Light and voids of fiber fuse: precise comparison of in situ image and fused fibers

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The damped oscillation of a fiber fuse light emission does not overlap the scattering pattern of the following periodic voids. This may be because the melted glass surrounding the quenched plasma shifts to form bullet-like voids.

In the two decades that have passed since the discovery of the fiber fuse phenomenon [1, 2], significant progress in laser technology has made it a real threat to optical communication systems. Since 2004, I have been investigating the nature of fiber fuse propagation through ultra-high speed videography [3, 4, 5]. This report discusses its modulated light emission in relation to its periodic void formation.

A fiber fuse was initiated at the output end of a commercial single-mode optical fiber (SMF-28e) delivering 9 W 1.48 nm light. Its propagation was observed through an ultra-high speed CCD camera (FASTCAM SA5, Photron Ltd., sensitivity range: 380–790 nm). Pictures with a resolution of 128×32 and a 4096-step gradation were taken every 1.43 μs with an exposure time of 0.37 μs (see Fig. 1).

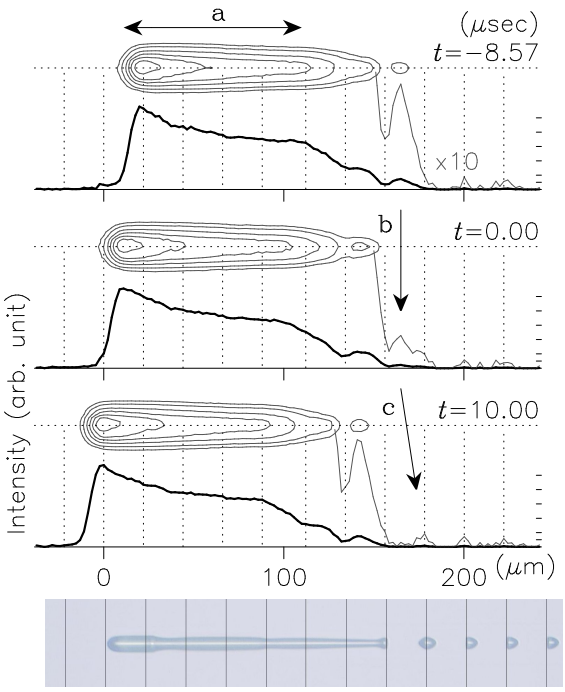

Figure 1: Intensity profiles of in situ image of fiber fuse propagating through a single-mode optical fiber pumped by 9 W 1480 nm light (upper) and generated voids (lower). The vertical line interval is 22 μm.

The front two-thirds of the intensity profile (see arrow **a**) remained constant during the propagation but the remainder was modulated periodically, i. e., a small peak appeared on the shoulder of the main peak and stayed in the same position until its extinction (see arrow **b**). Although the interval of these small peaks was the same as that of the periodic voids (see the photo in Fig. 1), the position of the emission decay did not coincide with the scattering points from the void train (see arrow **c**). Considering that the bullet-like shape of the voids is formed by their asymmetric contraction caused by the pressure of the optical discharge [4], this shift appears because the contraction occurs after the light extinction.

[1] R. Kashyap and K. J. Blow, "Observation of catastrophic self-propelled self-focusing in optical fibres," *Electron. Lett.*, vol. 24, pp. 47–49, Jan. 1988.

[2] D. P. Hand and P. St. J. Russell, "Solitary thermal shock waves and optical damage in optical fibers: the fiber fuse," *Opt. Lett.*, vol. 13, pp. 767–769, Sept. 1988.

[3] S. Todoroki, "In-situ observation of fiber-fuse propagation," *Jpn. J. Appl. Phys.*, vol. 44, pp. 4022–4024, June 2005.

[4] S. Todoroki, "Origin of periodic void formation during fiber fuse," *Optics Express*, vol. 13, pp. 6381–6389, Aug. 2005.

[5] http://www.youtube.com/Tokyo1406