

## Invention Disclosures / Patents

<b>Patents- Summary</b>	<ul style="list-style-type: none"> <li>• <b>Over 150 patent applications and/or invention disclosures filed.</b></li> <li>• <b>87 issued patents</b> (70 US and 17 International patents).</li> <li>• <b>70 US patents issued to date:</b> US Patent Nos. 5, 739, 086; 5, 741, 377; 5, 846, 912; 5, 898, 020; 5, 964, 966; 5, 958, 599; 5, 968, 877; 6, 077, 344; 6, 106, 615; 6, 114, 287; 6, 150, 034; 6, 156, 376; 6, 151, 610; 6, 159, 610; 6, 180, 570; 6, 235, 402; 6, 261, 704; 6, 270, 908; 6, 331. 199; 6,375,768; 6, 399, 154; 6, 451, 450; 6, 447, 714; 6, 440, 211; 6, 468, 591, 6, 486, 100; 6, 599, 346; 6, 602, 313, 6, 607, 313; 6, 607, 838; 6, 607, 839; 6, 610, 413; 6, 610, 414; 6, 635, 097; 6, 645, 313; 6, 663, 976; 6, 670, 308; 6, 675, 229; 6, 716, 795; 6, 740, 421; 6, 764, 770; 6, 784, 139; 6, 790, 253; 6, 797, 030; 6, 846, 344; 6, 782, 988; 6, 890, 369; 6, 902, 600; 7, 087, 113; 7, 258, 928; 7, 510 997; 7, 683, 010; 7, 879 161; 7, 906, 229; 7, 919, 435; 8, 034, 745; 8, 119, 571; 8, 178, 221; 8, 210, 420; 8, 227, 082; 8,424,745; 8,481,460; 8, 518, 526; 8, 536, 098; 8, 685, 549; 8, 748, 349; 8, 748, 350; 8, 795, 854; 8, 987, 736, 8, 993, 092.</li> <li>• <b>17 international patents issued to date:</b> Australian Patent No. 8349510, Australian Patent No. 713982, Canadian Patent No. 2,217,822, Japanese Patent No. 03601830, European Region Patent No. EP 0830218, South Korea Patent No. 418279, Switzerland Patent No. 0830218, Germany Patent No. 0830218, Spain Patent No. 0830218, France Patent No. 0830218, Great Britain Patent No. 0830218, Italy Patent No. 0830218, Sweden Patent No. 0830218, Hong Kong Patent HK 1150093, Chinese Patent CN101981699 and Chinese Patent CN1132585.</li> <li>• <i>A majority of these issued patents have been licensed during the course of the last decade and a half!</i></li> <li>• <b>Over 15 US patents presently pending.</b></li> <li>• <b>Over 20 International patents pending.</b></li> </ul> <p>This is the <u>highest</u> number of issued US patents for any employee in the Battelle system (<a href="http://www.battelle.org/careers/battelle/about.stm">http://www.battelle.org/careers/battelle/about.stm</a>). Battelle serves the U.S. Department of Energy in the management of four leading-edge national laboratories – Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory (PNNL), Brookhaven National Laboratory (BNL) and National Renewable Energy Laboratory (NREL).</p>
<b>Patents / Invention disclosures</b>	<ol style="list-style-type: none"> <li>1. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, “Structures Having Enhanced Biaxial Texture and Method to Fabricating Same - I”. <u>US Patent No. 5, 739, 086</u>, April 14, 1998.</li> <li>2. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, “Structures Having Enhanced Biaxial Texture and Method to Fabricating Same - II”. <u>US Patent No. 5, 741, 377</u>, April 21, 1998.</li> <li>3. V. Selvamanikam, A. Goyal and D. M. Kroeger, “Method of Preparing Y-123 by Melt Processing”, <u>US Patent No. 5, 846, 912</u>, December 8, 1998.</li> <li>4. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, “Structures Having Enhanced Biaxial Texture and Method to Fabricating Same - III”. <u>US Patent No. 5, 898, 020</u>, April 27, 1999.</li> <li>5. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, “Structures Having Enhanced Biaxial Texture and Method to Fabricating Same - IV”. <u>US Patent No. 5, 958, 599</u>, September 28, 1999.</li> <li>6. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, “Structures Having Enhanced Biaxial Texture and Method to Fabricating Same”. <u>Australian Patent No. 713892</u>.</li> <li>7. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, “Structures Having Enhanced Biaxial Texture and Method to Fabricating Same”. <u>European Umbrella Patent No. EP 0830218</u>.</li> <li>8. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, “Structures Having Enhanced Biaxial Texture and Method to Fabricating Same”.</li> </ol>

- Korean Patent No. 418279.
9. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, "Structures Having Enhanced Biaxial Texture and Method to Fabricating Same". Japanese Patent No. 03601830.
  10. A. Goyal, J. D. Budai, D. M. Kroeger, D. P. Norton, E. D. Specht and D. K. Christen, "Structures Having Enhanced Biaxial Texture and Method to Fabricating Same". Canadian Patent No. 2,217,822.
  11. A. Goyal, E. Specht, D. Kroeger and M. Paranthaman, "Method of Forming Biaxially Textured Alloy Substrates and Devices Thereon - I," US Patent 5, 964, 966., October 12, 1999.
  12. J. D. Budai, D. K. Christen, A. Goyal, Q. He, D. M. Kroeger, D. F., Lee, D. P. Norton, B. C. Sales and E. D. Specht, "High-T<sub>c</sub> YBCO Superconductor Deposited on Biaxially Textured Ni Substrate," US Patent 5, 968, 877, October 19, 1999.
  13. S.S. Shoup, M. Paranthaman, D.B. Beach, D.M. Kroeger, and A. Goyal, "Methods of Sol-gel Deposition of Buffer Layers on Biaxially Textured Ni Substrates," US Patent 6, 077, 344, June 20, 2000.
  14. A. Goyal, E. Specht, D. Kroeger and M. Paranthaman, "Method of Forming Biaxially Textured Alloy Substrates and Devices Thereon - II," US Patent 6, 106, 615, August 22, 2000.
  15. D. F. Lee, D. M. Kroeger and A. Goyal, "Method of Deforming a Biaxially Textured Buffer Layer on a Textured Metallic Substrate and Articles Thereform," US Patent 6, 114, 287, September 5, 2000.
  16. A. Goyal, "Method for Making Biaxially Textured Articles by Plastic Deformation," US Patent No. 6,180, 570.
  17. M. Paranthaman, D.F. Lee, D.M. Kroeger, and A. Goyal, "Buffer Layers on Rolled Nickel or Copper as Superconductor Substrates," U.S. Patent No. 6,150,034, November 21, 2000.
  18. M. Paranthaman, D.F. Lee, D.M. Kroeger, and A. Goyal, "Buffer Layers on Metal Surfaces Having Biaxial Texture as Superconductor Substrates," U.S. Patent No. 6,156,376, December 5, 2000.
  19. M. Paranthaman, D.F. Lee, D.M. Kroeger, and A. Goyal, "Buffer Layers on Metal Surfaces Having Biaxial Texture as Superconductor Substrates," U.S. Patent No. 6,159,610, December 12, 2000.
  20. A. Goyal, "Biaxially Textured Articles formed by Plastic Deformation," US Patent No. 6,180,570, January 30, 2001.
  21. S.S. Shoup, M. Paranthaman, D.B. Beach, D.M. Kroeger, and A. Goyal, "Buffer Layers on Biaxially Textured Metal Substrates," US Patent 6, 235,402, May 22, 2001.
  22. A. Goyal, "Biaxially Textured Articles formed by Plastic Deformation," US Patent No. 6,375,768.
  23. D. F. Lee, D. M. Kroeger and A. Goyal, "Preferentially oriented, High temperature superconductors by seeding and a method for their preparation," US Patent 6, 256.521, July 3, 2001.
  24. M. Paranthaman, A. Goyal, D. M. Kroeger and F. A. List, "MgO buffer layers on rolled nickel or copper as superconductor substrates," US Patent 6,261,704, July 17, 2001.
  25. R.K. Williams, M. Paranthaman, T.G. Chirayil, D.F. Lee, A. Goyal, and R. Feenstra, "Rare Earth Zirconium Oxide Buffer Layers on Metal Substrate," U.S. Patent No. 6,270,908, August 7, 2001.
  26. A. Goyal, R. Williams and D. M. Kroeger, "Methods of Forming Biaxially Textured Articles by Powder Metallurgy," US Patent No. 6,331,199, December 18, 2001.
  27. A. Goyal, "Method for making biaxially textured articles by plastic deformation," US Patent 6,375,768, April 23, 2002.
  28. R.K. Williams, M. Paranthaman, T.G. Chirayil, D.F. Lee, A. Goyal, and R. Feenstra, "Laminate Article," U.S. Patent No. 6,399,154, June 4, 2002.
