October 31, 2020

R&D Update Q3 2020

Dear Colleague:

An updated bibliography confirms why SINTX regards silicon nitride as the ideal biomaterial, particularly for bone fusion.

This volume of scientific discovery is the result of a sustained focus of SINTX's R&D team, and has positioned SINTX competitively for a range of commercial opportunities.

Silicon nitride is a bioactive, non-oxide ceramic. Our formulation is made by bonding silicon with nitrogen, with trace amounts of other elements.

Beyond the established safety and efficacy of our spinal implants, SINTX has pioneered the development of coatings, composites, and other formulations of silicon nitride. These have opened new and exciting opportunities well beyond our original focus on biomedical implants.

As one example, we discovered that silicon nitride quickly inactivates a number of bacterial and viral species, including SARS-2. SINTX is developing a "catch-and-kill" fabric for face masks and other applications that will contribute to global health and well-being.

With the science behind us, we are now focused on practical applications and commercial opportunities. All of us at SINTX truly appreciate your support.

Sincerely,

B. Sonny Bal, MD MBA JD PhD
President and CEO SINTX Technologies

SINTX Technologies

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34. B. Sonny Bal, "Investigation of the Osseointegration Characteristics of a Silicon Nitride Intervertebral Spinal Spacer: A Retrieval Study," 7th International Conference on Advances in Orthopaedic Osseointegration, Marriott Coronado Resort and Spa, San Diego, CA, (March 2017).

