading scientists and engineers from government and industrial laboratories, who prepared samples suitable for systematic microscopy studies. The major results from these investigations are summarized in the following paragraphs.

a) Surface passivation layers for HgCdTe infrared detectors 1
(work in collaboration with S. Tobin and P. Lamarre, BAE Systems)

The use of CdTe passivation layers for HgCdTe (MCT) infrared detectors has become standard practice during device processing but much remains unknown about the defects and lattice strain that is induced by chemical and/or annealing treatments. Thus, it is critical to characterize the structural and chemical nature of the CdTe/MCT interface for different CdTe deposition methods, and following different annealing conditions. Initial studies showed that thermal annealing changed the morphology of the CdTe epilayers and also greatly affected the nature of the interface, i.e. the crystallinity of the CdTe grains was found to be substantially improved, and the CdTe/MCT interface became more abrupt chemically after annealing. Recent studies focused on the effects of annealing the passivation layer on threading defects from the underlying MCT epilayer.

1 W.F. Zhao, J. Cook, T. Parodos, S. Tobin, and D.J. Smith, “Microstructural characterization of CdTe surface passivation layers”, J. Electronic Maters. 39, 924-929 (2010).

b) Characterization of CdTe(211)B/ ZnTe/ Si(211) heterostructures 2
(work in collaboration with R.N.Jacobs, M. Jaime-Vasquez, & L.O. Bubulac, NVESD)

The CdTe(211)B/ ZnTe/ Si(211) composite substrate is attractive for MCT growth using molecular beam epitaxy (MBE) because Si-based substrates offer several strategic advantages relative to the commonly-used, bulk CdZnTe substrates. Initiation of ZnTe growth on the Si(211) substrates, as well as the microstructure of the CdTe(211)B/ ZnTe/ Si(211) heterointerface, are important factors for determining the final materials quality. Thus, samples of CdTe(211)B/ ZnTe/ Si(211) grown by MBE at NVESD, have been characterized using a range of electron microscopy imaging and analytical techniques, including high-resolution electron microscopy, high-angle-annular dark-field (HAADF) imaging, and energy-dispersive X-ray spectroscopy (EDXS). Most growth defects consisted of {111}-type stacking faults that terminated close to the interface, typically within much less than about 50 nm. Higher magnification images revealed the stepped nature of the Si(211) surface and showed that the majority of the {111} lattice fringes were continuous across the interface. Measurements of (111) lattice-plane spacings as a function of distance from the substrate were used to determine the Zn concentration, based on Vegard’s Law; the results indicated a progressive change from ZnTe to CdTe upon moving further away from the substrate. Energy-dispersive X-ray spectroscopy (EDXS) was used to measure concentration profiles thereby establishing the extent of (Cd,Zn) intermixing, and it was also observed that most of the stacking faults terminated near the onset of CdTe growth, in agreement with in situ RHEED observations made during MBE growth. Most recent studies of this system have included observations of the CdTe(211) upper surface before and after deposition of thick HgCdTe(211) epilayers.

2 W.F. Zhao, R.N. Jacobs, . Jaime-Vasquez, L.O. Bubulac, and D.J. Smith, “Microstructural characterization of CdTe(211) B/ZnTe/Si(211) heterostructures grown by molecular beam epitaxy”, J. Electronic Maters. 40 (2011) 1733-1737.

c) Si-based substrates for defect reduction in HgCdTe 3
(work in collaboration with Y.-P. Chen and G. Brill, ARL)

Substrates based on silicon are of much potential interest for advancing MCT technology, but high defect densities have historically represented a major limitation on device performance. Thus, much effort has been directed towards composite substrates that serve to relieve the inevitable strain caused by large lattice mismatch. Representative samples of annealed CdTe(211)B /ZnTe / Si materials were initially examined, before and after annealing treatments, revealing high densities of short {111}-type stacking faults close to the As-passivated Si surfaces. Chemical line profiles showed considerable (Cd, Zn) interdiffusion in the vicinity of the heterointerface. Attention has since also been directed towards the growth of very thick (~5-9 μm) ZnTe epilayers, with a view towards minimizing the defect concentration in the uppermost parts of the ZnTe epilayers before initializing HgCdTe/CdTe growth. Experiments with different Zn/Te flux ratios for growth on both Si(100) and Si(211) substrates revealed that those heterostructures grown under Te-rich or equal Zn and Te fluxes had much better crystal quality than those grown under Zn-rich conditions.