  29. D. B. Beach, J. S. Morell, M. Paranthaman, T. Chirayil, E. D. Specht and A. Goyal,

“Method of Depositing Buffer Layers on RABiTS from Solution”, U.S. Patent No. 6,440,211, August 27, 2002.

30. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent No. 6,447,714, September 10, 2002.
31. A. Goyal, D. M. Kroeger, M. Paranthaman, D. F. Lee, R. Feenstra and D. P. Norton, “Method of Depositing a Protective Layer over a Biaxially Textured Alloy Substrate and Composition Therefrom”, U.S. Patent No. 6,451,450, September 17, 2002.
32. M. Paranthaman, A. Goyal, D. M. Kroeger and F. A. List, “Method for making MgO buffer layers on rolled nickel or copper as superconductor substrates,” ORNL/LMER Docket ERID No. 218. US Patent 6,468,591, October 22, 2002.
33. D. F. Lee, D. M. Kroeger and A. Goyal, “Method for Preparing Preferentially Oriented, High Temperature Superconductors using Solution Reagents,” ORNL/LMER Docket ERID No. 534. US Patent 6,486,100, November 26, 2002.
34. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,599,346, July 29, 2003.
35. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,602,313, August 5, 2003.
36. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,607,838, August 19, 2003.
37. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,607,839, August 19, 2003.
38. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,610,413, August 26, 2003.
39. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,610,614, August 26, 2003.
40. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,635,097, October 21, 2003.
41. A. Goyal and D. M. Kroeger, “Powder-in-tube and Thick Film Methods of Fabricating High Temperature Superconductors Having Enhanced Biaxial Texture,” US Patent 6,645,313, November 11, 2003.
42. D. B. Beach, J. S. Morell, M. Paranthaman, T. Chirayil, E. D. Specht and A. Goyal, “Laminate Articles on Biaxially Textured Metal Substrates”, US Patent 6,663,976, December 16, 2003.
43. A. Goyal, “Method of Depositing Epitaxial Layers on a Substrate,” US Patent 6,670,308, December 30, 2003.
44. D. P. Norton, A. Goyal and C. Park, “Buffer Architecture for Biaxially Textured Structures and Method of Fabricating Same,” US Patent 6,716,795, April 6, 2004.
45. M. Paranthaman, T. Aytug, D. K. Christen, R. Feenstra and A. Goyal, “Buffer Layers and Articles for Electronic Devices,” US Patent 6,764,770, July 20, 2004.
46. S. Sambasivan, A. Goyal, S. A. Barnett, I. Kim, D. M. Kroeger, “Conductive and Robust Nitride Buffer Layers on Biaxially Textured Substrates,” US Patent 6,784,139, August 31, 2004.
47. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,790,253, September 14, 2004.
48. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,797,030, September 28, 2004.
49. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,846,344, January 25, 2005.
50. A. Goyal, “Semiconductor Films on Iridium Substrates,” US Patent 6,872,988, March 29, 2005.
51. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,890,369, May 10, 2005.
52. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent 6,902,600, June 07, 2005.
53. A. Goyal, R. Williams and D. M. Kroeger, “Biaxially Textured Articles Formed by Powder Metallurgy,” US Patent Application Pending, Divisional XI.

54. A. Goyal, R. Williams and D. M. Kroeger, "Biaxially Textured Articles Formed by Powder Metallurgy," US Patent Application Pending, Divisional XII.
55. A. Goyal, R. Williams and D. M. Kroeger, "Biaxially Textured Articles Formed by Powder Metallurgy," US Patent Application Pending, Divisional XIII.
56. A. Goyal, "Textured Substrate and Devices Thereof," US Patent 7,087,113, Aug. 08, 2006.
57. A. Goyal, "Doped Y2O3 buffer layers for laminated conductors," US Patent 7,258,928, August 21, 2007.
58. A. Goyal, "Conductive and robust nitride buffer layers on biaxially textured substrates," US Patent 7,510,997, March 31, 2009.
59. S. Sambasivan, A. Goyal, S. A. Barnett, I. Kim, D. M. Kroeger, "Conductive and Robust Nitride Buffer Layers on Biaxially Textured Substrates," US Patent 7510997, issued 3/31/2009.
