Development of Active Porous Medium Filters Based on Plasma Textiles

Inexpensive, flexible, washable, and durable materials that serve as antimicrobial filters and self-decontaminating fabrics are needed to provide active protection to people in areas regularly exposed to various biohazards, such as hospitals and bio research labs working with pathogens. Airlines and cruise lines need such material to combat the spread of infections. In households these materials can be used in HVAC filters to fight indoor pollution, which is especially dangerous to people suffering from asthma. Efficient filtering materials are also required in areas contaminated by other types of hazardous dust particulates, such as nuclear dust. The primary idea that guided the undertaken study is that a microplasma-generating structure can be embedded in a textile fabric to generate a plasma sheath (“plasma shield”) that kills bacterial agents coming in contact with the fabric. The research resulted in the development of a plasma textile that can be used for producing new types of self-decontaminating garments, fabrics, and filter materials, capable of activating a plasma sheath that would filter, capture, and destroy any bacteriological agent deposited on its surface. This new material relies on the unique antimicrobial and catalytic properties of cold (room temperature) plasma that is benign to people and does not cause thermal damage to many polymer textiles, such as Nomex and polypropylene. The uniqueness of cold plasma as a disinfecting agent lies in the inability of bacteria to develop resistance to plasma exposure, as they can for antibiotics. Plasma textiles could thus be utilized for microbial destruction in active antimicrobial filters (for continuous decontamination and disinfection of large amounts of air) as well as in self-decontaminating surfaces and antibacterial barriers (for example, for creating local antiseptic or sterile environments around wounds and burns).

Biography

Dr. Kuznetsov joined Department of Mechanical and Aerospace Engineering at NC State University in 1998 after his postdoctoral appointments at Ruhr-University of Bochum (Germany), Ohio State University, and Vienna University of Technology. He received PhD in Mechanical Engineering from Russian Academy of Sciences in 1992. Dr. Kuznetsov’s research interests are in the general area of numerical modelling, including fluid mechanics, transport in porous media, transport in living tissues, bioheat transport, bioconvective sedimentation, Newtonian and non-Newtonian flows, flows in microgravity, and turbulence. His most recent research addresses axonal transport, left-right symmetry breaking in mammal embryos, modelling of electroporation, and thermal dose optimization in cancer treatment using hyperthermia. He attracted funding from many national and international agencies, including DARPA, NSF, NASA, EPA, NATO, USDA, DTRA, NTC, and Eastman Chemical. He edited two books, “Transport in Biological Media” and “Heat Transfer and Fluid Flow in Biological Processes”, which were published by Elsevier (2013, 2015). He published more than 400 journal papers, 10 book chapters, and more than 80 conference papers. He is also an affiliate faculty member of the UNC/NCSU Biomedical Engineering Department, Fellow of American Society of Mechanical Engineering, Associate Editor of the ASME Journal of Heat Transfer and the Journal of Porous Media, and a winner of a prestigious Humboldt Research Award. In 2014, Dr. Kuznetsov was elected as a Member of the Scientific Council of the International Center of Heat and Mass Transfer (ICHMT).