3 Y. Chen, S. Simingalam, G. Brill, P. Wijewarnaruriya, N. Dhar, J.J. Kim, and D.J. Smith, “MBE-grown ZnTe/Si, a low-cost composite substrate”, J. Electronic Maters. 41 (2012) 2917-2924

d) GaAs-based substrates for growth of HgCdTe 4
(work in collaboration with R.N. Jacobs and colleagues, NVESD)

The continuing search for alternative materials for MCT growth includes large-area, low-cost GaAs(211) substrates, which are readily available and of high quality. Thus, samples of HgCdTe(211)/ CdTe(211)/ GaAs(211)B grown by MBE at NVESD, have been characterized using a range of electron microscopy imaging and analytical techniques, including high-resolution electron microscopy, high-angle annular-dark-field (HAADF) imaging, and energy-dispersive X-ray spectroscopy (EDXS). Observations of the CdTe/ GaAs interface revealed the atomic-scale structure of the stepped GaAs surface, as well as showing larger defective regions, most likely pits, that were attributed to polishing damage of the as-received GaAs(211) wafers. Most recent studies of this system included observations of the CdTe(211) upper surface before and after deposition of thick HgCdTe(211) epilayers.

2 R.N. Jacobs, C. Nozaki, L.A. Almeida, M. Jaime-Vasquez, C. Lennon, J.K. Markunas, D. Benson, P. Smith, W.F. Zhao, D.J. Smith, C. Billman, J. Arias, and J. Pellegrino, “Development of MBE II-VI epilayers on GaAs(211)B”, J. Electronic Maters. 41 (2012) 2707-2713.

e) Investigation of HgCdSe Grown by Molecular Beam Epitaxy 5
(work in collaboration with G. Brill and Y. Chen, ARL)

The development of third-generation infra-red focal-plane-arrays using HgCdTe grown on scalable substrates, such as Si, is hindered by the approximately 100 times higher dislocation density relative to material grown on CdZnTe substrates. It has been proposed that HgCdSe could provide performance similar to HgCdTe in terms of its IR material properties, with the added advantage that large-area substrates suitable for HgCdSe growth are readily available commercially. Thus, samples of HgCdSe have been grown by MBE on ZnTe/Si(112) and GaSb(112) substrates at different temperatures and flux ratios, and the microstructure of the HgCdSe/ZnTe/Si(112) and HgCdSe/GaSb(112) heterostructures has been characterized by TEM. The thick (4-10µm) HgCdSe films were generally of high quality and most observed growth defects terminated close to the interface. High-resolution TEM images also indicated that the HgCdSe/ZnTe interface was considerably flatter than the HgCdSe/GaSb interface. HgCdSe films grown under different growth conditions on ZnTe/Si substrates had varying microstructure, with samples grown at the higher temperature of 140°C tending to have increased dislocation densities as well as more uneven top surfaces relative to films grown at 100°C. Strain fields originating from the presence of small plate-like defects were also observed, although it was not clarified whether these features were dislocation loops or precipitates.

5 W.F. Zhao, G. Brill, Y. Chen, and D.J. Smith, “Microstructural characterization of HgCdSe grown by molecular beam epitaxy on ZnTe/Si(112) and GaSb(112) substrates”, J. Electronic Maters. 41 (2012) 2852-2856.

f) Critical thickness for ZnTe on GaSb(100) and GaSb(211) substrates 6
(work in collaboration with J. Chai and T.H. Myers, Texas State-San Marcos)

Because of the ongoing interest in ZnTe as a possible buffer layer for subsequent growth of HgCdTe or HgCdSe, the critical thickness for generating misfit dislocations at the ZnTe/GaSb interface becomes an important issue for consideration. Thus, detailed microstructural observations of ZnTe/GaSb)(211)B samples with a range of ZnTe thicknesses have been made using cross-sectional electron microscopy. The ZnTe layers with thicknesses of 350 nm or less were found to have highly coherent interfaces and very low densities of dislocations, unlike the samples with thicker ZnTe layers. Additional ZnTe samples grown on GaSb(100) substrates were also examined for comparison purposes.

