Polymer-free Films of Single-walled Carbon Nanotubes as a Saturable Absorbers for Fiber Lasers

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Single-walled carbon nanotubes saturable absorbers (SWCNT-SA) are well known alternative for more expensive SESAMs. Among other advantages of SWCNT-SA are broad-band operation, self-starting of pulse generation, simplicity of implementation into laser resonator and possibility of realization of all-fiber scheme for passive mode-locking. The draw-back is low compared to SESAMs absorption modulation depth which, however, does not play crucial role for fiber lasers with high gain. The other disadvantage is low temperature stability of the SWCNT-SA that can be associated with polymer matrix degradation. Here we report the SWCNT-SA for fiber lasers, that has nor polymer nor any other support. Clean SWCNT can withstand 600 ^{0}C on air and more than 1000 ^{0}C in inert gas environment. SWCNT were synthesized by the aerosol (floating catalyst) CVD technique and collected on filter to produce thin films. From the filter SWCNT can be transferred to any substrate by dry deposition technic. No cleaning or separation steps needed for SWCNT-SA preparation in this method.

Previously passive mode-lock regime was demonstrated with this kind of SWCNT-SA implemented on the mirror in free-space scheme for various type of fiber lasers [1] and on the standard ferrule connectors for the Er-fiber laser [2]. In this work we report passive mode-locking on the Er-dopped and Bi-dopped fiber laser. To our knowledge, it is the first demonstration of picosecond fiber laser at 1.32 μm based on phosphosilicate fiber doped with bismuth mode-locked by SWCNT-SA. We investigate SWCNT-SA implementation in two geometries: on the standard ferrule and on D-shaped fiber. Pulse generation obtained in both anomalous dispersion and normal dispersion regimes. The D-shape fiber geometry allows to increase greatly the thermal stability of the system because only a part of the evanescent field of the laser mode interacts with the SWCNT. Our investigations show it becomes important when average laser power exceeds 10 mW, the power enough to induce an optical damage of SWCNT-SA on ferrule.

[1] A. G. Nasibulin et al "Multifunctional free-standing single-walled carbon nanotube films" ACS nano, 5(4), 3214-3221 (2011).
[2] S. Kobtsev et al "Ultrafast all-fibre laser mode-locked by polymer-free carbon nanotube film" Optics Express, Vol. 24, Issue 25, pp. 28768-28773 (2016)

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