35. Tetsuya Adachi, Toshiro Yamamoto, Bryan J. McEntire, B. Sonny Bal, Osam Mazda, Narisato Kanamura, and Giuseppe Pezzotti, “Application of Silicon Nitride Ceramics Stimulate Bone Regeneration in Dental Implants,” Poster #3783, 95th General Session and Exhibition of the IADR, San Francisco, CA, USA, (March 2017).
36. Bryan J. McEntire, Ryan M. Bock, Erin N. Jones, Darin A. Ray, B. Sonny Bal, and Giuseppe Pezzotti, “A Comparative Study of Bacterial Biofilm Formation on Silicon Nitride, PEEK, and Titanium Biomaterials,” Proceedings of the Annual Meeting of the American Academy of Orthopaedic Surgeons, Poster #P402, San Diego, CA (March 2017).
37. B. Sonny Bal, MD, Wenliang Zhu, Bryan J. McEntire, and Giuseppe Pezzotti, “Metal Staining Leads to Instability of Zirconia Toughened Alumina Femoral Heads,” Proceedings of the Annual Meeting of the American Academy of Orthopaedic Surgeons, Poster #P077, San Diego, CA (March 2017).
38. B.S. Bal, R.M. Bock, A. Rondinella, E. Marin, W. Zhu, T. Adachi, B.J. McEntire, and G. Pezzotti, “Osteoinductive Properties of Silicon Nitride, Alumina, and Titanium;” Poster #0826 in *Proc. Annu. Meet. Orthop. Res. Soc.* Orthopaedic Research Society, San Diego, CA, USA, (March 2017).
39. B.J. McEntire, R. Lakshminarayanan, D. Ray, I.C. Clarke, and G. Pezzotti, “Comparative Wear Performance of Ceramic-on-Ceramic Bearings under Non-Standard Hip Simulation;” Poster #1314 in *Proc. Annu. Meet. Orthop. Res. Soc.* Orthopaedic Research Society, San Diego, CA, USA, (March 2017).
40. G. Pezzotti, B.J. McEntire, R.M. Bock, W. Zhu, E. Vitale, L. Puppulin, T. Adachi, T. Yamamoto, *et al.*, “Enhanced Osteoblast Proliferation and Hydroxyapatite Formation on Surface Modulated Silicon Nitride;” Poster No. 1737 in *Proc. Annu. Meet. Orthop. Res. Soc.* Orthopaedic Research Society, San Diego, CA, USA, (March 2017).
41. G. Pezzotti, N. Oba, W. Zhu, E. Marin, A. Rondinella, F. Boschetto, B.J. McEntire, K. Yamamoto, *et al.*, “Surface Chemistry of a Silicon Nitride Bioceramic Enhances Spinal Fusion: A Case Study;” Poster No. 2277 in *Proc. Annu. Meet. Orthop. Res. Soc.* Orthopaedic Research Society, San Diego, CA, USA, (March 2017).
42. Bryan J. McEntire, Erin N. Jones, Darin A. Ray, Ryan M. Bock, B. Sonny Bal, and Giuseppe Pezzotti, “Bacteriostatic Characteristics of Silicon Nitride, Polyetheretherketone, and Titanium Biomaterials,” SFB-534, Annual Meeting of the Society for Biomaterials, Minneapolis, MN, (April 2017).
43. Giuseppe Pezzotti, Naoki Oba, Wenliang Zhu, Elia Marin, Alfredo Rondinella Francesco Boschetto, Bryan J. McEntire, Kengo Yamamoto, and B. Sonny Bal “Chemical and Structural Analysis of Osseous Tissue within Synthetic Intervertebral Spinal Spacers,” SFB-603, Annual Meeting of the Society for Biomaterials, Minneapolis, MN, (April 2017).
44. Giuseppe Pezzotti, Alfredo. Rondinella, Elia Marin, Wenliang Zhu, Tetsuya Adachi, Ryan M. Bock, Bryan J. McEntire, and B. Sonny Bal, “Comparative Osteoinductive Characteristics of Silicon Nitride, Alumina, and Titanium,” SFB-328, Annual Meeting of the Society for Biomaterials, Minneapolis, MN, (April 2017).
45. B. Sonny Bal, Bryan J. McEntire, Ryan M. Bock, Alfredo Rondinella, Elia Marin, Wenliang Zhu, Tetsuya Adachi, and Giuseppe Pezzotti, “Differential Osteoinductivity of Spinal Biomaterials,” Paper No. 17-A-61-ABJS, The Association of Bone and Joint Surgeons Annual Meeting, Austin, TX, (April 2017).
46. G. Pezzotti, “The 'Holy Grail' of Bioinert Ceramic Oxides for Hip Joints and the Paradigm Shift Towards Non-Oxides,” Ceramics Exposition, Cleveland, OH, (April 2017).
47. B. J. McEntire, “Engineering Bacteriostatic Behavior Into Implantable Medical Devices,” Ceramics Exposition, Cleveland, OH, (April 2017).
48. B. Sonny Bal, “Ceramics in Orthopaedic and Neurosurgery,” Ceramics Exposition, Cleveland, OH (April 2017).
49. Masahiro Ishikawa, Karen L. De Mesy Bentley, Chao Xie, Edward M. Schwarz, B. Sonny Bal, and Bryan J. McEntire, “Surface Topography of Silicon Nitride Affects Antimicrobial and Osseointegrative Properties,” 4th Stevens Conference on Bacterial-Material Interactions, Hoboken, NJ, USA, (June 14-15, 2017).
50. Giuseppe Pezzotti, Nakoi Oba, Wenliang Zhu, Elia Marin, Alfredo Rondinella, Francesco Boschetto, Bryan J. McEntire, Kengo Yamamoto, and B. Sonny Bal, “Surface Chemistry of Silicon Nitride Bioceramic Enhances Spinal Fusion: A Case Study,” ORS Midwest Musculoskeletal Workshop, Washington University School of Medicine, Saint Louis, MO, (July 20, 2017).
51. B. Sonny Bal, Ryan M. Bock, Alfredo Rondinella, Elia Marin, Wenliang Zhu, Tetsuya Adachi, Bryan J. McEntire, and Giuseppe Pezzotti, “Osteoinductive Properties of Silicon Nitride, Alumina, and Titanium,”

Poster No. 7, ORS Midwest Musculoskeletal Workshop, Washington University School of Medicine, Saint Louis, MO, (July 20, 2017). (This poster received the prize of "Best Poster" at the workshop.)