6 J. Chai, O.C. Noriega, A. Dedigama, J.J. Kim, A.A. Savage, K. Doyle, C. Smith, N. Chau, J.H. Dinan, D.J. Smith, and T.H. Myers, “Determination of critical thickness for epitaxial ZnTe layers grown by molecular beam epitaxy on (211)B and (100) GaSb substrates”. J. Electronic Maters. 42 (2013) 3090-3096.

g) Characterization of HgCdTe/ CdTe/ GaAs(211)B heterostructures 7
(work in collaboration with R.N.Jacobs, L.A. Almeida, and M. Jaime-Vasquez, NVESD)

The CdTe(211)B/ GaAs(211) composite substrate is also an attractive option for MCT growth using molecular beam epitaxy (MBE). Thus, samples of HgCdTe/CdTe /GaAs(211)B and CdTe / GaAs(211)B grown at NVESD were characterized using a range of electron microscopy imaging and analytical techniques, including high-resolution electron microscopy, high-angle-annular dark-field (HAADF) imaging, and energy-dispersive X-ray spectroscopy (EDXS). Detailed analysis of interfacial misfit dislocations and residual strain showed that the CdTe/GaAs interface was fully relaxed. In the case of HgCdTe/CdTe/GaAs (211)B, the use of thin HgTe buffer layers between HgCdTe and CdTe for improving the HgCdTe crystal quality were also investigated.

7 J.J. Kim, R.N. Jacobs, L.A. Almeida, M. Jaime-Vasquez, C. Nozaki, and D.J. Smith, “TEM characterization of HgCdTe/CdTe grown on GaAs(211)B substrates”, J. Electronic Maters. 42 (2013) 3142-3147.

h) Examination of defect propagation in thick HgCdTe epilayers
(work in collaboration with R.N.Jacobs, M. Jaime-Vasquez, and L.O. Bubulac, NVESD)

The possible role of contaminants at the Si(211) substrate surface in causing defect propagation through thick HgCdTe (MCT) epilayers continues to be an active area of investigation. However, the preparation of electron-transparent samples to confirm this possibility by direct microscope observation proved to be challenging. Since conventional ion-beam milling is inherently unsuitable for such a task, close attention was instead directed towards focused-ion-beam (FIB) milling, which is well known for its ability to provide site-specific samples for observation. Several different FIB-milling geometries were tried but without achieving success in thinning entire MCT layers simultaneously. Samples with thinner MCT layers (5 microns instead of 20 microns) also underwent evaluation, and wedge-polishing without ion-milling was also investigated as an alternative approach but without so far showing any marked success.

Technology Transfer

Scientific Progress and Achievements

The prime objective of this research program was to contribute towards the development of improved HgCdTe (MCT) detectors and devices. Advanced electron microscopy methods, including high-resolution imaging, nanoprobe spectroscopy, and nanoscale elemental mapping, were used to address key issues relating to MCT material growth and processing. These collaborative studies involved leading scientists and engineers from government and industrial laboratories, who prepared samples suitable for systematic microscopy studies. The major results from these investigations are summarized in the following paragraphs.

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[2] W.F. Zhao, R.N. Jacobs, . Jaime-Vasquez, L.O. Bubulac, and D.J. Smith, "Microstructural characterization of CdTe(211)B/ZnTe/Si(211) heterostructures grown by molecular beam epitaxy", *J. Electronic Maters.* **40** (2011) 1733-1737.

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[3] Y. Chen, S. Simingalam, G. Brill, P. Wijewarnaruriya, N. Dhar, J.J. Kim, and D.J. Smith, "MBE-grown ZnTe/Si, a low-cost composite substrate", *J. Electronic Maters.* **41** (2012) 2917-2924

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e) Investigation of HgCdSe Grown by Molecular Beam Epitaxy [5]
(work in collaboration with G. Brill and Y. Chen, ARL)

The development of third-generation infra-red focal-plane-arrays using HgCdTe grown on scalable substrates, such as Si, is hindered by the approximately 100 times higher dislocation density relative to material grown on CdZnTe substrates. It has been proposed that HgCdSe could provide performance similar to HgCdTe in terms of its IR material properties, with the added advantage that large-area substrates suitable for HgCdSe growth are readily available commercially. Thus, samples of HgCdSe have been grown by MBE on ZnTe/Si(112) and GaSb(112) substrates at different temperatures and flux ratios, and the microstructure of the HgCdSe/ZnTe/Si(112) and HgCdSe/GaSb(112) heterostructures has been characterized by TEM. The thick (4-10μm) HgCdSe films were generally of high quality and most observed growth defects terminated close to the interface. High-resolution TEM images also indicated that the HgCdSe/ZnTe interface was considerably flatter than the HgCdSe/GaSb interface. HgCdSe films grown under different growth conditions on ZnTe/Si substrates had varying microstructure, with samples grown at the higher temperature of 140°C tending to have increased dislocation densities as well as more uneven top surfaces relative to films grown at 100°C. Strain fields originating from the presence of small plate-like defects were also observed, although it was not clarified whether these features were dislocation loops or precipitates.

