HYPERBARIC LASER CHEMICAL VAPOR DEPOSITION OF HIGH-STRENGTH ALUMINUM-SILICON-CARBIDE NANOCOMPOSITE FIBERS FOR AEROSPACE AND TRANSPORTATION APPLICATIONS.

James Maxwell, La Trobe University, E∈MC^2 Centre, Engineering Dept., Melbourne, Victoria, Australia
j.maxwell@latrobe.edu.au
Avinash Baji, La Trobe University, E∈MC^2 Centre, Engineering Dept.
Ing Kong, La Trobe University, E∈MC^2 Centre, Engineering Dept.

Key Words: hyperbaric laser chemical vapor deposition, aluminum, silicon carbide, nanocomposite, fiber

For over 25 years, hyperbaric pressure laser chemical vapor deposition (HP-LCVD) has been studied by various authors as a mean for growing three-dimensional structures and fibers [1-2]. Novel normally-immiscible materials (NIMs) [3], amorphous/glassy ceramics [4], and high-strength fibers have been grown [5]. However, the highest experimental pressures to date have only reached beyond the critical point of certain alkanes (<60 bar) [6]. Our group has found it useful to synthesize materials from high pressure fluids, where the ensuing cooling rates after deposition can exceed 10^6 K/s. This has enabled the growth of (metastable) amorphous and nanostructured materials, including diamond-like carbon and boron carbides [7-8]. For this work, freestanding nanocomposite fibers were grown from mixtures of Bis(trimethylsilyl)methane and various organometallic and halide aluminum precursors. A chopped, cw fiber laser at 1064nm and diode lasers at 808nm were used for this work. The $1/e^2$ laser beam waists were approximately 10-15 microns across. The resulting Al-Si-C fibers could be grown continuously—and were nanostructured due to the precursor pressures and laser powers employed. A variety of phases were found to be present, including aluminum carbide, silicon carbide, carbon, and silicon-rich phases. Scanning electron microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS) were used to characterize the composition and structure of the resulting materials. A map of the ternary phase diagram under these non-equilibrium conditions will be provided and discussed in detail. These fibers will find utility in reinforcements for ceramic- and metal-matrix composites for aerospace and transportation applications.

References:

[1]F. T. Wallenberger, P. C. Nordine, M. Boman, Composites Science and Technology, 1994, 51, 192.
[2]J. L. Maxwell, US Patent #5,786,023, 1996.
[3]J. L. Maxwell, M. R. Black, C. A. Chavez, K. R. Maskaly, M. Espinoza, M. Boman, Applied Physics A-Materials Science and Engineering, 2008, 91, 507.
[4]F. T. Wallenberger, P. C. Nordine, Journal of Materials Research, 1994, 9, 527.
[5]M. Boman, D. Bauerle, Journal of the Chinese Chemical Society, 1995, 42, 405.
[6] J. Maxwell, Unpublished Results.
[7]J. Maxwell, M. Boman, W. Springer, J. Narayan, S. Gnanavelu, Journal of the American Chemical Society, 2006, 128, 4405.
[8]J. Maxwell, C. Chavez, W. Springer, K. Maskaly, D. Goodin, Diamond and Related Materials, 2007, 16, 1557.