52. Ryan M. Bock, Bryan J. McEntire, B. Sonny Bal, Giuseppe Pezzotti, "Effect of Ceramic Surface Chemistry on Polyethylene Oxidation", Materials Science & Technology 2017 (119th ACerS Annual Meeting), 10 October 2017, David L. Lawrence Convention Center, Pittsburgh, PA.
53. Ryan M. Bock, Elia Marin, Alfredo Rondinella, Francesco Boschetto, Tetsuya Adachi, B. Sonny Bal, Giuseppe Pezzotti, Bryan J. McEntire, "Development of a SiYAlON Glaze for Improved Osteoconductivity of Implantable Medical Devices", Materials Science & Technology 2017 (119th ACerS Annual Meeting), 11 October 2017, David L. Lawrence Convention Center, Pittsburgh, PA.
54. Bryan J. McEntire, "Bacteriostatic Behavior of Silicon Nitride, Polyetheretherketone, and Titanium Biomaterials," Keynote Address at the International Conference on Pharmaceutical and Biomedical Engineering, Osaka, Japan, October 16-17, 2017.
55. Giuseppe Pezzotti, "A Perspective on Future Developments of Hip-Joint Sliding Surfaces," Annual Meeting of the Japanese Hip Society, Tokyo, Japan, (October 19-21, 2017).
56. Giuseppe Pezzotti, Bryan McEntire, Naoki Oba, Wenliang Zhu, Elia Marin, Alfredo Rondinella, Francesco Boschetto, Kengo Yamamoto, and B. Sonny Bal, "Surface Chemistry of a Silicon Nitride Bioceramic Enhances Spinal Fusion: A Case Study," ORS PSRS 4th International Spine Research Symposium, Lake Harmony, PA (October 23-27, 2017).
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61. G. Pezzotti, R.M. Bock, B.J. McEntire, T. Adachi, E. Marin, F. Boschetto, W. Zhu, B.S. Bal, The Antimicrobial Resistance of Oxide and Non-Oxide Ceramics, Proc. Annu. Meet. Orthop. Res. Soc., New Orleans, LA (March 9-13, 2018), 333.
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64. G. Pezzotti, W. Zhu, N. Sugano, E. Marin, K. Yamamoto, N. Nishiike, T. Hori, B.J. McEntire, R. Bock, B.S. Bal, Oxide Ceramic Femoral Heads Contribute to Polyethylene Liner Degradation, Proc. Annu. Meet. Orthop. Res. Soc., New Orleans, LA (March 9-13, 2018) 275.
65. Neelam Ahuja, Kamal R. Awad, Ami Shah, Pranesh B. Aswath, Venu Varanasi, "Comparison of Silicon Nitride, Titanium and PEEK Surface Properties on Osteoblast Growth," Proc. Annu. Meet. Am. Assoc. Dent. Res., Ft. Lauderdale, FL, (March 21-24, 2018), 1020.
66. Karen L. de Mesy Bentley, Masahiro Ishikawa, Chao Xie, Bryan J. McEntire, B. Sonny Bal and Edward M. Schwarz, "Effect of Surface Topography on the Bacteriostatic and Osseointegration Behavior of Silicon Nitride," Spine Society of Australia 29th Annual Scientific Meeting, Adelaide, Australia, (April 27-29, 2018).
67. Ryan Trombetta, Karen L. de Mesy Bentley, Masahiro Ishikawa, Chao Xie, Bryan J. McEntire, B. Sonny Bal, and Edward M. Schwarz, "Effect of Surface Topography on the Bacteriostatic and Osseointegration Behavior of Silicon Nitride," 53rd Annual Meeting of the Rocky Mountain Neurosurgical Society, Banff, Alberta, Canada, June 20, 2018.