[5] W.F. Zhao, G. Brill, Y. Chen, and D.J. Smith, "Microstructural characterization of HgCdSe grown by molecular beam epitaxy on ZnTe/Si(112) and GaSb(112) substrates", *J. Electronic Maters.* **41** (2012) 2852-2856.

f) Critical thickness for ZnTe on GaSb(100) and GaSb(211) substrates [6]
(work in collaboration with J. Chai and T.H. Myers, Texas State-San Marcos)

Because of the ongoing interest in ZnTe as a possible buffer layer for subsequent growth of HgCdTe or HgCdSe, the critical thickness for generating misfit dislocations at the ZnTe/GaSb interface becomes an important issue for consideration. Thus, detailed microstructural observations of ZnTe/GaSb)(211)B samples with a range of ZnTe thicknesses have been made using cross-sectional electron microscopy. The ZnTe layers with thicknesses of 350 nm or less were found to have highly coherent interfaces and very low densities of dislocations, unlike the samples with thicker ZnTe layers. Additional ZnTe samples grown on GaSb(100) substrates were also examined for comparison purposes.

[6] J. Chai, O.C. Noriega, A. Dedigama, J.J. Kim, A.A. Savage, K. Doyle, C. Smith, N. Chau, J.H. Dinan, D.J. Smith, and T.H. Myers, "Determination of critical thickness for epitaxial ZnTe layers grown by molecular beam epitaxy on (211)B and (100) GaSb substrates". *J. Electronic Maters.* **42 (2013)** 3090-3096.

g) Characterization of HgCdTe/ CdTe/ GaAs(211)B heterostructures [7]
(work in collaboration with R.N.Jacobs, L.A. Almeida, and M. Jaime-Vasquez, NVESD)

The CdTe(211)B/ GaAs(211) composite substrate is also an attractive option for MCT growth using molecular beam epitaxy (MBE). Thus, samples of HgCdTe/CdTe /GaAs(211)B and CdTe / GaAs(211)B grown at NVESD were characterized using a range of electron microscopy imaging and analytical techniques, including high-resolution electron microscopy, high-angle-annular dark-field (HAADF) imaging, and energy-dispersive X-ray spectroscopy (EDXS). Detailed analysis of interfacial misfit dislocations and residual strain showed that the CdTe/GaAs interface was fully relaxed. In the case of HgCdTe/CdTe/GaAs(211)B, the use of thin HgTe buffer layers between HgCdTe and CdTe for improving the HgCdTe crystal quality were also investigated.

[7] J.J. Kim, R.N. Jacobs, L.A. Almeida, M. Jaime-Vasquez, C. Nozaki, and D.J. Smith, "TEM characterization of HgCdTe/CdTe grown on GaAs(211)B substrates", *J. Electronic Maters.* **42** (2013) 3142-3147.

h) Examination of defect propagation in thick HgCdTe epilayers
(work in collaboration with R.N.Jacobs, M. Jaime-Vasquez, and L.O. Bubulac, NVESD)

The possible role of contaminants at the Si(211) substrate surface in causing defect propagation through thick HgCdTe (MCT) epilayers continues to be an active area of investigation. However, the preparation of electron-transparent samples to confirm this possibility by direct microscope observation proved to be challenging. Since conventional ion-beam milling is inherently unsuitable for such a task, close attention was instead directed towards focused-ion-beam (FIB) milling, which is well known for its ability to provide site-specific samples for observation. Several different FIB-milling geometries were tried but without achieving success in thinning entire MCT layers simultaneously. Samples with thinner MCT layers (5 microns instead of 20 microns) also underwent evaluation, and wedge-polishing without ion-milling was also investigated as an alternative approach but without so far showing any marked success.