60. A. Goyal, "Doped LZO buffer layers for laminated conductors," US Patent 7,683,010, March 23, 2010.
61. A. Goyal, "Strong, non-magnetic, cube textured alloy substrates," US Patent 7,879,161, February 1, 2011.
62. A. Goyal, "Semiconductor-based, large-area, flexible, electronic devices," US Patent 7,906,229, March 15, 2011.
63. A. Goyal, "Superconductor films with improved flux pinning and reduced AC losses," US Patent 7,919,435, April 5, 2011.
64. A. Goyal, "High performance devices enabled by epitaxial, preferentially oriented, nanodots and/or nanorods," US Patent 8,034,745, October 11, 2011.
65. A. Goyal, "High performance electrical, magnetic, electromagnetic and electrooptical devices enabled by three dimensionally ordered nanodots and nanorods," US Patent 8,119,571, February 21, 2012.
66. A. Goyal, "{100}<100> or 45°-rotated {100}<100>, semiconductor-based, large-area, flexible, electronic devices," US Patent 8,178,221, May 15, 2012.
67. A. Goyal and C. Blue, "Composite biaxially textured substrates using ultrasonic consolidation," US Patent 8,210,420, July 3, 2012.
68. A. Goyal, "Faceted ceramic fibers, tapes or ribbons and epitaxial devices therefrom," US Patent 8,227,082, July 24, 2012.
69. A. Goyal and C. Blue, "Composite biaxially textured substrates using ultrasonic consolidation," US Patent 8,424,745, April 23, 2012.
70. A. Goyal, "Faceted ceramic fibers, tapes or ribbons and epitaxial devices therefrom," US Patent 8,481,460, July 9, 2013.
71. A. Goyal, "Structures with three dimensional nanofences comprising single crystal segments," US Patent 8,518,526, August 27, 2013.
72. A. Goyal, "High performance superconducting devices enabled by three dimensionally ordered nanodots and/or nanorods," US Patent 8,536,098, September 17, 2013.
73. A. Goyal, "High performance superconducting devices enabled by three dimensionally ordered nanodots and/or nanorods," US Patent 8,536,098, September 9, 2013.
74. A. Goyal and Jusnoo Shin, "Nanocomposites for ultra high density information storage, devices including the same, and methods of making the same," US Patent 8,685,549, April 01, 2014.
75. A. Goyal and S. H. Wee, "Buffer layers for REBCO films for use in superconducting devices," US Patent 8,748,350, June 10, 2014.
76. A. Goyal, M. Paranthaman and S. H. Wee, "Chemical solution seed layer for rabbits tapes," US Patent 8,748,349, June 10, 2014.
77. A. Goyal, "Semiconductor-based, large-area, flexible, electronic devices on {110}<100> oriented substrates," US Patent 8,795,854, August 5, 2014.
78. A. Goyal, US Patent Application - US20080265255, "Semiconductor-based, large-area, flexible, electronic devices on <100> oriented substrates".
79. A. Goyal, US Patent Application - US20080230779, "[100] Or [110] aligned,

- semiconductor-based, large-area, flexible, electronic devices”.
80. A. Goyal, US Patent Application - US20080176749, “High performance devices enabled by epitaxial, preferentially oriented, nanodots and/or nanorods”.
  81. A. Goyal, US Patent Application – 11/498,120, “High performance, electrical, magnetic, electromagnetic and electro-optical devices enabled by three dimensionally ordered nanodots and nanorods”.
  82. A. Goyal, US Patent Application - US20080217622, “Novel, semiconductor-based, large-area, flexible, electronic devices”.
  83. A. Goyal, US Patent Application - US20090038714, “Strong, Non-magnetic, cube textured alloy substrates”.
  84. A. Goyal, US Patent Application - US20080176749, “High performance devices enabled by epitaxial, preferentially oriented, nanodots and/or nanorods”.
  85. A. Goyal, US Patent Application – 11/498,120, “High performance, electrical, magnetic, electromagnetic and electro-optical devices enabled by three dimensionally ordered nanodots and nanorods”.
  86. “Superconductor Films with Improved Flux-pining and Reduced Ac Losses,” PCT application filed, WIPO Patent Application WO/2010/044928.
  87. “Faceted Ceramic Fibers, Tapes or Ribbons and Epitaxial Devices Thereform,” PCT application filed, WIPO Patent Application WO/2009/042363.
  88. A. Goyal, US Patent Application – 12/242,021, “Superconductor films with improved flux pinning and reduced AC losses”.
  89. A. Goyal and S.H. Wee, US Patent Application – 12/711309, “Structures with Three Dimensional Nanofences Comprising Single Crystal Segments”.