68. Michael Venezia, Scott A. Webb, Micah W. Smith, Daniel R. Romano, Bryan J. McEntire, and B. Sonny Bal, “Comparison of Allograft Spacers Versus Silicon Nitride Cages in Cervical Fusion,” 53rd Annual Meeting of the Rocky Mountain Neurosurgical Society, Banff, Alberta, Canada, June 20, 2018.
69. Tetsuya Adachi, Satoshi Horiguchi, Alfredo Rondinella, Francesco Boschetto, Elia Marin, Toshiro Yamamoto, Bryan McEntire, Osam Mazda, Narisato Kanamura, and Narisato Kanamura, “Osteoinductive Potential of Silicon Nitride Ceramics Versus Mesenchymal Stem Cells,” Poster 0658, 47th Annual Meeting of the AADR, Fort Lauderdale, FL, USA (Mar. 22, 2018).
70. Ryan M. Bock, David A. Cullen, Bryan J. McEntire, Karren L. More, Donovan N. Leonard, B. Sonny Bal, and Giuseppe Pezzotti, “Analytical Electron Microscopy Study of the Interface between Mineralized Extracellular Polymer and Osteogenic Si-Y-O-N Film Present at Annealed Silicon Nitride Surfaces,” Oak Ridge National Laboratory Center for Nanophase Materials Sciences User Meeting, Oak Ridge, TN, USA (2018).
71. Ryan M. Bock, Giuseppe Pezzotti, Wenliang Zhu, Elia Marin, Alfredo Rondinella, Francesco Boschetto, Bryan J. McEntire, and B. Sonny Bal1, “Compounded PEEK-Sintered Silicon Nitride Composite Exhibits Enhanced Osteoconductivity and Resistance to Biofilm Formation,” 31st Annual Congress of the International Society for Technology in Arthroplasty, London, UK (2018).
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75. T. Adachi, *et al.*, "Silicon Nitride Particulate Dispersion Enhances Antibacterial and Osteoconductive Activities of PEEK Implants,” 66th Annual Meeting of the Japanese Association for Dental Research, November 17-18, 2018, Hokkaido, Japan.
76. Ryan M. Bock, David A. Cullen, Bryan J. McEntire, Karren L. More, Donovan N. Leonard, Giuseppe Pezzotti, and B. Sonny Bal, “Characterization of Osteoconductive Phase Expressed to Surface of Silicon Nitride after Annealing,” University of Utah Nanofab Annual Open House, Salt Lake City, UT, USA (2018).
77. Michel Assad, Bryan J. McEntire, Sandra Iacampo, Madeleine Chagnon, Yannick Trudel, and B. Sonny Bal, “Osteoinduction and Osseointegration Evaluation of Si_3N_4 Implants using Rabbit Ectopic Bone Formation and Ovine Bilateral Long-bone Insertion Models,” Poster #52183, 39th Annual Meeting of the International Society of Orthopaedic Surgery and Traumatology Orthopedic World Congress, October 10-13, 2018, Montreal, Canada.
78. Scott Webb, “Polymers and Antimicrobial Activity in Interbody Cages,” Selby Spine Conference, Park City, UT, (Jan. 30 – Feb. 2, 2019).
79. Piyush Khullar and Jeremy L. Gilbert, “Head-Neck Taper Fretting Corrosion Performance: Si_3N_4 Vs. CoCrMo,” Poster #2132, Annual Meeting of the Orthopedic Research Society, Feb. 2-5, 2019, Austin, TX, USA.
80. Dongkai Zhu, Piyush Khullar, and Jeremy L. Gilbert, “Long-Term Fretting Corrosion Behavior of Si_3N_4/Ti-6Al-4V Head-Neck Taper Interface,” Poster 2216, Annual Meeting of the Orthopedic Research Society, Feb. 2-5, 2019, Austin, TX, USA.
81. Michel Assad, Bryan J. McEntire, Sandra Iacampo, Yannick Trudel, and B. Sonny Bal, “Osseointegration and Biocompatibility Evaluation of Silicon Nitride Composite Using Ovine Distal Femoral Epiphyseal Insertion and Rabbit Paravertebral Muscle Implantation Models,” Poster #1529, Annual Meeting of the Orthopedic Research Society, Feb. 2-5, 2019, Austin, TX, USA.
82. G. Pezzotti, “A Bioceramic with Antibacterial Properties,” Plenary Address at the Japanese Hip Society, Tokyo, Japan, Feb. 15, 2019.

