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Two Photon Polymerization of Nano- and Microstructured Biomaterials

Roger Narayan
North Carolina State University/University of North Carolina
Joint Department of Biomedical Engineering
United States
roger_narayan@msn.co

Extended Abstract

Two photon polymerization involves use of ultrashort (e.g., femtosecond) laser pulses to selectively polymerize and harden photosensitive resins; this technique has been used for 3D printing of materials with microscale and/or nanoscale features. The two photon polymerization technique involves near simultaneous absorption of two ultrashort photons within a small volume over a short time period, providing electronic excitation that is analogous to a single photon with much higher energy. The nonlinear nature of two photon absorption enables 3D printing of structures, including structures for biomedical applications, which contain features below the diffraction limit. Structures with precise geometries are created by polymerizing and hardening the photosensitive resin along the laser trace. Several kinds of photosensitive resins may be processed into medically-relevant structures with two photon polymerization. In addition, two photon polymerization can be set up in a conventional laboratory or manufacturing environment; no specialized facilities such as facilities are needed. It should also be noted that two photon polymerization is a straightforward and rapid process for creating structures with complex geometries. Recent medical uses of two photon polymerization have included processing of microscale structures out of polymers, zirconium oxide hybrid materials, and other organically-modified ceramic materials. Processing of medically-relevant structures, including microneedles, scaffolds and patterned interfaces for cell growth, will be reviewed. In vitro evaluation of two photon polymerization-fabricated materials with the MTT assay and with other assays will be considered. The end use of two photon polymerization-produced microstructured biomaterials (e.g., testing of microneedles with cadavermic porcine skin) will be described. Our results indicate that two photon polymerization is an important technique for creating microstructured biomaterials and medical devices.