  90. A. Goyal, S.H. Wee, C. Cantoni and E. Specht, US Patent Application – 12/850,398, “Critical current density enhancement via incorporation of nanoscale Ba<sub>2</sub>(Y,RE)NbO<sub>6</sub> in REBCO films”.
  91. A. Goyal, S.H. Wee, C. Cantoni and E. Specht, US Patent Application – 12/850,521, “Critical current density enhancement via incorporation of nanoscale Ba<sub>2</sub>(Y,RE)TaO<sub>6</sub> in REBCO films”.
  92. A. Goyal, US Patent Application – 12/849,970, “Vertically-aligned nanopillar array on flexible, biaxially-textured substrates for nanoelectronics and energy conversion applications”.
  93. A. Goyal, US Patent Application – 12/011,450, “<100> or 45 degrees-rotated <100>, semiconductor-based, large-area, flexible, electronic devices”.
  94. A. Goyal, US Patent Application – 13/136,357, “High performance superconducting devices enabled by three dimensionally ordered nanodots and/or nanorods”.
  95. A. Goyal and Junsoo Shin, US Patent Application – 12/956598, “Nanocomposites for ultra high density information storage, devices including the same, and methods of making the same”.
  96. A. Goyal, US Patent Application – 13/030260, “Polycrystalline ferroelectric or multiferroic oxide articles on biaxially textured substrates and methods for making same”.
  97. A. Goyal, US Patent Application – 13/088,179, “Buffer layers for REBCO films for use in superconducting films”.
  98. A. Goyal, US Patent Application – 13/088,182, “Chemical solution seed layer for RABITS tapes”.
  99. A. Goyal, US Patent Application – 13/529,410, “Faceted Ceramic Fibers, Tapes or Ribbons and Epitaxial Devices Thereform”.
  100. A. Goyal and C. Blue, “Composite biaxially textured substrates using ultrasonic consolidation,” PCT application filed, WIPO Patent Application WO/2012/106196.
  101. A. Goyal and S. H. Wee, “Critical current density enhancement via incorporation of nanoscale Ba<sub>2</sub>(Y,RE)TaO<sub>6</sub> in REBCO films, WIPO Patent Application WO/2011/017454.
  102. A. Goyal and S. H. Wee, “Critical current density enhancement via incorporation of nanoscale Ba<sub>2</sub>(Y,RE)NbO<sub>6</sub> in REBCO films, WIPO Patent Application WO/2011/017439.

- 103.A. Goyal, "Vertically-aligned nanopillar array on flexible, biaxially-textured substrates for nanoelectronics and energy conversion applications," WIPO Patent Application WO/2011/017392.
- 104.A. Goyal, "Superconductor films with improved flux pinning and reduced AC losses," WIPO Patent Application WO/2010/044928.
- 105.A. Goyal, "Semiconductor-based, large-area, flexible, electronic devices on {110}<100> oriented substrates," WIPO Patent Application WO/2009/110872.
- 106.A. Goyal, "[100] OR [110] aligned, semiconductor-based, large-area, flexible, electronic devices," WIPO Patent Application WO/2009/096932.
- 107.A. Goyal, "Semiconductor-based, large-area, flexible, electronic devices," WIPO Patent Application WO/2009/096931.
- 108.A. Goyal, "Semiconductor-based, large-area, flexible, electronic devices," WIPO Patent Application WO/2009/096931.
- 109.A. Goyal, "Semiconductor-based, large-area, flexible, electronic devices on {110}<100> oriented substrates," European Patent Application EP2266135.
- 110.A. Goyal, "Semiconductor-based, large-area, flexible, electronic devices," European Patent Application EP2250674.
- 111.A. Goyal, "100 OR 110 aligned, Semiconductor-based, large-area, flexible, electronic devices," European Patent Application EP2250664.
- 112.A. Goyal, "Faceted Ceramic Fibers, Tapes or Ribbons and Epitaxial Devices Therefrom," European Patent Application EP2205434.
- 113.A. Goyal, "Scalable Fabrication of One-Dimensional and Three-Dimensional Conducting, Nanostructured Templates for Diverse Applications Such as Battery Electrodes for Next Generation Batteries," US Patent Application Filed, Oct. 2014.
- **Trademark: RABiTS™** (Rolling-Assisted-Biaxially-Textured-Substrates)
  - **Trademark: SSIFFS™** (Sapphire Single-crystal Faceted Fiber Substrates)