83. Ryan M. Bock, Francesco Boschetto, Nami Toyama, Satoshi Horiguchi, Bryan J. McEntire, Tetsuya Adachi, Elia Marin, Wenliang Zhu, Osam Mazda, B. Sonny Bal, and Giuseppe Pezzotti, "Assessment of *in vitro* Antibacterial Activity of Oxide and Non-oxide Bioceramics for Arthroplastic Devices using Time-Lapse Vibrational Spectroscopy," 30th Annual Meeting of the Spine Society of Australia, Gold Coast Convention Center, Queensland, Australia, April 7, 2019.
84. Ryan M. Bock, Elia Marin, Tetsuya Adachi, Federica Lerussi, Alfredo Rondinella, Francesco Boschetto, Wenliang Zhu, Bryan J. McEntire, B. Sonny Bal, and Giuseppe Pezzotti, "Enhancements to Cell Proliferation, Bone Tissue Formation, Bacterial Biofilm Resistance, and Radiolucency Exhibited *in vitro* when Silicon Nitride-Type Materials are Compounded into PEEK," 30th Annual Meeting of the Spine Society of Australia, Gold Coast Convention Center, Queensland, Australia, April 7, 2019.
85. John Choi, Ryan M. Bock, Micah Smith, Daniel Romano, Bryan J. McEntire, and B. Sonny Bal, "A Single Center Retrospective Clinical Evaluation of Anterior Cervical Discectomy and Fusion Comparing Allograft Spacers to Silicon Nitride Cages," 30th Annual Meeting of the Spine Society of Australia, Gold Coast Convention Center, Queensland, Australia, April 5-7, 2019.
86. Francesco Boschetto, Ryan M. Bock, Bryan J. McEntire, Tetsuya Adachi, Elia Marin, Wenliang Zhu, Osam Mazda, B. Sonny Bal, and Giuseppe Pezzotti, "*In situ* Observations of Interactions between Bacteria and Bioceramic Surfaces using Time-Lapse Vibrational Spectroscopy," Poster presented at the 5th Stevens Conference on Bacteria-Material Interactions, Hoboken, NJ, USA June 12-13, 2019.
87. Francesco Boschetto, Ryan M. Bock, Bryan J. McEntire, Tetsuya Adachi, Elia Marin, Wenliang Zhu, Osam Mazda, B. Sonny Bal, and Giuseppe Pezzotti, "*In situ* Observations of Interactions between Bacteria and Bioceramic Surfaces using Time-Lapse Vibrational Spectroscopy," Elevated podium presentation at the 5th Stevens Conference on Bacteria-Material Interactions, Hoboken, NJ, USA June 12-13, 2019.
88. Francesco Boschetto, Ryan M. Bock, Bryan J. McEntire, Tetsuya Adachi, Elia Marin, Wenliang Zhu, Osam Mazda, B. Sonny Bal, and Giuseppe Pezzotti, "Raman and FTIR Time-Lapse Assessment of *in situ* Bacteria-Bioceramic Interactions," 4th International Conference on Innovations in Biomaterials, Biomanufaturing, and Biotechnologies, (Bio-4), Toronto, Canada, July 22-26, 2019.
89. Ryan M. Bock, Erin N. Jones, Giuseppe Pezzotti, B. Sonny Bal, and Bryan J. McEntire, "Refined PEEK/Silicon Nitride composite Resists Biofilm Formation," 121st Annual Meeting of the American Ceramics Society at Materials Science & Technology 2010, Portland, OR, USA (2019).
90. Francesco Boshetto, Ryan M. Bock, Bryan J. Mcentire, Tetsuya Adachi, Elia Marin Wenliang Zhu, Osam Mazda, B. Sonny Bal, and Giuseppe Pezzotti, "Time-Lapse *in vitro* Vibrational Spectroscopic Assessment of Antibacterial Activity of Oxide and Nitride Bioceramics Used in Implantable Medical Devices," 121st Annual Meeting of the American Ceramics Society at Materials Science & Technology 2010, Portland, OR, USA (2019).
91. Elia Marin, Tetsuya Adachi, Matteo Zanocco, Francesco Boschetto, Shota Somekawa, Ryutaro Ashida, Ryan M. Bock, Bryan J. McEntire, B. Sonny Bal, and Giuseppe Pezzotti, "Biomedical Applications of Non-Stoichiometric $Si_{(3+x)}N_{(4-y)}$ Coatings: Antibacterial and Osteoconductive Effects on Ceramic, Polymeric, and Metallic Substrates, ISTA 2019, Toronto, Canada, Oct. 2 – 5, 2019.
92. Francesco Boschetto, Ryan M. Bock, Bryan J. McEntire, Elia Marin, B. Sonny Bal, and Giuseppe Pezzotti, "Hinderance of Bacterial Proliferation by a Silicon Nitride Surface Buffering Effect," ISTA 2019, Toronto, Canada, Oct. 2 – 5, 2019.
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94. Ryan M. Bock, David A. Cullen, Bryan J. McEntire, Karren L. More, Donovan N. Leonard, B. Sonny Bal, and Giuseppe Pezzotti, "Analysis of Osteoconductive Si-Y-O-N Film Present at Annealed Silicon Nitride Surface," *Proc. of the 3st Annual Bioceramics Conference,* New Orleans, LA USA (October 2019).
95. Bryan J. McEntire and Giuseppe Pezzotti, "Antimicrobial Effectiveness of Nitric Oxide Releasing Compounds, Coatings, and Ceramics," ASTM International Symposium on Antimicrobial Combination Devices, Houston, TX, USA (November 5, 2019).
96. R. M. Bock, "Unique Benefits of Silicon Nitride as a Spinal Fusion Device Material," Annual Meeting of the Taiwan Neurological Society, Great Skyview, Taiwan, Taipei, Nov. 30 – Dec. 1, 2019.